Practical Aspects of Hair Transplantation in Asians

Damkerng Pathomvanich
Kenichiro Imagawa
Editors

With contributions by
Robert Haber

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Foreword

Do we really need another hair transplant textbook? I think that question is part of the Foreword of quite a few textbooks. And why one that focuses on Asians? Couldn't that just be a chapter in one of the "standard" textbooks? The answers to those questions will be evident within the pages of this text. Few surgical procedures see so many advances on a regular basis. By the time a textbook is published, advances will have made some chapters obsolete, and technique refinements will have changed recommendations found in others. And while some surgeons are content to perform the same technique and see the same results year after year, the really great ones are constantly striving toward the unreachable goal of perfection, and in that pursuit eagerly absorb the contents of the latest articles and textbooks.

I am a "lumper" and not a "splitter," meaning that I do not like to subdivide categories, unless there is a significant benefit to doing so. Thus, I like the simple categories of "Caucasian" and "Asian" and "African." But as a Caucasian myself, I was ignorant of the remarkable breadth of what constitutes "Asian." Only after accepting Damkerng's offer to assist with the editing of this text, and educating myself regarding what it means to be Asian, did I truly understand that only a comprehensive Asian textbook can adequately address the myriad phenotypic, ethnic, and societal aspects of hair transplantation in this diverse category.

This text does not limit itself to the unique hairline design approaches required for brachycephalic skulls, as that would indeed only require a chapter in another text. Rather, this is a comprehensive text including all aspects of hair restoration, from general recommendations and scalp diseases, to strip and FUE donor harvesting, hairline design and implantation techniques, to complications. Staff training approaches are reviewed, as well as adjunctive pharmacologic treatments and non-pharmacologic interventions such as PRP, SMP, and light therapy. In addition, highly advanced techniques such as eyebrow, eyelash, pubic hair, beard, and transgender transplantation techniques are discussed. While I edited, I also learned. Because of language barriers, many of these authors will not be seen at the podium of the ISHRS World Congress, and that is a shame, as clearly the quality of work performed in the included Asian regions is excellent. I feel very fortunate to be one of the first people to actually read this text cover to cover, as I have had the advance opportunity to try some of the many ideas and techniques in my office. And while the task of converting these manuscripts into grammatically correct English was at times arduous, I cannot imagine writing a scientific chapter in a language other than my own, so my profound respect goes to the authors from so many countries who did just that. It was both a pleasure and an honor to work with Damkerng Pathomvanich and Kenichiro Imagawa, two individuals who have successfully bridged the East and the West, and who I am fortunate to call friends, and not just colleagues.

Beachwood, OH, USA Robert Haber

Preface

Since the publication of our first Asian textbook entitled *Hair Transplantation in Asians* in 2010, we have come to realize that the scope of the textbook did not cover the entire Asian continent (please see Chap. 1, "The Asian Continent: Its Origin and Evolution," for details). We realize that even among Asians countries, differences in culture, skin texture, and skin color greatly contribute to the success of the procedure and, ultimately, to the patient's utmost satisfaction. Hence, the concept of a second edition that encompasses the challenges of hair transplantation in different Asian ethnicities is introduced.

The contents of this new book include the majority of Asian countries where hair transplantation is actively performed with optimal results. Luckily, Asians have only black hair which makes it a bit easier for hair transplant surgeons to deal with in comparison to Caucasians with different color shades.

It was a very arduous task to gather and select prominent physicians from East, Southeast, South, and West Asian regions with extensive experience in hair transplantation for over a decade, to write and give the reader an insight into different hairline designs among Asians and to enlighten us as to the differences in hair transplantation in Asia compared to Europe and North America in terms of techniques and the like. This practical book also caters to all types of readers, be it an entrepreneur, a new doctor yearning to gain experience in hair transplantation, an experienced hair surgeon, or anybody interested in this field. This book will prove to be a valuable tool.

The number of hair transplantation procedures in Asian countries has continued to increase and has actually surpassed the United States of America and Europe, based on the 2015 data from the ISHRS. After one and a half decades, the number of FUE procedures performed in treating male pattern hair loss almost equaled FUT for the first time. It was predicted that FUE might outperform FUT in the future but this remains to be seen. PRP and LLLT which continue to proliferate as alternative treatments for hair loss are included in this textbook. Hair cloning is now trending in popularity and might be available in the United Kingdom soon to treat thinning hair, but it will take a few more years to see the effectiveness of this treatment. Innovations in new FUE machines and punches to improve and minimize transection of the follicles are emerging each year. Hopefully in the future, we might have a device that allows the surgeon to see the mysterious direction of the hair follicle beneath the scalp, which, for now, we blindly try to harvest.

Editing this text was challenging since English is not the primary language in Asia. I'm very fortunate and excited that Dr. Robert Haber, a good old friend who completed his fellowship training at the Stough Clinic (as I did), accepted the role of an associate editor. I would like to thank Bob Haber who has been working tirelessly the whole year editing and providing grammar checks in the manuscripts. I have learned that he also has another book to edit, must prepare lectures for various meetings, and runs a busy private practice and takes care of his beloved father. Without the assistance of Dr. Dell Kristie A. Ortega-Castillejos, my fellow from the Philippines, and Dr. Sittichai Ingprasert, my fellow from Thailand, I would be dead. They have organized all the chapters, contacted the authors, and checked the manuscript format before sending to Bob Haber for editing. Thank you Drs. Dell and Sittichai. My thanks also goes to Ms. Natenapa Arunrattanapong, my nurse, who helped me select the best pictures for my text. I would also like to extend my heartfelt gratitude to all contributing authors for putting their valuable time and knowledge toward writing for this book. Lastly, I would like to thank my loving family for their patience in coping with me and for the stolen family time for the past 2 years.

There are many new textbooks in hair transplantation. However, this text focuses only on *the practical aspects of hair transplantation in Asians*. The tips and pearls provided in the boxes in each chapter will give the reader easy access to valuable information for their practice. I sincerely hope this textbook will be a good asset to all of us who practice hair restoration surgery.

Phayathai, Bangkok
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Damkerng Pathomvanich, M.D., F.A.C.S., F.I.S.H.R.S.

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Chapter 1
The Asian Continent: Its Origin and Evolution

Dell Kristie A. Ortega-Castillejos

1.1 Asia's Geography

The history of Asia can be seen as the collective history of coastal regions such as East Asia, South Asia and Middle East linked by the interior mass of the Eurasian steppe [1]. Asia is the earth's largest and most populous continent, located primarily in the Eastern and Northern Hemispheres [3]. It comprises 30% of the earth's land area and has the bulk of the planet's human population, currently roughly at 60% [2]. It is bounded on the east by the Pacific Ocean, on the south by the Indian Ocean, and on the north by the Arctic Ocean (Fig. 1.1). It is subdivided into 48 countries, two of them (Russia and Turkey) having part of their land in Europe [2] (Fig. 1.2).

Asia has a mix of different climates, ranging from the equatorial south via the hot desert of the Middle East, temperate areas in the East, and the extremely cold weather in polar areas of Siberia [2]. This has led to adaptation of its inhabitants to its environment, hence the racial diversity in the looks and build of each ethnic group in Asian countries (Fig 1.3).

Such ethnic groups are mainly subdivided into North Asians, South Asians, East Asians, Southeast Asians, and West Asians. For purposes of discussion with regard to hair transplantation, we have excluded North Asians in this book, as we rarely get patients from these countries.

East Asia, in general terms, consists of China, Hong Kong, Macao, Taiwan, Japan, South Korea, and North Korea. (Table 1.1) The dominant influence histori-

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Fig. 1.1 Ocean boundaries of Asia (Reproduced from www.mapsofworld.com)

cally has been China, but in modern times, cultural exchange has flowed bidirectionally [2] (Fig. 1.2).

South Asia mainly consists of the countries of Bangladesh, Bhutan, India, Maldives, Nepal, Afghanistan, and Sri Lanka [2] (Fig. 1.2) (Table 1.1).

Southeast Asia is often split into two parts: Mainland Southeast Asia, comprising Burma, Cambodia, Laos, Peninsular Malaysia, Thailand, and Vietnam. The other part is Maritime Southeast Asia which includes Brunei, East Timor, Indonesia, East Malaysia, the Philippines, and Singapore [2] (Fig. 1.2) (Table 1.1).

Southeast Asia has had a lot of Western influence due to the lasting legacy of colonialism. One example is the Philippines, which has been heavily influenced by Spain and the United States over the course of almost four centuries of colonization [2].

West Asia largely corresponds with the term Middle East [2]. It consists of Armenia, Azerbaijan, Bahrain, Cyprus, Iran, Iraq, Israel, Georgia, Jordan, Kuwait,

Fig. 1.2 Asian countries (Reproduced from Geography of Asia. http://en.wikipedia.org/wiki/Geography_of_Asia)

Fig. 1.3 Racial diversity among Asian people (Reproduced from Mongoloid. https://en.wikipedia.org/wiki/mongoloid)

Table 1.1 Asian countries according to geographical subdivision

East Asia	China, Hong Kong, Macao, Taiwan, Japan, South Korea, and North Korea
Southeast Asia	Burma, Cambodia, Laos, Malaysia, Thailand and Vietnam, Brunei, East Timor, Indonesia, the Philippines, and Singapore
West Asia	Armenia, Azerbaijan, Bahrain, Cyprus, Iran, Iraq, Israel, Georgia, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, and Yemen
South Asia	Bangladesh, Bhutan, India, Maldives, Nepal, Afghanistan, and Sri Lanka

Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, and Yemen [2] (Fig. 1.2) (Table 1.1).

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Chapter 2
Practical Anatomy in Hair Transplantation

Sittichai Ingprasert, Patra Pinyopawasutthi, and Damkerng Pathomvanich

2.1 Introduction

The authors have selected and illustrated specific anatomical features of the scalp that are essential for the surgeon when performing hair restoration surgery and not general scalp anatomy as described elsewhere.

2.2 Embryology

Hair follicles are derived from an interaction between embryological ectoderm and mesoderm. The full development of the hair follicle is the result of a complex sequence of signals both within and between the epidermis and dermis. The hair follicle development is differentiated into four stages: placode, germ, peg and bulbous peg, and between the 10th week and 18th week of intrauterine life [1].

2.3 Anatomy of Hair Follicle

The hair follicles consist of the infundibulum, isthmus, and bulb. The dividing line between two parts is just below the bulge or the insertion of the arrector pili muscle [2] (Fig. 2.1).

The outer root sheath is the site of follicular stem cells, and most stem cells are in the bulge and along the isthmus located 1.0 mm from skin surface [3]. Therefore,

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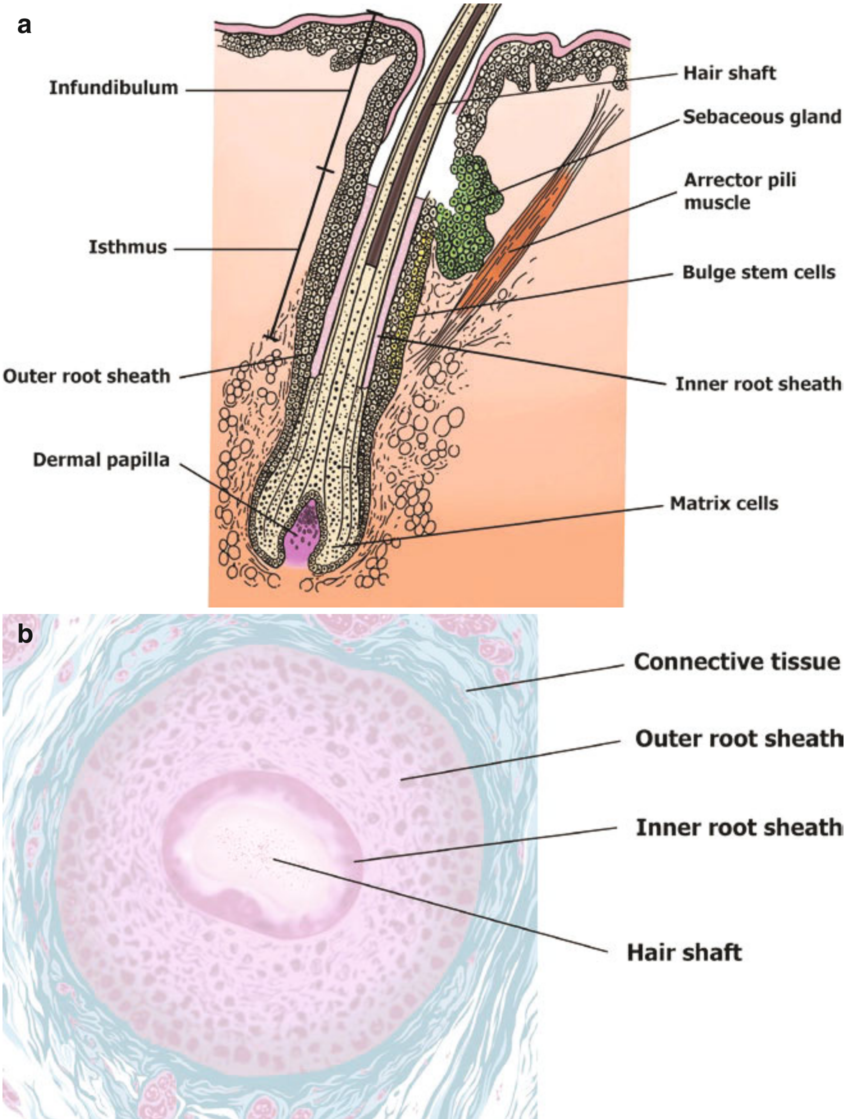


Fig. 2.1 Anatomy of hair follicle in longitudinal section (**a**) and cross section (**b**)

transections less than 1.0 mm in depth, including trichophytic closure, will not affect hair growth.

The arrector pili muscle attaches to the hair bulge and may have some interaction with the stem cells. Recent findings demonstrate an association between the loss of arrector pili muscle attachment and miniaturization in androgenetic alopecia (AGA) [4]. In AGA, the arrector pili muscle gradually degenerates and is replaced by adipose tissue, while this change has not been noticed in other reversible hair loss problems such as telogen effluvium or alopecia areata [5].

Hair shaft thickness can be classified as vellus, intermediate, and terminal hairs (Fig. 2.2):

Vellus hair is fine and poorly pigmented. The depth of the vellus hair root is 0.646±0.140 mm [6], and the thickness of hair shaft is less than 30 μm.

Intermediate hair is less pigmented than the terminal hair and is a transition of vellus to terminal hair. The length below the skin surface is 2.59±0.07 mm [7].

Terminal hair has a longer length and a larger diameter compared to other hair fibers. It is a thick and pigmented hair that has fully matured, with a hair diameter of more than 60 μm.

Asian hair has different characteristics from Caucasians (Fig. 2.3). The average depth of the hair root in Asians is 4.0–5.0 mm [8] (Fig. 2.4) which is deeper than in Caucasians (3.8–4.6 mm) [3]. Hair shaft thickness in East Asians is 100 μm, compared with 70 μm for Caucasians [9]. There is a positive correlation between the hair shaft diameter and hair root depth [10]. Hence, harvesting with FUE in Asians has higher transection rates and more vascular injury. Hair exit angle at the scalp varies from site to site. The exit angle becomes more acute at the neck and temple regions and more obtuse toward the crown or top area. Furthermore, the hair

Fig. 2.2 Follicular unit (FU) consisting of terminal hair in 1-hair, 2-hair, and 3-hair FU (*upper row*) and miniaturized hair with terminal hair (*lower row*)

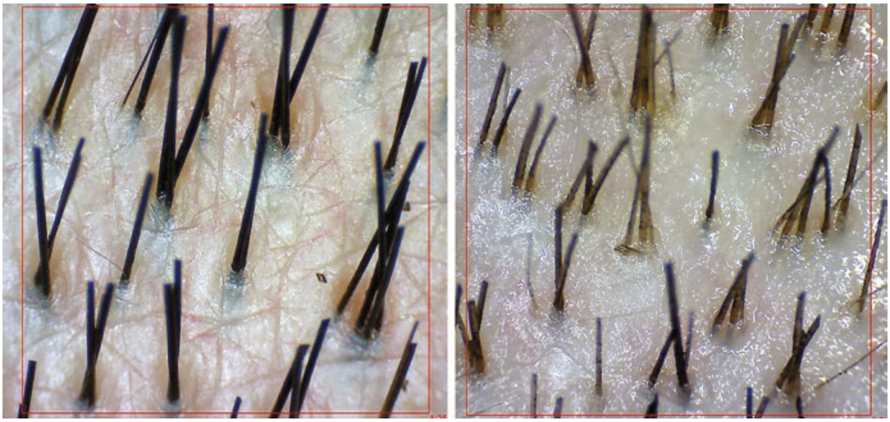
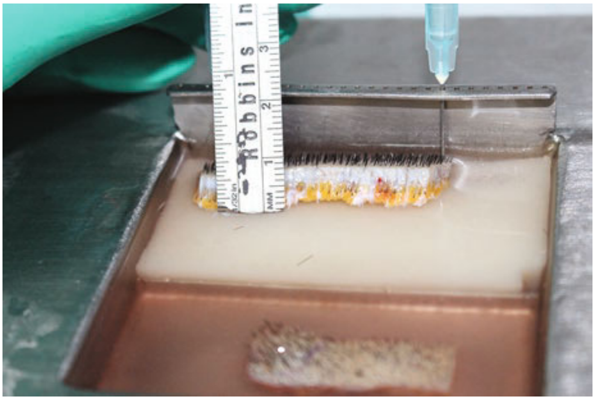


Fig. 2.3 The comparison of follicular unit between Asian (*left*) and Caucasian (*right*) with the same magnification at the external occipital protuberance (see text in detail)

Fig. 2.4 Depth of Asian hair follicle and variation in length



alignment underneath the skin can be altered. The change between internal and external angle has been studied and showed that the average angle change was 6.43° and 14.65° in straight and curly hair, respectively [11]. Therefore, the FUE surgeon should consider changing the hand movement according to the depth or use a larger punch size to reduce the transection rate.

2.4 Anatomy

2.4.1 Head Shape

The head shape proportion differs from race to race. The Asian skull is brachycephalic with a rounder skull in comparison with dolichocephalic or longer skull in Caucasians (Fig. 2.5) [12].

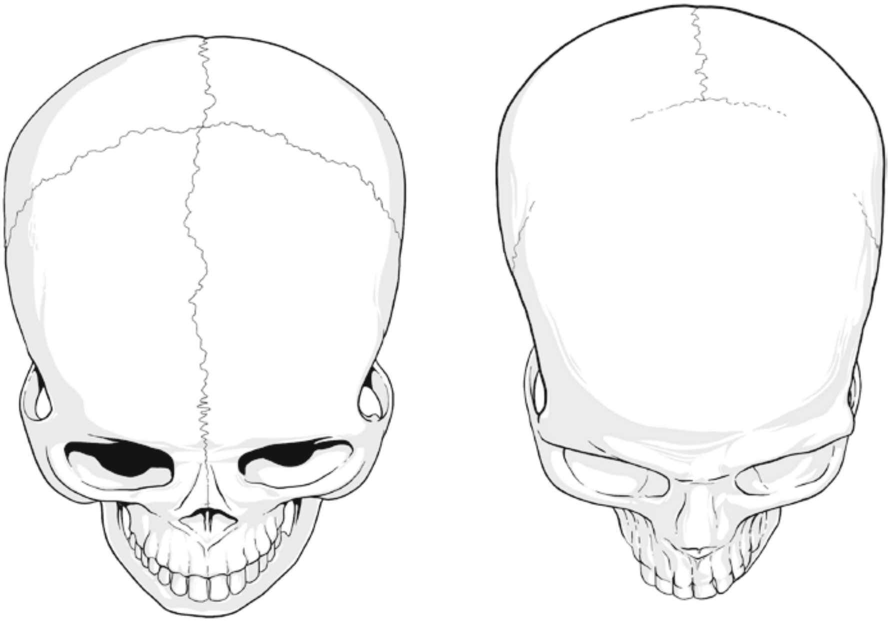


Fig. 2.5 Skull comparison between Asian (*left*) and Caucasian (*right*)

2.4.2 Scalp Layers

The scalp consists of five layers and extends from the top of the forehead to the superior nuchal line. The first three layers are bound together and easily separate from the other two [13]. The acronym "SCALP" denotes these five layers (Fig. 2.6):

*S*kin. The thick skin of the scalp is hairy and rich in sebaceous glands.

*C*onnective tissue. It contains numerous blood vessels, nerves, and fibrofatty tissue. Dissecting in this plane will encounter profound bleeding from the anastomoses between branches of the occipital, superficial temporal, and supraorbital vessels.

*A*poneurosis. Epicranial aponeurosis is a thin, tough, fibrous sheet connected to occipitofrontalis muscle and temporal fascia.

*L*oose areolar tissue is the subaponeurotic space and loosely attaches the aponeurosis and pericranium. This layer is avascular and excellent for dissecting in flap surgery.

*P*ericranium is the periosteum of skull.

2.4.3 Vascular Supply of the Scalp

Supratrochlear and supraorbital arteries are branches of ophthalmic arteries (internal carotid arteries), which arise from the medial part of superior orbital rim and ascend to supply the frontal scalp. The superficial temporal artery, a branch of

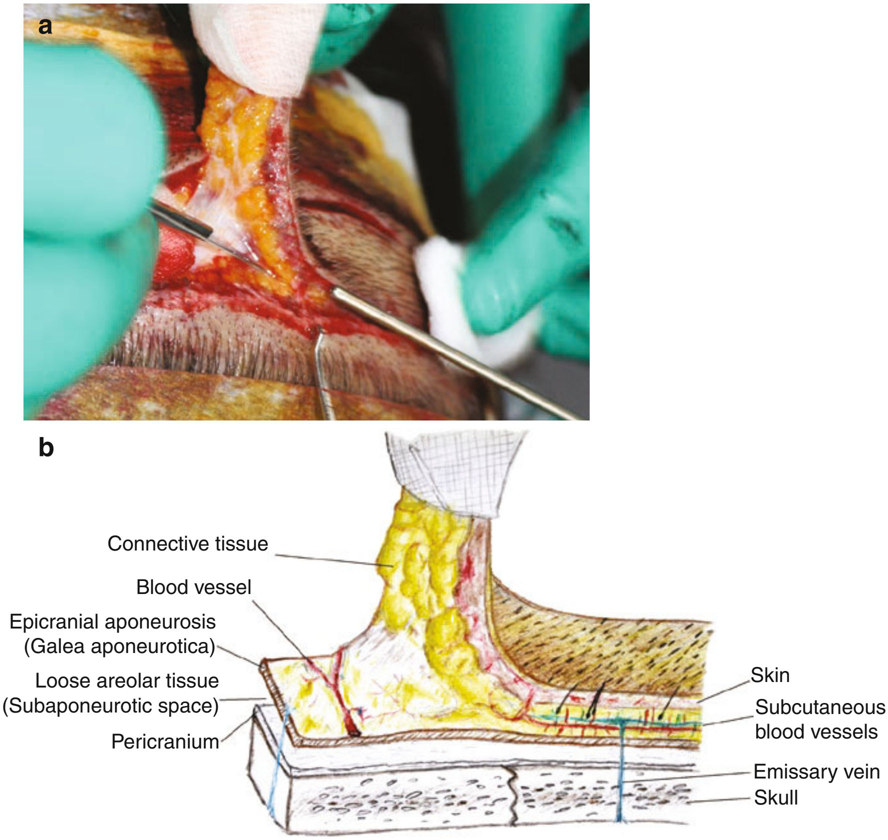


Fig. 2.6 Dissection plane of strip harvesting above the aponeurosis but below hair bulbs (**a**). Illustration shows scalp layers with vascular supply (**b**). Scalp layers at temporal area (2.7**c**)

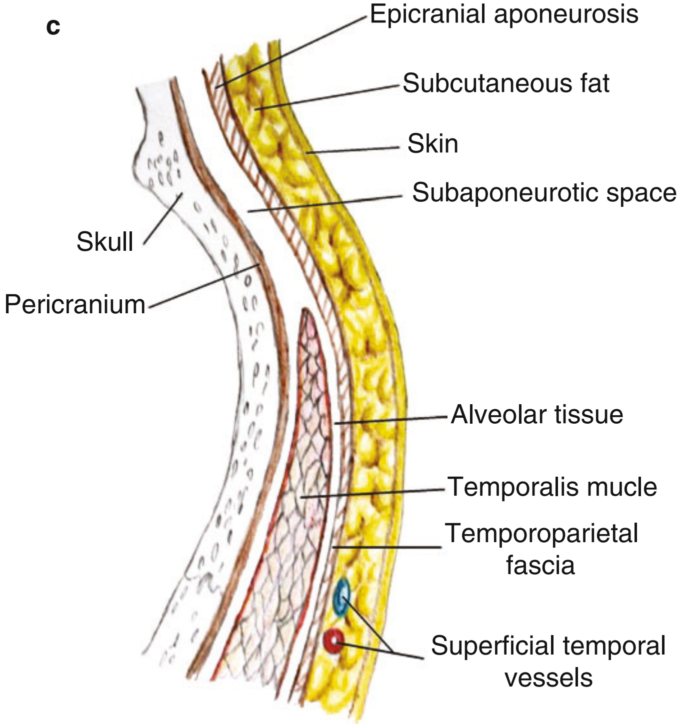


Fig. 2.6 continued

external carotid artery, gives anterior and posterior branches to supply the scalp over the frontal and temple regions. Posterior auricular arteries ascend behind the ears and supply the skin above the auricles. Occipital arteries, which are branches of the external carotid artery, emerge to the scalp by passing between the trapezius and sternocleidomastoid near their occipital attachment and supply the posterior part of the scalp. All of these arteries freely anastomose with one another. The veins of the scalp accompany the arteries and have similar names (Fig. 2.7).

Vascular injury can occur during strip harvesting or scalp flap surgery, especially the occipital vessels which ascend beneath the fascia overlying the occipitalis muscle (Fig. 2.8). The distance between occipital arteries ranges from 10–11.5 cm [14]. Occasionally, superficial temporal arteries are encountered if the donor harvesting is performed beyond the ears (Fig. 2.9).

2.4.4 Sensory Nerve Supply of the Scalp

Innervation on the donor area is mostly contributed by the greater occipital, lesser occipital, and auriculotemporal nerves (Fig. 2.10). The greater occipital nerve is accompanied by the occipital artery. The lesser occipital nerve ascends along the

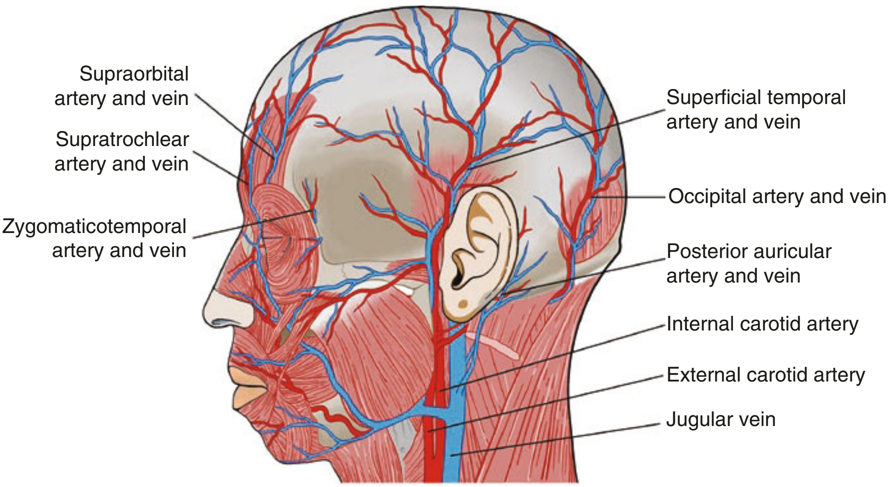


Fig. 2.7 Vascular supply of the scalp

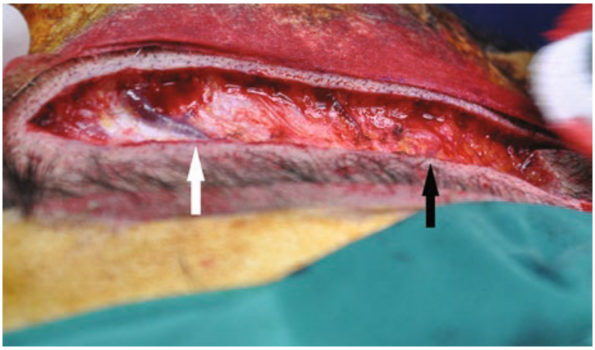


Fig. 2.8 Superficial temporal vessel (*white arrow*) and occipital vessel (*black arrow*)

Fig. 2.9 Superficial temporal vessel when strip harvesting above the auricle

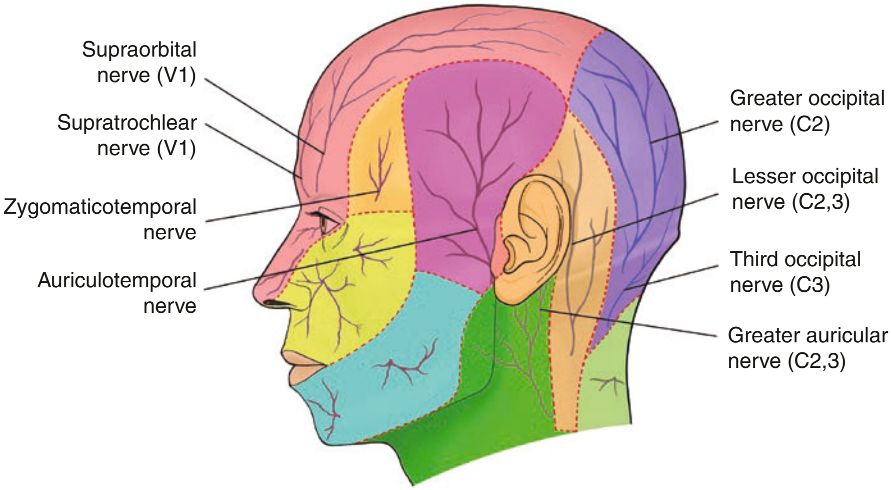


Fig. 2.10 Sensory nerve supply of the scalp

posterior margin of sternocleidomastoid and passes up on to the scalp behind the ear, while the auriculotemporal nerve emerges behind the temporomandibular joint and ascends to supply temple area.

Supratrochlear and supraorbital nerves are the small and large terminal branches of the frontal nerve. The supraorbital nerve transverses from supraorbital foramen located on the medial 1/3 of supraorbital rim and gives off medial and lateral branches that supply the skin of the forehead to the vertex. The medial branch perforates the frontalis muscle, while the lateral branch ascends further and pierces the epicranium. The supratrochlear nerve emerges between the trochlea and supraorbital foramen to supply the skin of the lower forehead near the midline. The frontotemporal area and temple points are supplied by zygomaticotemporal and auriculotemporal nerves.

2.4.5 Lymphatic Drainage of the Scalp

Lymphatic drainage from the forehead, temporal region, and sideburns go to the superficial parotid nodes, which lie just anterior to the tragus. The scalp above and behind the ear drains to the upper deep cervical and posterior auricular nodes which are located on the mastoid process. The occipital part of the scalp drains to the occipital nodes and lower deep cervical nodes. Occipital nodes are commonly superficial to the upper attachment of the trapezius muscle (Fig. 2.11). Enlargement of lymph nodes leads to the area of lymphatic drainage as described.

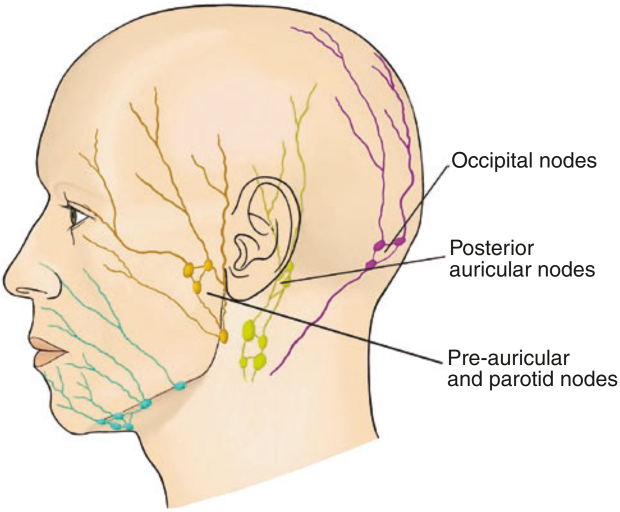


Fig. 2.11 Lymphatic drainage of the scalp

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Chapter 3
Hair Characteristics of East and Southeast Asians

Dell Kristie Ortega-Castillejos

3.1 Introduction

Most Asian hairs are black in color, coarse, and straight [1]. This stark contrast with the light color of the scalp makes hair transplantation a tad more difficult in the sense that the color differences of the scalp and hair is a factor in creating acceptable densities for each patient. However, the thick-caliber hair shafts of Asian hairs compensate for this disadvantage, as it requires very small graft numbers to produce a natural look [1].

Caucasians are reported to have more density compared to Asians [1, 2]. Avram et al. noted that the average follicular unit density in the donor area of Caucasians ranges from 70–100 FU/cm^2 with the average hair density count of 260 (±) 30 hairs/cm^2 [3].

East and Southeast Asian hairs do not differ much in terms of color, caliber, curl, and densities. However, there are certain specific qualities of each ethnicity that separates East from Southeast Asians. East Asia is comprised primarily of China, Hong Kong, Taiwan, Japan, and South and North Korea, while Southeast Asia is comprised of Burma, Cambodia, Laos, Malaysia, Thailand, Vietnam, Brunei, East Timor, Indonesia, the Philippines, and Singapore (refer to Chap. 1).

In a study done by Tsai et al., the normal Chinese scalp was found to have an average density of 71.78 FU/cm^2, translating to 137.08 hairs/cm^2, with a predominance of 2-hair follicular units at 50.29% [4]. This study also concluded that Chinese men with androgenetic alopecia have an average of 68.07 FU/cm^2 [4]. Kim likewise noted in a different unit of measurement that Korean scalps have an approximate density of 120 hairs/cm^2 in the occipital zone and about 100 hairs/cm^2

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in the temporal area [1]. He also stated that Korean subjects were noted to have the following proportion of follicular groupings: 45% of 1-hair FU, 42% of 2-hair FU, and 7% of 3-hair FU [1].

In a retrospective assessment done by Ortega-Castillejos and Pathomvanich, East and Southeast Asian men with androgenetic alopecia had an average density of 61.1 FU/cm^2 with 111.2 hairs/cm^2 [5] (Table 3.3) (Fig. 3.1). The study also noted the following proportion of follicular unit grafts in different points of the scalp: 57.5 FU/cm^2 for the left temporal area, 61.6 FU/cm^2 for the left parietal area, 65.6 FU/cm^2 for the central occipital area, 63.6 FU/cm^2 for the right parietal area, and 57.2 FU/cm^2 for the right temporal area [5] (Table 3.1).

It is also interesting to note that East and Southeast Asians have a predominance of 2-hair FU grafts at 54.2%, which is found to be densest at the central occipital region [5]. The proportion of each follicular unit in different points of the scalp is further outlined on Table 3.2.

Having determined the average number of FUs/cm^2, the authors in the similar study have also determined the average number of hairs in different points of the scalp (Table 3.3).

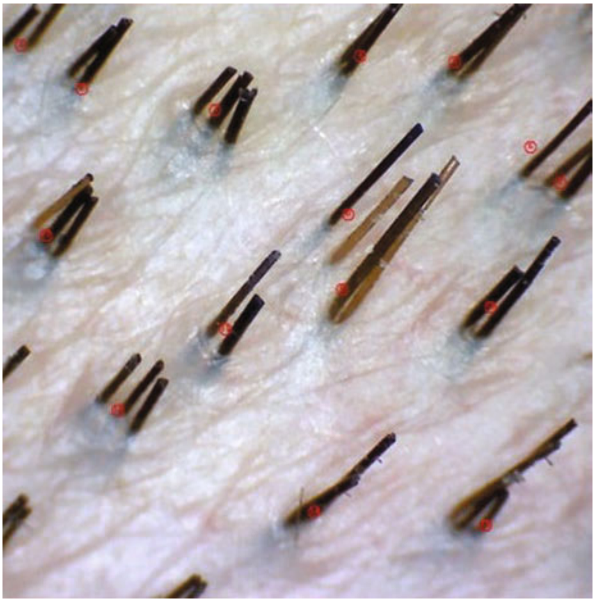

Fig. 3.1 Southeast Asian Hair

Table 3.1 Follicular unit density for each reference point in East and Southeast Asians

Left temporal	Left parietal	Central occipital	Right parietal	Right temporal	Average density
57.5 FU/cm^2	61.6 FU/cm^2	65.6 FU/cm^2	63.6 FU/cm^2	57.2 FU/cm^2	61.1 FU/cm^2

Excerpts from Retrospective Assessment of Follicular Unit Density in Asian Men with Androgenetic Alopecia. Ortega-Castillejos, MD, Pathomvanich MD. Dermatol Surg 2017; 43(5): Table 1, pp. 675

While the density of the donor area is an important factor in hair restoration, the degree of miniaturized hair is also of utmost concern in predicting the success of this procedure [6, 7]. Ortega-Castillejos and Pathomvanich have studied this aspect in East and Southeast Asians and have concluded that the average number of miniaturized hairs in this ethnicity is 7.8 hairs/cm^2, which is 7% of the total amount of hairs/cm^2 [5]. Table 3.4 will show that the temporal areas have the largest amount of miniaturized hairs and thus depict that this reference point is the most unstable area for harvesting in East and Southeast Asians (Table 3.4).

Table 3.2 Breakdown of follicular units in each reference point in East and Southeast Asians

Reference Pt.	1-hair/cm^2	2-hair FU/cm^2	3-hair FU/cm^2	4-hair FU/cm^2
Left temporal	4.9 × 4 = 19.6	7.6 × 4 = 30.4	1.8 × 4 = 7.2	0
Left parietal	5.4 × 4 = 23.6	8.5 × 4 = 34	1.6 × 4 = 6.4	0
Central occipital	4.1 × 4 = 16.4	9.4 × 4 = 37.6	2.8 × 4 = 11.2	0
Right parietal	5.2 × 4 = 20.8	8.6 × 4 = 34.4	2.3 × 4 = 9.2	0
Right temporal	4.9 × 4 = 19.6	7.6 × 4 = 30.4	1.7 × 4 = 6.8	0
Average no. of FU/cm^2	20	33.3	7.93	0
Percentage (%)	32.5	54.2	13.2	0

Excerpts from Retrospective Assessment of Follicular Unit Density in Asian Men with Androgenetic Alopecia. Ortega-Castillejos, MD, Pathomvanich MD. Dermatol Surg 2017; 43(5): Table 4, pp.675

Table 3.3 Number of hairs per reference point (East and Southeast Asians)

Reference point	Total no. of hairs/cm^2
Left temporal	102
Left parietal	110.8
Central occipital	125.2
Right parietal	117.2
Right temporal	100.8
Average no. of hairs	111.2

Excerpts from Retrospective Assessment of Follicular Unit Density in Asian Men with Androgenetic Alopecia. Ortega-Castillejos, MD, Pathomvanich MD. Dermatol Surg 2017; 43(5): Table 7, pp.677

Table 3.4 Miniaturized hairs for East and Southeast Asians

Reference point	Number of miniaturized hairs/ cm^2
Left temporal	2.3 × 4 = 9.44
Left parietal	1.74 × 4 = 6.96
Central occipital	1.92 × 4 = 7.68
Right parietal	1.68 × 4 = 6.72
Right temporal	2.14 × 4 = 8.56
Average no. of miniaturized hairs/ cm^2	7.8 hairs/cm^2
Percentage (with reference to total no. of hairs)	7.0%
*Total no. of hair is 111.2/cm^2	

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Chapter 4
Hair Characteristics of South Asians

Radha R. Palakurthi and Raghuveer Palakurthi

4.1 Introduction

Hair transplant surgery has gone through major refinements in the past three decades especially in terms of newer and innovative techniques. Learning hair characteristics specific to people of various geographic origins helps plan the surgery better and set realistic expectations for patients.

The data published on hair characteristics of South Asians is scanty. South Asians come from predominantly the Indian subcontinent along with Afghanistan and Maldives. The data presented here is collected from 1310 South Asian patients who underwent hair transplant surgery at the author's clinic located on the southeastern coast of India, Visakhapatnam, in the last 5.5 years.

The four hair characteristics that affect hair transplant results are colour, curl, calibre and density of the follicular unit. Hair protein called keratin is responsible for the physical characteristics [1]. The patient group included men (97%) and women (3%). These were from North (39%) as well as South India (57%), Bangladesh (0.4%), Nepal (0.2%) and Sri Lanka (0.4%) between age groups 24 and 61. South Asian hair was found to be black, either straight or wavy, with an average calibre of 0.062 mm (62 μm) and an average follicular unit density of 84 per cm^2.

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4.2 Hair Characteristics

4.2.1 Colour

Contrast of hair to skin is significant in creating an illusion of fullness or thickness. Less contrast as in light hair over light scalp conceals more of the underlying bald area. South Asian hair was black in colour in 73% of the patient group, dark brown in 5%, grey in 13% and 'salt and pepper' in appearance in 9% of the patient group. South Indians by virtue of dark skin and black hair have less hair to skin contrast. North Indians have higher hair to skin contrast and therefore reveal the lacunae.

4.2.2 Curl

The majority of hair samples were straight. The rest were wavy (see Fig. 4.1 and Table 4.1). Straight hair falls flat, whereas wavy hair adds volume by interlocking with adjacent hair. Wavy hair, mostly observed in South Indian patients, is of concern during FUE for risk of increased graft transection. However, the wavy hair had straight grafts.

Fig. 4.1 The wavy hair with straight grafts typical of South Indian populace

Table 4.1 Hair characteristics of patients at our clinic

Black and straight	64%
Black and wavy/curly	9%
Dark brown straight and wavy	5%
Grey and straight	13%
Grey and black 'salt-and-pepper' straight	9%

4.2.3 Calibre

Hair calibre plays a vital role in bringing out greater volume to the transplanted hair. Hair at the mid-occiput region is usually of higher calibre than the temporal areas. In view of the better laxity as well as donor hair density in the occipital region, the major chunk of donor hair needs to be obtained from this region. This practice is in contrast to many surgeons from the West who harvest strips of uniform width.

Hair samples were collected from the mid-occipital region above the occipital notch. An average of the diameters of ten hair follicles was determined using a digital micrometre. It is stated that diameters less than 0.06 mm give a sparse quality to the transplant [1].

The author found the average diameter of hair follicles in men to be 0.062 mm. The minimum diameter was 0.042 mm and the maximum 0.09 mm. The average diameter in women was 0.058 mm, while the minimum and maximum diameters were 0.036 and 0.077 mm, respectively.

The fine temporal hair is useful for creating a natural-looking hairline. The occipital hair may be reserved for adding volume.

4.2.4 Donor Hair Miniaturisation

There are limited publications on donor hair miniaturisation. Among the hair transplant procedures performed in the last 2 years at the clinic, miniaturisation was recorded in 14% of the patients. The percentage of miniaturised hair out of the donor harvest was not recorded for individuals. Hair less than 0.03 mm (30 μm), less than 1 cm in length, hypopigmented and unmedullated is vellus or miniaturised hair. The maximum diameter of the miniaturised hair at the recipient site recorded was 0.036 mm (36 μm). Therefore this donor hair bearing resemblance in diameter to the vellus hair was considered miniaturised (see Fig. 4.2).

The minimum age at which donor miniaturisation was recorded was 24 and the maximum was 51. Patients with hair calibre less than 0.06 mm (60 μm) showed more chances of donor miniaturisation. The author used the miniaturised grafts for filling in inter-follicular spaces to add density rather than for primary coverage. Patients with donor miniaturisation were advised to take oral finasteride.

More scientific work is required to establish the prevalence of donor hair miniaturisation and thereafter the solution.

4.2.5 Density

Follicular unit density (follicular unit grafts per square centimetre) is more applicable when planning the required number of grafts for a hair transplant procedure, rather than hair density which is the number of follicles per cm^2 [2]. Using a square

Fig. 4.2 Miniaturised 1-hair (row 1) and 2-hair FU (row 2) in comparison to normal grafts (row 3)

centimetre template, donor hair density was calculated at two sites, mid-occiput and temporal regions using digital photography. The average of two readings was recorded. It was determined that South Asians have an average density of 89 follicular units (FU) per cm^2. North Indians had 86 FU per cm^2. But one hair grafts comprise approximately 30% of the harvest bringing down the hair density. Average density in women was 62 FU per cm^2 which is less than 70–75 FU per cm^2 reported by Damkerng Pathomvanich [3].

4.3 Conclusion

The colour of South Asian hair is generally black and straight to wavy. These characteristics can be used to the patient's advantage in order to minimise hair and skin contrast and create a dense look. Hair calibre varies from a minimum of 0.042 mm to a maximum of 0.09 mm. Lower calibre helps create natural hairlines and higher calibre hairs have higher cosmetic value. Donor miniaturisation should be reported. Average follicular unit densities among South Asians are 84 FU per cm^2, which is higher than that reported in Chinese and lower than Caucasians [4], but the hair density is low in view of one hair grafts comprising 30% of donor harvest, similar to 24–30% reported by K. Imagawa [5]. It is more challenging to achieve dense packing in women due to the lower average donor densities of 62 FU per cm^2.

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Chapter 5
Hair Characteristics of West Asians

Ali Abbasi, Ramin Rabbani, and Sheida Abbasi

5.1 Background

Differences in hair characteristics have been described according to the ethnic background in African, Caucasian, and Asian. Asians are known to have fewer hairs than Whites [1].

Asia can be divided into two parts: West (the concept is in limited use, as it significantly overlaps with the Middle East) and East Asia. In Asian, hair parameters and characteristics have been studied mostly in East Asian, whereas few data on West Asian have been reported in the literature. West Asia is a territory and included three big subgroup ethnic, Persian, Turkish, and Arabian, so in West Asian there are more differences in hair characteristics (color, caliber, shape, density and in terminal-to-vellus hair ratio, and anagen-to-telogen ratio) but no differences in the intimate structures of fibers were observed among these three types of hairs [2].

Through research in medical literature, the author could not find more about Arabian and Turkish subgroup ethnics' hair characteristics, so this data is restricted to Persian (Iranian) subgroup ethnic and comparison with East Asia and Caucasian. Studies in Persian (Iranian) hair characteristic evaluated hair color, caliber, density, curl, and anagen-to-telogen and terminal-to-vellus hair ratio, in three regions of the scalp, vertex, temporal, and occipital areas. These studies demonstrated that there are significant differences between Persian and East Asia hair parameters.

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5.2 Evaluation of Persian Hair Characteristic

5.2.1 Density

(Evaluation on Iranian hair count and density in children and adult)

5.2.1.1 Density in Children

In a study done in 135 children, 70 males (51.9%) and 65 females (48.1%), aged 10–15 years old, average 12.5, without any hair and systemic disease (Table 5.1), the main density of hairs were on the frontal area, the average terminal hairs 288.78 ± 58.83 and vellus 34.74 ± 16.51 and total number of hairs were 323.58 ± 66.34; on the parietal area, terminal hairs 199.28 ± 61.46 and vellus 27.11 ± 9.28 and total number of hairs were 266.44 ± 65.55; on the temporal area, terminal hairs 234.78 and vellus 24.13 and total number of hairs were 258.78 ± 60.34; and on the occipital area, terminal hairs 259.15 ± 57.17 and vellus 32.8 ± 15.76 and total number of hairs were 258.19 ± 60.34 [3] (Table 5.1).

5.2.1.2 Density in Adult

Another study in Iranian adult compared the number of hairs in normal male and female Iranian people in average age 30–33 year old and found out 37.7 hairs/4 mm.-punch for male and 33.1/4 mm.-punch for female, and for AGA males and females, the average age was 29.1 and 30.1/4 mm-punch, respectively; there is no significant difference between two groups in respect of terminal, vellus, total, and terminal count [4] and 1.92/hairs per follicular unit [5].

In another study of 400 men, 29–47 years old, who were type IV Norwood on the occipital area, the total number follicular units (FUs) were 36.3% 1-hair, 40% 2-hair, 19.3% 3-hair, 4% 4-hair, and 0.4% grafts of 5-hair. The mean number of hairs per follicular unit was 1.92 [5] and 97 FUs/cm^2 [4].

As shown in Table 5.2, the total hair density of Iranian is significantly higher than of other East Asian people.

And Tables 5.3 and 5.4 show the hair density of Iranian people in comparison with Asian and American White people and that Iranian hair count is the same or

Table 5.1 Comparing the mean density of terminal, vellus, and total hair per cm^2 on different areas of the scalp of children 10–15 years old in the study

	Terminal	Frontal vellus	Total no. of hair
Frontal area	288.87	34.74	323.52
Parietal area	199.26	27.11	226.44
Temporal	234.78	24.00	258.78
Occipital area	259.15	32.81	288.19

Table 5.2 Compare the hair follicle count on occipital by punch 4 mm in Asian population

	Terminal hair	Vellus hair	Total hair	Anagen/ telogen hair	Terminal/vellus hairs
Persian [4]	34 ± 6.5	2.4	36.4	93.7: 6.3	17.8:1
Thai [5]	16.5 ± 8.4	6.9 ± 7.0	28.3 ± 9.2		
Korean [6]	14.9 ± 3.2	1.1	16.1	93.6: 6.4	13.5:1
Taiwanese [7]	20.5	0.8	21.3	91.6:8.4	25.3:1
Chinese [8, 9]		s	24.3		

Table 5.3 Comparison of normal hair count between Koreans, American Whites, and Blacks with Iranians [3]

	Persian (Iranian)	Korean [1]			American Whites [10]
		Asian	Thai	Taiwan	
Age (year)	35.5	35	34	36	43.5
Total hair	36.4	16.1	28.3	21.3	40.2

Table 5.4 Comparison Iranian FU with other ethnic

FU	Caucasian (%)	Koreans (%)	Japanese (%)	Thai (%)	Iranian (%)
1-hair	10	37	30	24	36.3
2-hair	40	38	50–55	64	40
3-hair	50	25	15–20	13	19.3
4–5-hair					4.4

close to White people and significantly higher than other Asian people. Compare the hair follicle count on occipital by punch 4 mm. in Asian population.

5.2.2 *Hairline in Persian*

The most hairline shape in Persian (Iranian) is wide and flat with a curve in fronto-temporal angle like East Asian people, up-sloping [12] considers this criteria (frontotemporal, parietal, and temporal hairline and apex) Fig. 5.1, in recreate normal hairline design is critical, because they often affect facial contours. Recreation of the temple in young adult usually necessitates some degree of lateral flare of the frontal hairline, but not in the older people (Figs. 5.2 and 5.3).

5.2.3 *Caliber*

The avenge hair caliber in Persian men is #95 μm compared with 71 μm in East Asia and 70 μm for Caucasian [11].

Fig. 5.1 The most hairline shape in Persian (Iranian) is wide and flat with a curve in frontotemporal angle like East Asian people

Fig. 5.2 Design the hairline in Persian (Iranian)

Fig. 5.3 Recreation of the temple in young adult usually necessitates some degree of lateral flare of the frontal hairline, but not in older people

5.2.4 Color

Mostly, Persian people have dark to black hair.

5.2.5 Shaft

Straight.

5.3 Length of Hair Follicle

Considering the length of hair follicle from epidermis to dermal papillae (in anagen phase of hair follicle) is very important; the average length of hair follicle in Persian people is #4.5 mm in comparison with East Asian and Caucasian which is 5.5 and 4.5 mm, respectively; so in FUE method, in order to prevent to transection, considering the length of hair follicle is very important, because the chance of transection increases with increase the length of graft.

5.4 Patient Selection

The incidence of keloid or hypertrophic scar especially in younger people on harvesting and recipient, with each method (FUT or FUE) in Persian people, is like as East Asia, and keloid formation in people prone to keloid is more in FUT method than FUE. In FUT method, in order to prevent keloid formation, the donor strip should excise longer and narrower, should use trichophytic closure to minimize the linear scar, and so should be cautioned and screened for these problems before method selection of surgery and during consolation session.

5.5 Donor Harvesting Considerations

Today, two methods FUE and FUT are popular in West Asia.

5.6 Recipient Consideration

For achieving natural hairline and desirable cosmetic density, in recipient area, in Persian people, three important points should be considered:

1. Creating a wide flat, some degree of lateral flare of the frontal hairline and rounded frontotemporal angle.
2. The normal density is 30–40 FUs/cm^2, and more than 40 FUs/cm^2 is questionable for survival graft and regrowth (Fig. 5.2).
3. Consider the hair direction flowing from left to right [12], and in order to prevent of postoperative edema (with any method FUT or FUE) the days after surgery and hair growth outcome, using Abbasi solution (Saline Normal 100 cc + Epinephrine 1/1000 1 mL + 40 mg Triamcinolone) [13, 14], is recommended.

5.7 Conclusion

According to the above information about Iranian hair characteristics (more density, thicker diameter of hair shaft and hairs in follicle units) in FUE method, we cannot use the regular punch size that is usually used in other Asian people; in other words, it needs a slightly larger punch size than other Asian people (1 mm punch or more), so the final result is clear: the fine white pinpoint scar in Iranian people in FUE is more visible than other Asian and Caucasian people because of used larger diameter punch, and in FUT method the donor strip should excise longer and narrower and use trichophytic closure to minimized the linear scar.

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Chapter 6
Diseases of the Hair and Scalp in Asians that are of Interest to Hair Surgeons

M.J. Kristine Bunagan

6.1 Introduction

The relevance of hair and scalp diseases as it affects hair transplantation largely depends on the underlying nature of the disease, whether the disease may be induced or worsened by the surgical procedure or the possibility of the condition interfering with some of the procedural techniques. For instance, papulosquamous diseases such as psoriasis and seborrheic dermatitis could flare up because of the hair procedure, while transplanted grafts in patients with cicatricial alopecia would most probably shed eventually due to the underlying disease process. The relevance and recommended actions for each pertinent hair and scalp disease are summarized in Table 6.1.

6.2 Noncicatricial Alopecias

6.2.1 Alopecia Areata

The concern with this disease is the possibility that affected hair follicles would undergo hair shedding postoperatively in cases where a patient with alopecia areata (AA) has undergone hair transplantation. The occurrence of lesions is unpredictable, and the disease may recur at any point in time; thus it is important to diagnose this condition in a potential hair transplantation candidate.

The common patchy type of alopecia areata (AA) appears as alopecic non-scarring patches which can be readily diagnosed clinically (Fig. 6.1) [1]. The diffuse

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Table 6.1 Summary of hair diseases relevant to hair transplantation (HT) with management recommendations

Hair diseases	Relevance to HT	Diagnostics/management prior and/or after HT
Alopecia areata (AA)	Diffuse variant clinically may appear similar to pattern hair loss (PHL) HT not indicated for AA due to risk of grafts shedding due to underlying disease	Dermoscopy: AA—exclamation point and broken hairs PHL—varying hair diameters and miniaturized hairs Biopsy if still in doubt
Psoriasis	Psoriatic lesions may be induced or aggravated by trauma (Koebner phenomenon) thus treatment prior to HT	Mild to moderate—tar-based shampoo and topical steroid Severe—above plus systemic drugs (e.g., methotrexate or acitretin)
Seborrheic dermatitis	Lesions of scaling and pruritus may worsen after the procedure	Tar, salicylic, selenium, or ketoconazole shampoo Corticosteroid lotion/solution (e.g., triamcinolone) may be used for acute flares
Cicatricial alopecia (e.g., lichen planopilaris (LPP)) Frontal fibrosing alopecia (FFA)	In pre-existing disease any transplanted grafts may eventually undergo shedding and scarring due to underlying disease Risk of developing LPP following hair transplantation procedure FFA appears similar to frontotemporal recession seen in the Norwood Hamilton type of hair loss (mostly women)	Dermoscopy of perifollicular scaling, erythema, and scarring (lack follicular ostia) May have symptoms of pain and burning sensation Biopsy needed to confirm diagnosis
Telogen effluvium (TE)	Confusion with TE is mainly seen in women with PHL due to diffuse thinning over the midscalp or vertex area HT not indicated for thinning due to TE	Excessive hair shedding leading to diffuse hair thinning with no discernable pattern Hair pull test positive for active TE and negative for PHL Dermoscopy PHL—varying hair diameters and miniaturized hairs TE—hairs of same caliber and minimal miniaturized hairs
Seborrheic keratosis (SK) and skin cancer	Larger SK in the recipient area may interfere with slit creation and insertion of grafts	No need to biopsy SK. Remove with electrocautery and curettage Biopsy needed for skin cancers. Surgical management recommended
Trichorrhexis nodosa (TN)	Case study of TN following hair transplantation	Dermoscopy or light microscopy of hair shaft Nodal swellings consisting of fiber fraying and splaying appearing like ends of a brush

Fig. 6.1 AA common patchy type

variant of this disease is the one of concern due to the lack of well-demarcated alopecic lesions. Rather the patient complains of diffuse thinning which may even appear similar to pattern hair loss (PHL) or androgenetic alopecia (AGA) in cases affecting the midscalp or vertex area [2]. Since clinically the features of diffuse AA are not apparent to the naked eye, the use of a dermoscopy device can be helpful in identifying exclamation point hairs and broken and dystrophic hairs which are features of AA (Fig. 6.2). In contrast PHL or AGA on dermoscopy would show primarily miniaturized hairs or hairs in varying diameters to signify the miniaturization process (Fig. 6.3) [3]. In cases where there is still doubt of the diagnosis, then a skin punch biopsy should be performed.

In some cases a patient may have undergone hair transplantation with good growth of transplanted grafts but may then develop alopecia areata years later, seemingly independent and unrelated to the hair surgery. This occurred in a patient of the author wherein there was hair shedding and thinning over the midscalp area about 3 years after the transplanted hairs had successfully grown well. Clinically only diffuse thinning was apparent, and only on dermoscopy were the exclamation point and broken hairs seen indicating diffuse AA. In these situations, treatment with topical (e.g., clobetasol or betamethasone dipropionate ointment) and

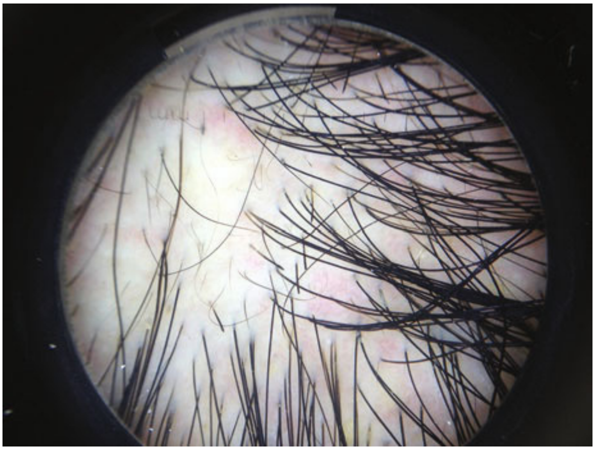

Fig. 6.2 Dermoscopy of broken and dystrophic hairs seen in AA

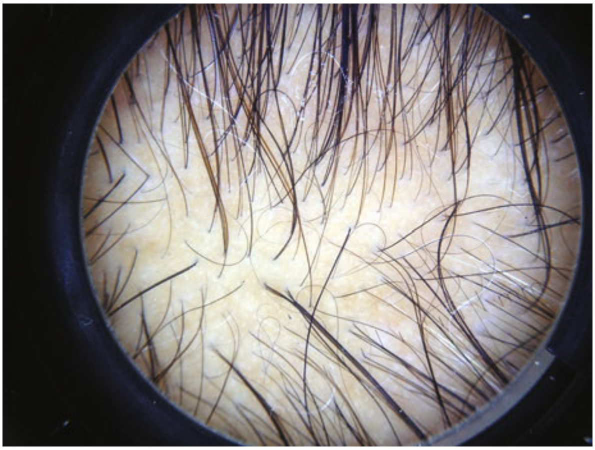

Fig. 6.3 Dermoscopy of hairs of varying diameters and vellus hairs in PHL

intralesional corticosteroids (2.5–5 mg/mL triamcinolone) leads to regrowth of the affected areas [2].

6.2.2 *Telogen Effluvium*

Patients with the primary complaint of hair shedding and who upon examination show diffuse hair thinning without any discernable pattern should be evaluated for the possibility of telogen effluvium (TE). History for the past 2–6 months prior to the condition has to be probed to ascertain the probable trigger of the condition (e.g., febrile illness, systemic disease, medications, childbirth, surgical procedures, or significant psychological stress) [4, 5]. The patient usually complains of excessive shedding of more than 100–150 hairs per day. This could be telogen effluvium or less commonly bouts of active shedding in pattern hair loss (PHL) which may occur at certain intervals indicating disease progression. PHL in general manifests as gradual hair thinning without apparent excessive hair fall, and confusion with TE is mainly seen in early female pattern hair loss (FPHL) where there is diffuse thinning over the midscalp or vertex area. A dermatoscope would be helpful to appreciate the significant number of hairs with varying diameters signifying miniaturization in FPHL as compared to TE which would have hairs of same caliber and very minimal miniaturized hairs if any. A hair pull test can also be done and would yield positive results for active TE. If TE has been established, then control or resolution of the condition would be possible with avoidance or correction of the triggering factor(s). It should be explained to the patient that hair transplantation is not the solution to the hair shedding. In cases where there is PHL and TE concomitantly and the patient asks about the possibility of hair transplantation for the PHL, then it should be discussed with the patient that this hair procedure would be better done after the problematic hair fall has normalized.

6.3 Cicatricial Alopecias

The main focus is the primary cicatricial alopecias (e.g., lichen planopilaris (LPP), discoid lupus erythematosus) due to the eventual permanent destruction of hair follicles. In cases with active pre-existing disease, any transplanted grafts over the recipient site would be affected wherein growing hair follicles would eventually undergo hair shedding and irreversible scarring due to the underlying disease process. In inactive disease the hair transplantation process can be a triggering mechanism which activates the disease with the same outcome of eventual destruction of the hair follicles over the recipient or donor area. Several studies have reported the development of LPP following a hair transplantation procedure with a time interval ranging from 4 to 36 months post operation [6–8]. Although in many cases patients undergoing hair transplantation may not manifest any signs and symptoms of cicatricial alopecia, it is recommended that a thorough examination of the scalp be performed as well as a symptom check of patients with suspicion of primary cicatricial alopecia. In the early stages, dermoscopy may show perifollicular scaling and erythema (Fig. 6.4) with minimal alopecic scarring. Other clues to the possibility of scarring alopecia are the symptoms of pruritus, pain, and burning sensation. A skin punch biopsy is needed to establish the diagnosis and to properly exclude the condition before proceeding with the surgical procedure [8, 9]. As of the present, there are no clear predictive or risk factors which would help determine who may develop a primary cicatricial alopecia following hair transplantation; thus a strong index of suspicion is needed.

Aside from LPP (mainly the classic more common variant affecting the scalp), DLE can also be seen in the Asian population. The occurrence of frontal fibrosing

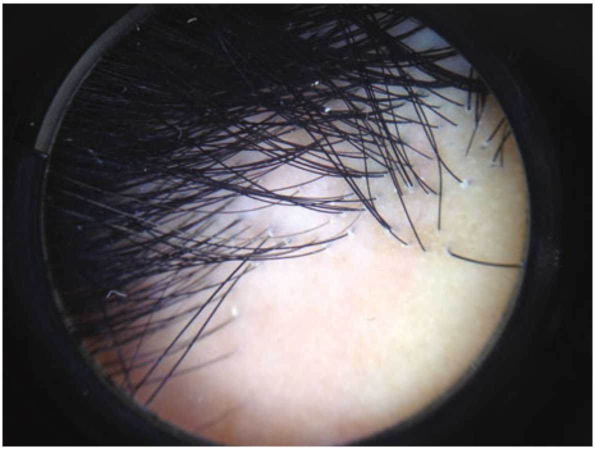

Fig. 6.4 Dermoscopy of LPP with perifollicular scaling and erythema

Fig. 6.5 Scarring band over frontal and temporal hairline area in FFA

alopecia (FFA) (a variant of LPP occurring over the frontal hairline area) mainly occurs in Caucasian women, and central centrifugal cicatricial alopecia (CCCA) is almost exclusively seen in black African races [8, 9]. Though uncommon in Asians, it is still important to know the features of FFA as the author has seen the condition in some Asians, and the presentation can be similar to frontotemporal recession seen in the Norwood Hamilton type of hair loss. For instance in a 36-year-old Asian female patient of the author, there was frontotemporal recession with the frontal hairline receding about 1 in. behind the previous hairline and with involvement of the temporal areas (Fig. 6.5). Upon closer examination of the scalp, the cutaneous surface appears smooth and shiny with lack of follicular openings. This is where a dermoscope will be helpful in identifying the perifollicular scaling, erythema, and absence of follicular ostia even prior to doing a biopsy because there are features which will not be apparent to the naked eye but with dermoscopic magnification will be appreciated, thus aiding in the initial diagnosis of the condition.

6.4 Papulosquamous Disorders

6.4.1 Psoriasis

Scalp psoriasis is characterized by erythematous plaques with thick silvery scales. Patients may complain of varying degrees of pruritus or may be asymptomatic. Due to the inherent nature of psoriatic lesions to arise in areas affected by trauma (Koebner phenomenon), this condition has to be medically controlled before the hair transplantation procedure. In patients with pre-existing lesions, there may be flare-up with increase in disease severity due to possible trauma over the donor incision wound and the recipient site during slit creation. To the author's knowledge, no studies have reported any deleterious effects of psoriasis on the eventual transplanted hair growth; however the possibility of flare-up post-surgery has to be discussed with the patient. Management of psoriatic lesions about 2 weeks pre-operation should be adequate time to achieve control of the disease. Resolution of lesions would likewise decrease the possibility of significant pruritus over the donor site which may occur during the healing period of the suture wound.

Mild to moderate erythema and scaling can be managed with tar-based shampoos and application of a potent corticosteroid solution such as triamcinolone or clobetasol scalp solution. For moderate to severe pruritus, antihistamines may help. For severe psoriasis referral to a dermatologist would be recommended because the patient may need systemic medications such as methotrexate or acitretin [4, 9].

6.4.2 Seborrheic Dermatitis

This is a common condition which presents as chronic, recurrent, mild to moderately erythematous, scaly patches mainly over the scalp. The scales can be minimal, and there may be slight to absent pruritus. However in moderate to severe seborrheic dermatitis, there might be extensive thick scaling with associated severe pruritus. In such cases it is recommended to manage this condition before the hair transplantation procedure to lessen the scaling and control the pruritus. Management options include the use of tar-, salicylic-, or selenium-based shampoos and/or ketoconazole shampoo as well as a topical antifungal medication (e.g., ketoconazole) or a topical calcineurin inhibitor (e.g., tacrolimus). Corticosteroid lotions or solutions (e.g., triamcinolone scalp solution) may be used for acute flares but are not recommended for chronic use [5, 6].

Fig. 6.6 Brownish to *black-colored* hyperkeratotic plaques of seborrheic keratosis

6.5 Seborrheic Keratoses and Skin Cancer

Seborrheic keratoses are common benign growths which may occur on the scalp. Lesions may range from light brown- to black-colored rough surfaced papules or plaques which appear to be stuck on the skin. These lesions may be small (<1 cm) or may enlarge to several centimeters and may be multiple in number (Fig. 6.6). Few smaller lesions are usually left alone; however larger and multiple lesions may occur over the scalp especially in the recipient area with alopecia in PHL. Larger seborrheic keratoses in the recipient area may interfere with the creation of slits and the ease of insertion of grafts especially in dense packing sessions which is the norm in most HT cases. In such cases removal of the lesions through electrocautery and curettage can be performed before the hair transplantation procedure.

Although in Asians skin cancers are not common, with the loss of hair as protective covering over the scalp in PHL, there may be occurrence of skin cancers such as basal cell carcinoma (BCC) which is seen more than squamous cell carcinoma in the Asian population [10, 11]. The suspicion of a possible skin cancer such as BCC will warrant a biopsy and subsequent surgical management.

6.6 Trichorrhexis Nodosa

Hair shaft abnormalities including trichorrhexis nodosa can be congenital or acquired. In general the inherited types are rare conditions and mostly manifest at birth or in young children, some associated with different syndromes. The hair shaft defect which may be inherited but is more commonly acquired is trichorrhexis nodosa. This defect can be the result of direct damage to the hair shaft following repeated physical (e.g., excessive brushing, hot comb, etc.) and chemical trauma (e.g., hair bleaching, perming, or straightening chemicals) which may be too harsh on the hair strand. The resultant hair shaft abnormalities are nodal swellings where there is a breach in the cuticular layer exposing the inner cortex with resultant fiber fraying and splaying appearing like ends of a brush [8]. This makes the hair fragile, and the shaft may break off easily where the fractured nodes occur with hair strands unable to grow to a longer length. A case study was reported wherein trichorrhexis nodosa occurred following hair transplantation. This patient had normal hair findings prior to the hair procedure. The postulated reason was that the transplanted hairs were placed more deeply than surrounding hairs [12]. As of the present, there are no mechanisms or known predictive factors to determine who will develop a hair shaft defect after hair transplantation; thus proper procedural technique has to be followed, and thorough evaluation of the hair prior to the procedure is recommended. On consultation, assessment of the hair shaft may be added to the physical examination process with the aid of a dermatoscope or light microscope to determine if there are any abnormalities to the hair shafts.

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Chapter 7
Differential Diagnosis of Male and Female Pattern Hair Loss

Eileen Tan

7.1 Introduction

Androgenetic alopecia is the most common cause of hair loss worldwide. The term was coined by Orentreich in 1960 [1]. Patterned progressive hair loss is the hallmark feature of this condition; however, there are similar conditions that a hair restoration doctor has to be aware of in order to avoid unnecessary surgery and inappropriate medical intervention.

This chapter will discuss the salient features of androgenetic alopecia and other hair loss conditions that may pose a diagnostic challenge. An outline of a practical clinical approach will enable the clinician to make the correct diagnosis and avoid pitfalls in the decision and planning of hair transplantation.

7.1.1 Androgenetic Alopecia (AGA)

7.1.1.1 Classification and Pathogenesis

Synonyms for AGA include common baldness, male or female pattern hair loss, and androgen-dependent alopecia.

Androgenetic (or pattern) alopecia is a genetically determined disorder characterized by the miniaturization process. It entails a gradual progression from terminal hairs into vellus hairs in androgen-sensitive hair follicles [2–4].

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7.1.1.2 Salient Features

Gradual and progressive hair miniaturization is the hallmark of androgenetic alopecia. In this condition, a typical patterned distribution of hair loss can be observed in both genders. The most widely adopted clinical classification of androgenetic alopecia belongs to the Hamilton/Norwood staging [4, 5] and the Ludwig classification [6].

Hamilton/Norwood classification arbitrarily divides male pattern androgenetic alopecia into seven stages (Fig. 7.1) [4, 5]. In men, it starts with gradual recession of frontotemporal region in stage II, progressively worsen in severity to stage III (Fig. 7.2) with deeper hairline recession, and gradual loss of hair on the vertex region to stage IV (Fig. 7.3) with visible crown miniaturization. Loss of the bridge of hair in the mid portion extending from frontal to the vertex of the scalp is evident in stage V (Fig. 7.4). Finally, almost complete or complete loss of hair with sparing of the lateral and back of the scalp concludes stages VI–VII (Fig. 7.5).

Besides the role of androgen in pattern hair loss in women, Olsen and several authors have suggested several etiopathogenesis to represent this diverse group with

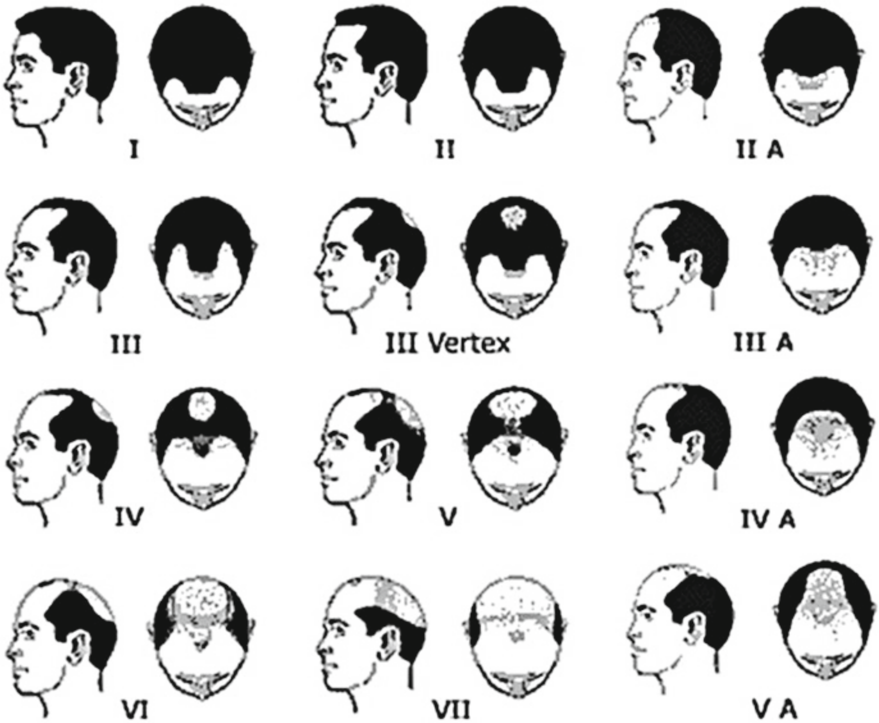

Fig. 7.1 Norwood Hamilton Classification of Hair Loss based on severity. Reproduced from Norwood, O.T. (1973) Hair Transplant Surgery (1st edition), courtesy of Charles C. Thomas, Publisher, Ltd., Springfield Illinois, USA [4, 5]

Fig. 7.2 HN stage III with deep receding hairline

Fig. 7.3 HN stage IV with prominent miniaturization in crown region

Fig. 7.4 HN stage V with loss of bridge of hair connecting the frontal and crown region

Fig. 7.5 HN stage VII with almost complete loss of hair of the frontal and vertex with preservation of hairs along the sides and back of the scalp

progressive and diffuse hair loss. Hence, female pattern hair loss (FPHL) has been coined as preferred terminology over female androgenetic alopecia [2, 7, 8]. The author illustrates the clinical severity of hair loss in women based on a well- accepted Ludwig classification (Fig. 7.6) [6]. Hair is diffusely and progressively lost over the frontal and crown region of the scalp. This produces a gradual and visible hair thinning with a relatively intact hairline (Figs. 7.6, 7.7, 7.8, and 7.9). Bitemporal recession does occur in women but usually to a lesser degree than in men. In clinical

Fig. 7.6 AGA Ludwig classification of hair loss based on severity. Reproduced with permission from the British Journal of Dermatology 1977;97:247 [6]

Fig. 7.7 A female with Ludwig stage I

practice, there is often a considerable overlap between the two classifications (Fig. 7.10) [2–6].

7.1.1.3 Investigations

Laboratory investigations are not necessary in classical pattern presentation. However, when the physician notes signs of hyperandrogenism in female patients, a hormonal profile may be beneficial [7].

Scalp dermoscopy reveals variability in hair shaft diameter. Hair miniaturization with reduction in hair shaft pigmentation and diameter is illustrated in Fig. 7.11. Empty follicles and peripilar signs may also be observed [9–11].

Fig. 7.8 A female with Ludwig stage II with visible hair part width

Several histologic findings have been described in androgenetic alopecia, including a reduction in anagen to telogen ratio (increased percentage of telogen follicles), follicular miniaturization, a reduction in follicular density, and a characteristic "streamer" appearance of residual connective tissue and nerves [12–14].

7.1.2 Telogen Effluvium (TE)

7.1.2.1 Classification and Pathogenesis

Telogen effluvium, a form of non-scarring alopecia, is characterized by diffuse hair shedding. In a normal hair growth cycle, the growth phase is termed anagen [2, 3, 15]. The anagen phase consists of 80–90% of the scalp hair follicles, and it lasts approximately 3 years. The resting phase is termed telogen, consisting of 10% of the scalp hair follicles and lasts approximately 3 months. In telogen effluvium, there is a shift of anagen hairs to telogen hairs, resulting in a noticeable increased shedding of normal club hair (telogen hairs). Telogen effluvium can affect hair on all parts of the body, but loss of scalp hair is generally more noticeable. This clinical

Fig. 7.9 A female with Ludwig III presenting with Christmas tree pattern of diffuse alopecia

condition can occur at any age and gender; however, women seem to have a higher prevalence of telogen effluvium, possibly due to hormonal changes in various stages of the life cycle [15–17].

There are a variety of classification and causative factors for telogen effluvium. In clinical practice, it can be broadly classified into acute versus chronic telogen effluvium [13–17]. Acute telogen effluvium is often triggered by an underlying event (Table 7.1: Common causative factors for telogen effluvium) [15–17]. The severity of hair shedding and duration depends on the causative factor, and most episodes spontaneously recover within 6 months from the onset of insult. In the author's experience, drug-induced alopecia often goes undiagnosed if the physician is unaware of its possibility. The author has summarized common drugs that have been reported to cause hair loss in Table 7.2 for quick reference [3]. Telogen effluvium can also unmask underlying androgenetic alopecia, especially if the process of increased hair shedding accelerates the underlying genetically programmed miniaturization process (Fig. 7.12) [15, 17].

Chronic telogen effluvium is a distressing condition but fortunately uncommon. It is characterized by recurrent episodic diffuse hair shedding lasting longer than 6 months. It has a more insidious onset and can be difficult to associate with an inciting trigger [15–17].

Fig. 7.10 A 39-year-old male presenting with Ludwig stage II

Fig. 7.11 Scalp dermoscopy illustrating hair diameter variability and empty hair follicles in AGA

Table 7.1 Possible causative factors for telogen effluvium (Adapted with permission from Sperling LC, Mezebish DS. Hair diseases. Med Clin North Am 1998;82:1160)

Physiologic conditions	Injury or stress	Drugs and other substances
Physiologic effluvium, e.g., newborn, postnatal	High or prolonged fever	Anticoagulants (especially heparin)
Early stages of androgenetic alopecia	Hyper- or hypothyroidism and other endocrinopathies	Anticonvulsants
	Crash dieting	Antikeratinizing agents (e.g., etretinate)
	Severe chronic illness	Antithyroid agents
	Severe infection	Heavy metals
	Severe psychologic stress (e.g., life-threatening situations)	Hormones
	Major surgery	

7.1.2.2 Salient Features

The physical examination is similar in both acute and chronic telogen effluvium. History plays an important role in enabling the diagnosis of telogen effluvium and eliciting its underlying etiology. Physical findings are sparse, and in the early phase, the physician may not even appreciate a reduction in hair density. The patient is generally anxious and may bring bags of shed hair to the consultation room. The author encourages patients to bring in old photographs, as this often helps determine the severity of hair thinning [2, 3, 16].

Clinical examination often reveals diffuse non-scarring alopecia. It has a female predominance, and the patient will often notice a sudden onset of a receding hairline. A positive hair pull test during the active phase is a useful clue. In long-standing or severe cases of telogen effluvium, it may unmask previously unrecognized androgenetic alopecia with a decrease in hair diameter, part width, and bitemporal recession (Figs. 7.13 and 7.14) [2, 16, 17].

7.1.2.3 Investigations

Diagnosis is based on a high index of clinical suspicion. A detailed history cannot be stressed enough in hair loss evaluation and to search for underlying inciting agents. The hair pull test is positive with prominent telogen hairs (club hairs) [2, 16, 17].

Laboratory tests are often carried out to rule out possible underlying triggers. They include full blood count, iron, zinc, vitamin D, hormonal profile, thyroid, and autoimmune studies (Table 7.3: Suggested laboratory tests in hair loss evaluation) [2, 13].

A trichogram will show a reduction of anagen to telogen ratio with greater than 20% telogen hairs. Scalp dermoscopy is nonspecific; however, it may reveal a large number of short, thin regrowing hairs in the absence of hair diameter variability.

Table 7.2 Common drugs reported to cause hair loss

Anticoagulants	Analgesics	Antimicrobials	Anticonvulsants	Antipsychotics	Cardiovascular	Hormones	Others
Coumarin	NSAIDs, e.g., naproxen, indomethacin, ibuprofen, diclofenac	Nitrofurantoin	Carbamazepine	Haloperidol	Amiodarone	Antithyroid drugs, e.g., carbimazole, iodine, thiouracil	Allopurinol
Heparin, heparinoids		Benzimidazole, e.g., albendazole, mebendazole	Clonazepam	Flupenthixol, fluphenazine	ACE inhibitors, e.g., captopril, enalapril	Oral contraceptives	Appetite suppressant
		Chloramphenicol	Hydantoins	Serotonin uptake inhibitors, e.g., fluoxetine	Beta blockers, e.g., metoprolol		Bromocriptine
		Cidofovir	Lithium	Tricyclic antidepressant, e.g., imipramine	Minoxidil		Colchicine
		Ethambutol	Troxidone		Spironolactone		Danazol
		Gentamicin	Troxidone				Glibenclamide
		Indinavir	Valproic acid				Gold salts
		Nitrofurantoin	Vigabatrin				Immunoglobulins
		Triazoles, e.g., fluconazole, itraconazole					Interferons
							Levodopa, methyldopa
							Pyridostigmine
							Retinol (vitamin A)
							Retinoids, e.g., acitretin, etretinate
							Sulfasalazine

Histologic features of telogen effluvium include a disproportionate number of telogen hairs. Absence of follicular miniaturization and peribulbar lymphocytes help to differentiate it from androgenetic alopecia and alopecia areata (Fig. 7.15) [2, 15, 18].

7.1.3 Alopecia Areata

7.1.3.1 Classification and Pathogenesis

Alopecia areata is an unpredictable, non-scarring alopecia affecting any hair-bearing area. The etiology is largely unknown, but T-cell immune-mediated processes, genetics, and environmental interactions have been implicated. The disease can affect both genders and can occur at any age. Although alopecia areata often causes tremendous emotional stress, it is relatively benign in nature [18, 20, 21].

7.1.3.2 Salient Features

Although alopecia areata is mostly asymptomatic, some patients have described a burning sensation or pruritus in the affected area prior to the onset of hair loss. Most patients complain of a sudden onset of increased hair shedding. Variable clinical presentations include single or multiple patchy areas of alopecia (Fig. 7.16), alopecia totalis (total loss of scalp hair) (Fig. 7.17), alopecia universalis (loss of scalp and body hairs), and ophiasis pattern alopecia (loss of hair localized to the sides and lower back of the scalp) (Fig. 7.18). In particular, diffuse alopecia areata may create confusion with androgenetic alopecia (Fig. 7.19) [2, 3, 20, 21]. Alopecia areata can occur in any stage of one's life, and it can certainly coexist with androgenetic alopecia (Fig. 7.20). Hence, it is important to ask about a past history of sudden and patchy hair loss.

Nail involvement, predominantly of the fingernails, is found in 40% of patients, most commonly in severe cases [20, 21]. Pitting is the most common nail dystrophy reported, while other reported abnormalities include trachyonychia, Beau's lines, onychorrhexis, onychomadesis, koilonychia, leukonychia, and red lunulae [18, 20, 21].

7.1.3.3 Investigations

In alopecia areata, diagnosis can usually be made on clinical grounds [2, 3, 20].

Scalp dermoscopy may reveal the following: exclamation point hairs, yellow dots, and twisted hairs broken at the scalp level (Fig. 7.21) [9, 11].

Histologic features suggestive of alopecia areata include the following: a peribulbar lymphocytic infiltrate ("swarm of bees"), increase in telogen follicles,

Fig. 7.12 Unmasking an underlying androgenetic alopecia in the presence of drug-induced alopecia

Fig. 7.13 TE—A top view illustrating widening in part width

follicular miniaturization, and follicular dropout with decreased follicular density (Fig. 7.22) [3, 12, 18].

7.1.4 Cicatricial Alopecia

7.1.4.1 Classification and Pathogenesis

Cicatricial alopecia represents a widely diverse group of disorders in which hair follicles are permanently destroyed and replaced with scars and permanent hair loss (Fig. 7.22). In a retrospective 5-year study by Tan et al., 3.2% of patients evaluated for hair disorders had a primary form of cicatricial alopecia [22, 23].

Fig. 7.14 TE—A woman with PCOS presenting with receding hairline, diffuse alopecia, and acne

Table 7.3 Suggested laboratory tests in hair loss evaluation

Strongly recommended	Suggested depending on personal history
Full blood count	If suspect androgen excess: Suggest total testosterone/SHBG ratio, free testosterone, androstenedione, and dehydroepiandrosterone. Females to include FSH, LH, and 17-beta hydroxyprogesterone
Ferritin	Fasting glucose if suspect metabolic syndrome
Zinc	Antinuclear antibody, anti-dsDNA if suspect autoimmune diseases
Vitamin D	Other investigations deem appropriate based on individual history
Free T4/TSH	

Classification of primary cicatricial alopecia is broadly based on the predominant histologic cell type into lymphocytic and neutrophilic cicatricial alopecia. In the same study, the two commonly occurring lymphocytic cicatricial alopecia are chronic cutaneous lupus erythematosus and lichen planopilaris [22, 23].

For the purpose of this chapter, the author will only discuss lymphocytic cicatricial alopecia, namely, lichen planopilaris (LPP) and lupus erythematosus (LE), which can often be missed if the physician is not familiar with these conditions. In addition, cicatricial alopecia can coexist with androgenetic alopecia, and the decision on hair transplantation has to be carefully evaluated in such clinical scenarios [23].

7.1.4.2 Salient Features

The hallmark of cicatricial alopecia is the lack of follicular ostia on careful scalp inspection (Fig. 7.23) [22, 23]. Both chronic cutaneous lupus erythematosus and lichen planopilaris have a female predominance. There are diverse clinical presentations which include diffuse hair shedding, follicular hyperkeratosis, erythematous plaques, scalp itching, and tenderness [22–24].

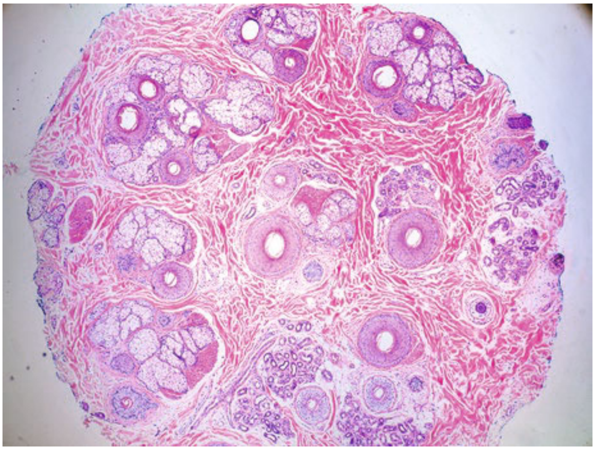

Fig. 7.15 A histological transverse section of TE demonstrating a disproportionate increase in telogen hairs. Reproduced with permission from a guide to healthy scalp and hair [19]

Fig. 7.16 Alopecia areata presenting with multiple patchy non-scarring alopecia

In scalp cutaneous lupus, scalp atrophy, telangiectasia, and scalp hypo- and hyperpigmentation can be observed. Follicular plugging and adherent scaling may be seen. Follicular hyperkeratosis, in particular, is more active in the *center* of a discoid lupus plaque (Fig. 7.24). This is a helpful clue when differentiating scalp cutaneous lupus from lichen planopilaris. Peripheral symptoms and signs of lupus are also helpful diagnostically (Fig. 7.25) [22–24].

Lichen planopilaris usually runs an insidious process, and a variety of clinical manifestations of lichen planopilaris have been described. Symptoms such as itching, burning, and pain of the scalp are usually more intense than other forms of lymphocytic cicatricial alopecia. Clinical examination reveals patchy or diffuse thinning with characteristic perifollicular erythema and violaceous-brown papules, follicular hyperkeratosis, and scaling (Fig. 7.26). Interestingly, follicular hyperkeratosis tends to occur at the *periphery* of the plaque. A variant, known as frontal

Fig. 7.17 Alopecia totalis with hair loss affecting the whole scalp

fibrosing alopecia, presents with symmetrical frontotemporal recession (Fig. 7.27). The disease activity is often subtle and is often missed if the margin of the hairline is not carefully examined for clinical activity and inflammation (Fig. 7.28) [24, 25].

7.1.4.3 Investigations

A thorough history and detailed clinical examination is requisite. Comparison to normal hair-bearing scalp may be necessary to appreciate subtle signs as clinically active disease areas may be limited during the early phase. A positive hair pull test may be detected during the active phase of the disease.

Scalp dermoscopy is a useful bedside tool and allows a magnified view of the following: absence of follicular ostia and perifollicular changes such as hyperkeratosis and pigmentary and vascular alteration [9–11].

Scalp biopsy for histopathology and/or direct immunofluorescence examination is particularly important. The biopsy site must be carefully selected to represent active disease site in order to secure the diagnosis. The classical histopathology of cutaneous lupus includes follicular vacuolar interface changes, a superficial and

Fig. 7.18 AA ophiasis pattern (hair loss in the temporo-occipital scalp)

deep perivascular and periadnexal lymphocytic infiltrate, increase in dermal mucin deposits, and fibrosis. In lichen planopilaris, the histopathology often displays lichenoid interface dermatitis and fibrosis. Perivascular and periadnexal lymphocytic infiltrate is usually not present in LPP [12, 13, 26].

7.2 Conclusion

The objective of this chapter is to equip practicing hair restoration doctors with the ability to develop differential diagnoses apart from male or female pattern hair loss. A number of both non-scarring and scarring alopecias that are relevant to this chapter have been discussed. Fig. 7.29 summarizes salient points of the common differential diagnoses of pattern alopecia. A concise history, detailed physical examination, rapid bedside tools, laboratory investigations, and scalp biopsy will enable the proper hair diagnosis to be made.

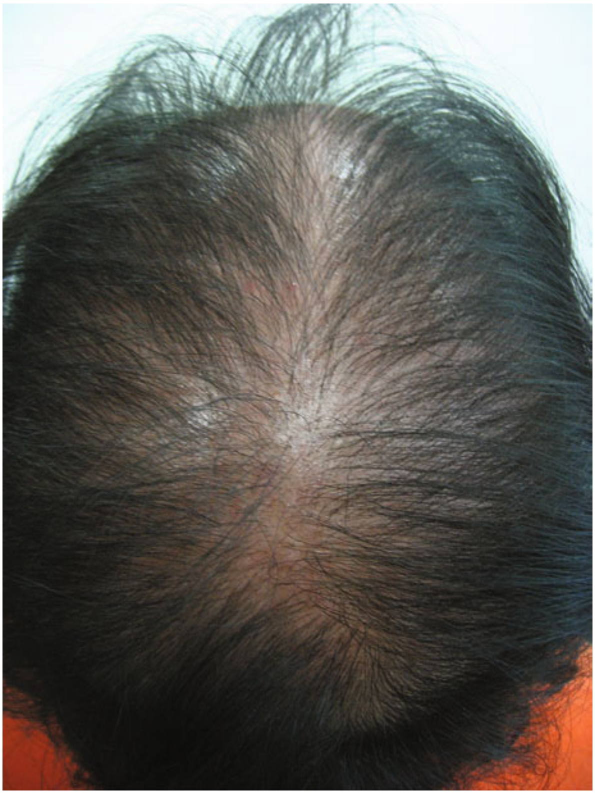

Fig. 7.19 Diffuse AA which can be misdiagnosed as pattern hair loss

7.2.1 A Practical Clinical Approach to Pattern Hair Loss in a Hair Restoration Office

History includes salient points such as the onset, duration, and pattern of hair loss. For example, a gradual increase in hair part width and reduction in hair volume point toward androgenetic alopecia.

Scalp symptoms such as itch, redness, flaking, and tenderness may signify underlying scalp diseases and cicatricial alopecia. Diet history, drug history, present and past medical history, and family history of alopecia are essential to determine. Correlation between physical, emotional, or mental stressors and the onset of hair loss are also beneficial to note.

Physical examination of the scalp and hair is an integral part of the clinical evaluation. A systematic approach includes the following: firstly, inspect the scalp for inflammation, erythema, and scaling and, secondly, observe the distribution, pattern, and density of the hair (i.e., focal versus diffuse alopecia, scarring (cicatricial) versus non-scarring (non-cicatricial)). Careful documentation of clinical information will serve as an important platform for baseline, serial follow-up, and hair transplant surgery evaluation and assessment.

Fig. 7.20 A woman with a sudden onset of alopecia areata in the background of AGA

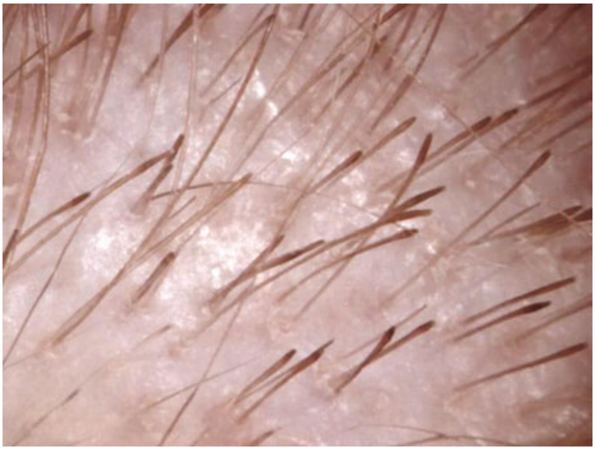

Fig. 7.21 Scalp dermoscopy illustrating the presence of yellow dots and exclamation point hairs. Reproduced with permission from a guide to healthy scalp and hair [19]

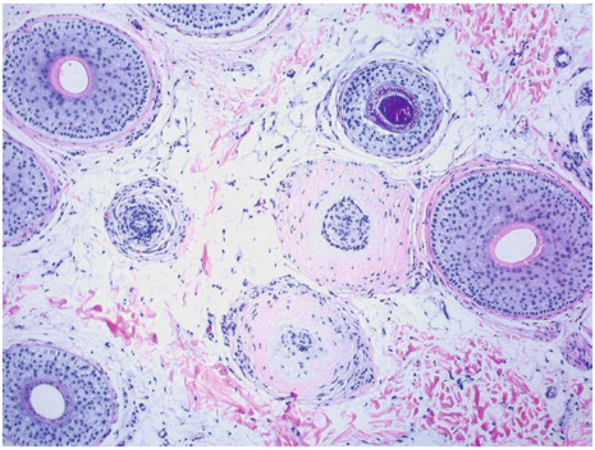

Fig. 7.22 A histological transverse section of AA demonstrating peribulbar lymphocytic infiltrate. Reproduced with permission from a guide to healthy scalp and hair [19]

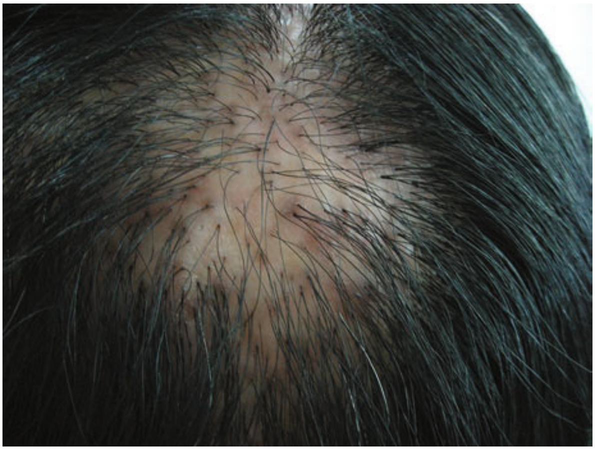

Fig. 7.23 Lack of follicular ostia is the hallmark feature of cicatricial alopecia

An easy bedside assessment technique known as "hair pull test" serves as a useful tool to assess the activity of hair loss. Patients should not shampoo their hair 24 hours prior to the hair pull test. Approximately 60 hairs are grasped from the base of the scalp between the thumb, index, and middle fingers. The hairs are then gently but firmly tugged away from the scalp. If more than six hairs or 10% are removed with each pull, this indicates active hair shedding. It is advisable to conduct the hair pull tests on at least four different sites, i.e., four quadrants of the scalp.

Trichogram/pluck test is another regular bedside assessment test to evaluate hair loss. About 60–80 hairs are grasped with a hemostat covered with rubber. They are then plucked rapidly in the direction of emergence from the scalp. The hairs are trimmed to approximately 1 cm from the root sheaths and rearranged to lay side by side on a slide for counting. Quantitative analysis of anagen to telogen hairs is calculated.

Fig. 7.24 Active DLE illustrating follicular plugging, adherent scaling. Follicular hyperkeratosis is more active in the center of a discoid lupus plaque

Fig. 7.25 DLE illustrating classical atrophic erythematous and hypopigmented plaques of the ear and face

Scalp dermoscopy is another useful and noninvasive tool to examine the scalp surface changes and hair characteristics. Examination of the entire scalp, using a 3X or greater magnifying lens to view the hair-bearing areas, is recommended. Handheld dermoscopy instruments such as the DermLite Pro DP-R® (3Gen Inc., San Juan Capistrano, CA 92675) provide clear magnification of surface details. Salient dermatoscopic features of each hair loss condition have been described in the respective hair loss condition [9–11]. In the author's experience, dermoscopy proves to be a valuable tool in daily clinical practice, and frequent practice will allow the physician to become familiar with various pattern recognitions.

Fig. 7.26 LPP—a female presenting with multiple minute scarring alopecia which can be misdiagnosed as AGA

Laboratory tests may be beneficial to rule out underlying medical diseases that are often associated with hair loss (Table 7.3: Suggested laboratory tests in hair loss evaluation). Blood tests including ferritin, zinc, vitamin D, thyroid function test (free T4/TSH), full blood count, antinuclear antibody, and anti-dsDNA are most commonly carried out. In women with diffuse thinning and virilizing signs such as hirsutism, acne, or irregular menses, investigations which include free testosterone, dehydroepiandrosterone (DHEA), androstenedione, FSH (in female), and LH (in female) are advisable to rule out hyperandrogenism [7, 27].

Scalp biopsy may be necessary in alopecias which pose a diagnostic challenge. The minor surgical procedure is as follows: administer local anesthetic (lidocaine 1% with epinephrine) to the selected active disease site, a 4-mm punch biopsy should be placed parallel to the hair direction and inserted into the scalp to the subcutaneous tissue level (approximately 3.5–4 mm in depth), and the specimen is removed with forceps. The small defect is then closed with suture. The physician should specify that the tissue specimen is for transverse-sectioning histological examination. If cicatricial alopecia is suspected, two biopsies are generally taken. The first tissue specimen is taken for transverse sectioning. The second specimen is divided into two halves, one for direct immunofluorescence and the other half for longitudinal sectioning [3, 14].

Fig. 7.27 Frontal fibrosing alopecia presenting with symmetrical recession of hairline and a few strands of "lonely" hair on her sideburns

Fig. 7.28 Frontal fibrosing alopecia illustrating active inflammation and follicular hyperkeratosis at the margin of her hairline

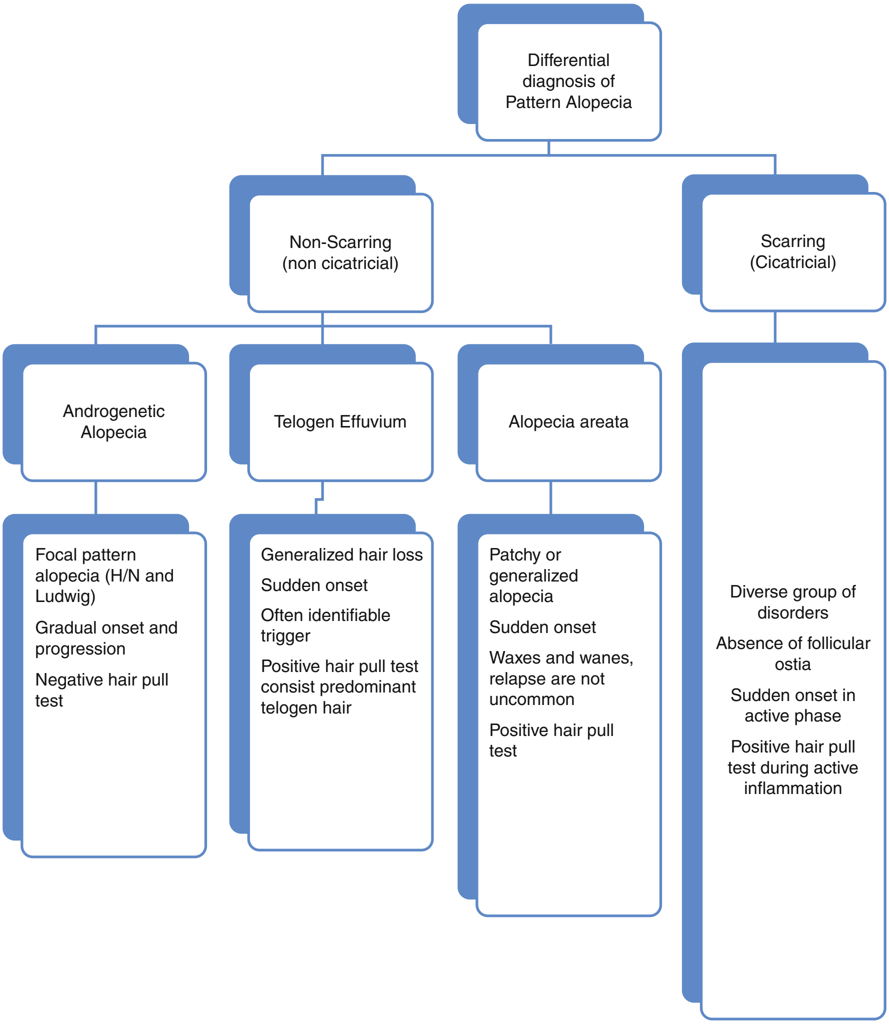

Fig. 7.29 Key features of differential diagnoses of pattern alopecia

Scalp biopsy is also useful to evaluate disease activity, in particular cicatricial alopecia. It is important to make sure the disease is dormant before considering hair transplantation procedure. It is imperative to note that individuals with alopecia areata are rarely ever candidates for hair transplantation. Hair follicles moved from a normal-appearing area of the scalp into a bald area remain susceptible to attack by the patient's immune system.

Various hair loss conditions may mimic and/or coexist with androgenetic alopecia. A systematic approach as discussed above will allow the physician to make a proper diagnosis and administer appropriate medical treatment. In active cicatricial alopecia and alopecia areata, medical treatment instead of hair transplantation may be the preferred first-line treatment of choice [28–30].

Summary Box

- A detailed history and physical examination is the most important step toward the diagnosis of alopecia.
- Diffuse alopecia with rapid onset: think of telogen effluvium.
- Patchy alopecia with rapid onset: think of alopecia areata.
- Shiny, dyspigmented, or atrophic scalp without follicular ostia: think of cicatricial alopecia.

Diagnostic tests include blood investigations, scalp dermoscopy, and skin biopsy.Disclosure Dr. Eileen Tan has nothing to disclose. Unless otherwise indicated, the clinical images are courtesy of Dr. Eileen Tan.

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Chapter 8
Stem Cell: Current and Future State

Nilofer Farjo

8.1 Introduction

In order to understand some of the concepts behind cellular regeneration, it is important to use common terminology. Unfortunately some of the terms that are used have been loosely interchanged and sometimes in a misleading manner. Trichogenic refers to the ability to form hair follicles. There are different cells in the hair follicle that have this ability, for example, research has shown that dermal papilla (DP) and connective tissue sheath (CTS) cells are two cell lineages that demonstrate this ability [5–15]. The next challenges are in maintaining this trichogenicity in vitro, finding the mechanisms of HF regeneration from dissociated cells and assessing ways of delivering trichogenic cells into scalp tissue.

The next term that needs defining is 'cell therapy' which is the process of introducing new cells into a tissue in order to treat a disease. Blood transfusion is one example of this type of therapy. Advanced cellular therapies include the transplantation of autologous or allogeneic stem cells or progenitor cells. The term 'cloning' is the process of creating copies of DNA fragments (molecular cloning), cells (cell cloning) or entire organisms to produce an exact replica, i.e. has the same DNA. Because cells from donor hair follicles are expanded in vitro, this approach has been also referred to as 'hair cloning'; however, the hair follicle is a complex of different cell types, so 'cloning' one cell type is not the same as 'cloning' a hair follicle. On the other hand, hair multiplication refers to the production of multiple hairs from a single hair, but this term is often used interchangeably with the term cloning in reference to follicular cell regeneration. Hair multiplication is also used by some hair restoration surgeons when bisecting follicles and reimplanting each part to form two hairs or by plucking hairs and implanting the plucked hairs [16]. The rationale with plucked hairs is that there are germinative cells adhering to the base

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so that a new hair follicle grows, but enough are still left behind for the original hair to grow back. So far neither the bisection technique nor the plucking technique has shown consistent results.

8.2 Studies with Trichogenic Cells

In order to identify the types of cells that have trichogenic potential, cell populations from different parts of the hair follicle were isolated by dissection and tested for hair-inducing capacity [5–15]. In one of these studies, microdissected dermal papillae from rat whiskers were reimplanted under truncated hair follicles devoid of dermal papilla, and regeneration of hair follicles occurred. These dermal papillae were also capable of inducing new follicle formation when inserted into a follicular skin. Similarly, the inductive capacity of CTS cells was demonstrated in mouse models [14] and then later confirmed in humans [15]. These experiments demonstrated the regenerative capability of the mesenchymal DP and CTS cells, but they did not produce an increase in hair numbers.

8.3 Studies with Cell Systems

Once trichogenic potential was demonstrated, researchers next turned their attention to culturing the different cell types to generate hair follicles. From a clinical point of view, if these cells were capable of generating new hair follicles when implanted into animal models, then the next step would be hair regeneration as a treatment for androgenetic alopecia and other types of hair loss. In 1981 Jahoda and Oliver were the first to publish their research on the successful culture of DP cells in vitro using rat vibrissae [17]. Later, Messenger achieved the same results using human DP cells [18], and soon others were successful also with cultured CTS cells [10, 14, 15]. The next part of the puzzle that needed to be solved was the finding that these monoculture cell lines lost their trichogenicity after extended passages in culture. Therefore researchers next turned to experimenting with different cell culture systems such as adding growth factors known to be involved in the process of follicle neogenesis. Kishimoto et al. tried Wnt3a protein, [19] Osada et al. [20] fibroblast growth factor 2 and Rendl et al. [21] bone morphogenetic proteins, and all found greater hair follicle-inducing efficiency in the culture systems.

In addition, others looked at the mechanical behaviour in vitro as an explanation for the loss of hair-forming ability. When DP cells are cultured, they tend to form aggregates initially, and this aggregative behaviour was found to gradually diminish during cell replication, suggesting that aggregation of cells is important to the trichogenic activity [22]. Additionally, Osada et al. showed that not only did papilla cells of mouse vibrissae lose both their aggregative phenotype and inductivity after multiple passages; but also, if these cells were reaggregated into spheres, they regained the ability to form new hair follicles. Upregulation of several DP-specific genes was found in cells grouped in spheres compared to dissociated cells [20]. More recent research by Angela Cristiano's group not only confirmed these findings but also showed by genetic heat maps that genes were up- and downregulated in disassociated cells compared to aggregated cells that were grown in hanging drops to replicate a three-dimensional structure [23].

Similar to the original embryonic development that occurs in utero, the currently accepted view is that hair formation in the adult relies on reciprocal signalling between inductive dermal cells and responsive epidermal cells [4, 24]. Importantly, in 1999, it was demonstrated that placing the amputated dermal papillae of a male subject into the forearm of a female generated a HF with male genetics, not only showing that the interaction of mesenchymal-epithelial interaction occurred but that there was no rejection of the HF [25]. Together with other experiments, this would explain the loss of trichogenicity in vitro because of the absence of these important dermal-epidermal interactions. Clinical trials (see clinical studies below) have used these concepts by using either medium preconditioned by epidermal cells, which contain the necessary signalling molecules to maintain the trichogenic activity of DP cells [26], or two-cell systems which maintain the interaction between dermal and epidermal cells by coculturing the two cell types (keratinocytes and DP cells). Proof of principle has been demonstrated in animal models such as using silicon chambers on the backs of immune-compromised mice into which separated murine neonatal dermal cells and epidermal cells were placed [27, 28]. At the 4-week stage, tufts of hair grew, and these HFs underwent multiple cycles. Another example is work by Qiao et al. using a 'flap graft assay' where cells were placed under a skin flap and HFs grew [29]. Another two-cell model used by Zheng et al. involved dissociated dermal and epidermal mouse neonatal cells which were injected into the hypodermis of nude mice, and within 10 days hair follicles formed [30]. In this system fewer cells were required, and multiple samples could be used in a single mouse. Of significance was the fact that the new hair follicles had normal histology and went through the normal stages of the hair cycle.

8.4 Mechanisms of Hair Follicle Regeneration

There are several theories that have been proposed to explain the mechanism of generation of new hair follicles from dissociated cultured cells. The first theory is that the dissociated dermal and epidermal cells produce an epidermal cyst, an elongated column of epidermal cells is induced to form from this cyst, and this produces the hair shaft. If this occurs close to the epidermis, then the cyst fuses with the epidermis of the host skin, which allows the hair shaft to emerge. This theory was based on the outcome of experiments using the trichogenic patch assays [29].

McElwee et al. reported their work in which only one cell type (cultured CTS cells from vibrissae) was injected into the ear of severe combined immunodeficiency (SCID) mice resulting in hairs that resembled vibrissae [15]. Following these reports two further theories of HF regeneration were proposed. The first was that inductive donor dermal cells trigger a response from host epidermal cells, causing down-growth of epidermal cells to form a new HF. The second theory was called the morphological switch model in which donor cells—dermal, epidermal or both—are incorporated into existing vellus follicles, where they initiate transformation of these hairs into terminal hairs.

8.5 Clinical Studies

Delivery of cultured cells into the scalp is the critical step in the process of regenerating HFs. The method that is used for this delivery system will depend on the proposed mechanism by which the hair follicles are formed. So if trichogenic cells either as a single-cell system or two-cell system are injected and fusion with or down-growth from the epidermis is needed, then the cells need to be placed superficially.

Alternatively, if the mechanism of action is that existing vellus follicles incorporate donor cells, then injections need to be into the upper dermis. Since this technique uses the natural density, orientation and distribution of existing hairs, an aesthetically pleasing result is easier to achieve. However, in those patients lacking in vellus hair such as in cicatricial alopecia, treatment using this mechanism of action would not be beneficial. This is partly why researchers developed rudimentary HFs ('proto-hairs') in vitro that could then potentially be transplanted into the scalp in a similar manner to current hair transplantation [31].

Using these concepts from in vitro and animal models, several clinical trials have been attempted. The first in human trials took place in 2008 in our Manchester clinic with phase I safety trials. This study used both the one- and two-cell system to show safety of autologous cell cultures, and the outcome was that no adverse events occurred. In subsequent phase II clinical trials, we used the following strategies: cultured cells injected into bald scalp, cells injected into/near vellus follicles and cells injected after wounding to stimulate the Wnt-pathway [19, 32]. The cells obtained for the 8-week expansion were obtained by taking approximately 100 hairs by biopsy from the occipital area of the scalp in 19 patient volunteers. DP cell concentration in the culture for injection was 4 × 10 [6] per μl with the best outcomes in terms of cosmetically significant follicles (hairs > 30μ) occurring in the abraded (wounded) sites (11.8% increase; $N = 19$). These studies, although encouraging, did not produce the dramatic results that were produced in mouse models.

Further work continues with other research groups who have looked at improving on the culture medium, expansion process and types of cells cultured, but to date there is still no commercially viable product available.

8.6 Manufacturing and Regulation

Cohen [33] in 1961 and then Oliver [5] in 1967 were the first to publish work on the concept of hair follicle regeneration, so why is it that a commercial product has not been developed in more than 50 years? Apart from the fact that the intervening work has shown that human hairs don't behave in the same way as murine HFs, one of the major problems is the huge costs involved in research and development and then the subsequent manufacturing process. Cell manipulation is a highly regulated activity that needs a Good Manufacturing Procedures (GMP) facility, written documentation of every phase of manufacture, validation of manufacturing processes as well as equipment performance, use of clean rooms to ensure aseptic technique, highly trained specialist staff, medical grade reagents for all parts of the process and specialised storage and transportation.

8.7 Conclusion

The aim of cell therapy is to overcome the problems of donor limitation. Studies have shown the trichogenic potential of dermal papillae and connective tissue sheath cells, so the development of a reliable culturing system is the next hurdle to overcome. Identifying growth factors and culture conditions that maintain cell trichogenicity in vitro has been a significant breakthrough, but translating these concepts to human cells in vivo is now the challenge. So far all attempts at using any type of cell system, whether using DP cells, CTS cells or stem cells either from the HFs or adipocytes, have failed to produce cosmetically significant results.

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Chapter 9
Autologous Platelet-Rich Plasma Injection Therapy

Sung Bin Cho and Jin-Soo Kang

9.1 Platelet-Rich Plasma

9.1.1 Growth Factors in Platelet-Rich Plasma

Autologous platelet-rich plasma (PRP), a solution of concentrated platelets, has been widely used to promote wound repair and tissue regeneration [1–3]. Platelets are essential to hemostasis, and activated platelets secrete numerous growth factors, including platelet-derived growth factor (PDGF), epidermal growth factor (EGF), transforming growth factor-β (TGF-β), vascular endothelial growth factor (VEGF), insulin-like growth factor 1, and fibroblast growth factor (FGF), mainly from α-granules [2]. In treatment of pattern hair loss, platelets in autologous PRP secrete an abundance of growth factors, including PDGF, FGF, and TGF-β, which stimulate increases in signaling molecules and accelerate cell proliferation [1]. Additionally, VEGF, PDGF, EGF, TGF-β, and FGF promote vascularization for improved nutrient supply during the formation of new follicles [1]. Although EGF and TGF-β may exert negative effects on hair growth and formation, their activity in tissue

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angiogenesis and in stimulating wound healing and new organ formation provides therapeutic effects beneficial to treating pattern hair loss [1].

PDGF and VEGF play crucial roles in hair follicle formation and determining follicle size [1]. PDGF contributes significantly to tissue interactions between the hair bulge and associated components during follicular morphogenesis, especially during hair canal formation [3]. Moreover, PDGF induces the differentiation of specific populations of progenitor cells into several cell types [3]. Previously, functional analysis demonstrated that adipocyte lineage cells are essential to inducing follicular stem cell activation and that PDGF expression in immature adipocyte cells regulates follicular stem cell activity [4]. When evaluating the PDGF-releasing properties of PRP preparations without specific exogenous platelet activation, PRP prepared by kits yielding high concentrations of platelets showed continuous and increasing release of PDGF over the first 5 days after preparation [5]. Also, injecting PRP to the backs of rabbits generated higher levels of PDGF expression at the mRNA and protein level for 7 weeks after PRP injection, compared to injections in the same rabbits with phosphate-buffered saline as a control [6]. Therefore, by inducing increased expression of molecules important to follicular development, PRP injections are effective in treating pattern hair loss.

9.1.2 Cellular Components of Platelet-Rich Plasma Solutions

Preparations of PRP can be categorized into classic (or pure) PRP and leukocyte-rich PRP [2]. Classic PRP is mainly composed of red blood cells (RBCs) and platelets in concentrated plasma, whereas leukocyte-rich PRP contains RBCs, platelets, and leukocytes [2, 5]. When choosing a PRP preparation method, the platelet concentration is generally regarded as more relevant than the growth factor levels therein [1]. The optimal platelet concentration for stimulating the angiogenic potential of endothelial cells is 1.5×10^6 platelets/μL [7]. Lower platelet concentrations of $<0.5 \times 10^6$ platelets/μL fail to induce angiogenesis in vitro, whereas higher concentrations of $>5.0 \times 10^6$ platelets/μL can inhibit angiogenesis [7]. Therefore, choosing a PRP preparation method that consistently yields a sufficient concentration of platelets is important to achieving effective PRP treatment.

To help obtain sufficient concentrations of platelets, highly concentrated leukocytes are also included in PRP preparations [2, 5]. Although leukocytes may exert negative effects on hair growth by releasing proinflammatory cytokines, the degranulation of or damage from leukocytes included in PRP does not occur during the course of sample preparation [8, 9]. Meanwhile, the inclusion of leukocytes in PRP preparations may increase platelet production from megakaryocytes, accelerate wound healing, attract other leukocytes, and prevent infection in non-sterile wounds [2, 8]. Leukocytes also produce large amounts of VEGF, and proteases in leukocytes convert latent forms of growth factors to active forms that promote tissue healing and regeneration [2, 8].

Previously, in a preliminary study, leukocyte-rich PRP preparations were found to contain mobilized CD34+ cells [10]. Bone marrow-derived CD34+ hematopoietic stem cells promote angiogenesis and vasculogenesis and show therapeutic effects in inflammatory and noninflammatory diseases. Mobilized CD34+ cells, referring to CD34+ cells in peripheral blood, also hold angiogenic potential [11, 12]. In leukocyte-rich PRP preparations, an approximately two- to fivefold concentration of CD34+ cells can be obtained using an automated platelet concentrate system, compared to peripheral blood mononuclear cells [10]. Although the precise mechanisms of action remain to be determined, interfollicular injections of mobilized CD34+ cells in leukocyte-rich PRP preparations are suggested to exhibit synergistic effects in hair follicle formation and hair growth cycling [10].

9.1.3 Activation and Storage of Platelet-Rich Plasma Preparations

The platelets in a PRP preparation can be activated by either exogenous or endogenous methods. Exogenous activators include bovine thrombin and calcium chloride, adenosine diphosphate and ITA gelling agent, autologous thrombin, and calcium gluconate and batroxobin [2]. Among the exogenous activating methods, bovine thrombin and calcium chloride have been most commonly used; however, they do seem to generate lower levels of TGF-β and PDGF and introduce the risk of anti-factor Va antibody induction [2]. Endogenous activating methods, meanwhile, are considered more suitable for use in PRP injections [2]. Endogenous activation enables slower and more efficient release of growth factors from platelets and leukocytes [2, 13]. Endogenous activators include calcium, collagen, thrombin, thromboxane A2, adenosine diphosphate, serotonin, vasopressin, thrombospondin, fibrinogen, platelet-activating factor, von Willebrand factor, immune complexes, and plasmin [2, 13]. Indeed, previous studies have found that methods utilizing endogenous activation of platelets in autologous PRP preparations facilitate the maintenance of higher levels of growth factors in sterile conditions, compared to exogenous activation [6, 10].

P-selectin (CD62P) is a cell surface adhesion molecule found on the membranes of α-granules in platelets and the Weibel-Palade bodies of endothelial cells [14, 15]. Showing increases in various pathologic conditions, P-selectin is regarded as a useful marker of platelet activation [14, 15]. Accordingly, researchers are recommended to choose a proper preparation method, or an automated kit, for PRP preparation that consistently yields sufficient platelet counts with low P-selectin levels. Once activated by exogenous activators, PRP preparation can be stored for 2 h or less at room temperature and even 2–10 days at −20 °C and −70 °C, but not at 4 °C [2, 16]. However, preparation of blood and activated samples is not recommended for long-term storage [2, 16].

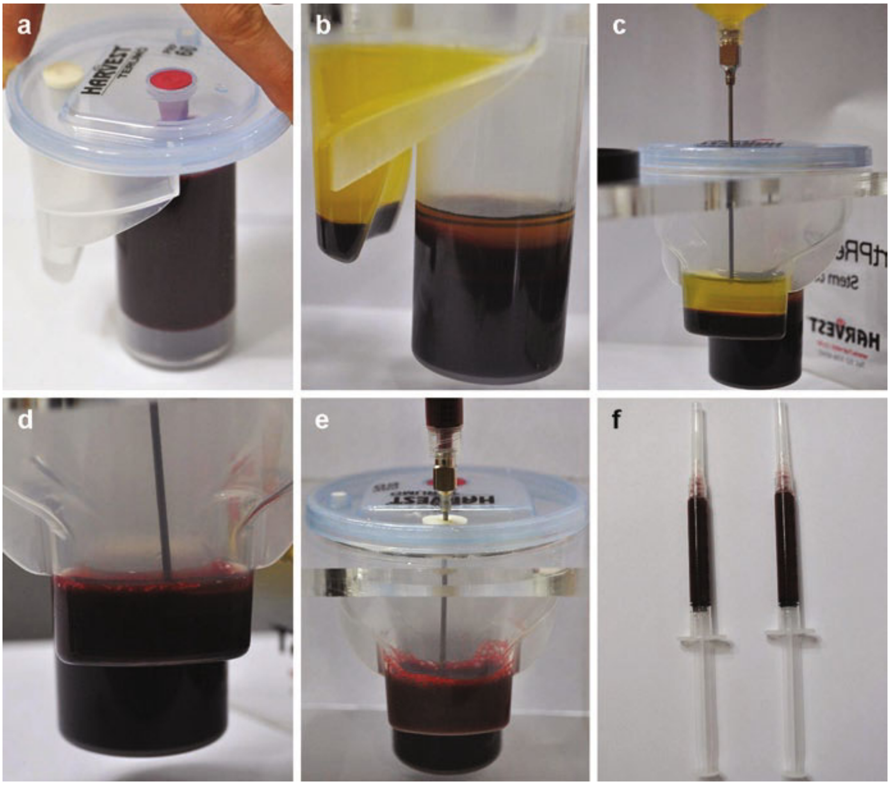

Fig. 9.1 Preparation of autologous platelet-rich plasma (PRP). (**a**) A kit containing 54 mL of peripheral blood and 8 mL of 4% sodium citrate solution before centrifugation. (**b**) Immediately after centrifugation in the automated 2-spin platelet concentrate system. (**c**) Remove platelet-poor plasma. (**d**) Gently stir the PRP preparation. (**e**) Slowly put the PRP preparation into a syringe. (**f**) PRP preparation in a 3-mL Luer-lock syringe with a 26-gauge needle

9.2 Platelet-Rich Plasma Therapy for Pattern Hair Loss

9.2.1 Autologous Platelet-Rich Plasma Preparation and Injection

According to previous research, leukocyte-rich PRP containing CD34+ cells can be prepared using the SmartPReP2 APC+ (Harvest Technologies Corp., Plymouth, MA, USA) platelet concentrate system, which has been approved by the US Food and Drug Administration [2, 10]. To do so, 27 and 54 mL of peripheral blood obtained from patients are transferred to the 30-mL and 60-mL SmartPReP2 APC+ kits, containing 4 and 8 mL of 4% sodium citrate solution (Baxter Healthcare Corp., Deerfield, IL, USA), respectively (Fig. 9.1). Then, the peripheral blood in the SmartPReP2 APC+ kits is centrifuged with the automated 2-spin SmartPReP2

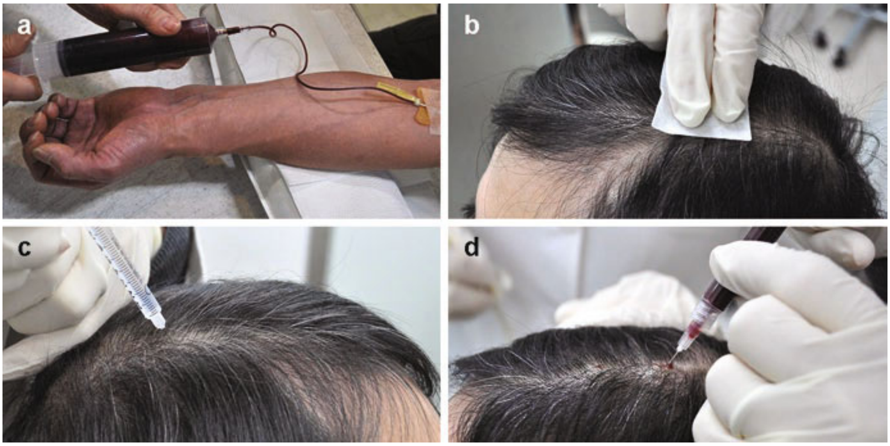

Fig. 9.2 PRP treatment steps. (**a**) Obtain peripheral blood from the patient. (**b**) Cleanse the patient's scalp with 70% alcohol. (**c**) Inject local anesthesia of 2% lidocaine with 1:100,000 epinephrine and then wait for 5 min. (**d**) Inject 0.05–0.1 mL/cm^2 of the leukocyte-rich PRP preparation along the scalp

centrifuge (Harvest Technologies Corp.). After removing platelet-poor plasma, 4 and 10 mL of PRP preparation can be maximally obtained from the 30-mL and 60-mL SmartPReP2 APC+ kits, respectively. Notwithstanding, preparation methods can vary according to type of PRP and for different manufacturer's protocols. Moreover, platelet and leukocyte counts in both peripheral blood and PRP from each patient should be microscopically counted to evaluate the quality of the PRP preparation.

Before administering PRP injections, the patient's scalp should be cleansed with 70% alcohol, and for local anesthesia, injections of 2% lidocaine and 1:100,000 epinephrine (3–5 mL) should be applied along the frontal, mid, and vertex areas (Fig. 9.2). Ring blocks or supraorbital and supratrochlear nerve blocks are also applicable as methods of local anesthesia for PRP injection. However, lesional injection of local anesthetic containing epinephrine helps prevent PRP-injection site bleeding, regurgitation of the injected PRP, and rapid absorption or drainage into lymphatic and vascular components.

Next, 0.05–0.1 mL/cm^2 of the leukocyte-rich PRP preparation (4–10 mL in total) can be injected along the scalp using a 26-gauge needle (Fig. 9.3). The injection depth should reach the deep dermis or upper subcutaneous fat layer. PRP tends to regurgitate through the injection sites when injected too superficially, whereas PRP seems to be readily absorbed or drain when injected too deeply. Additionally, tighter and more focused injections of PRP on limited areas of the frontal and vertex scalp seem to be more effective than diffuse and uniform injections across larger areas of the scalp.

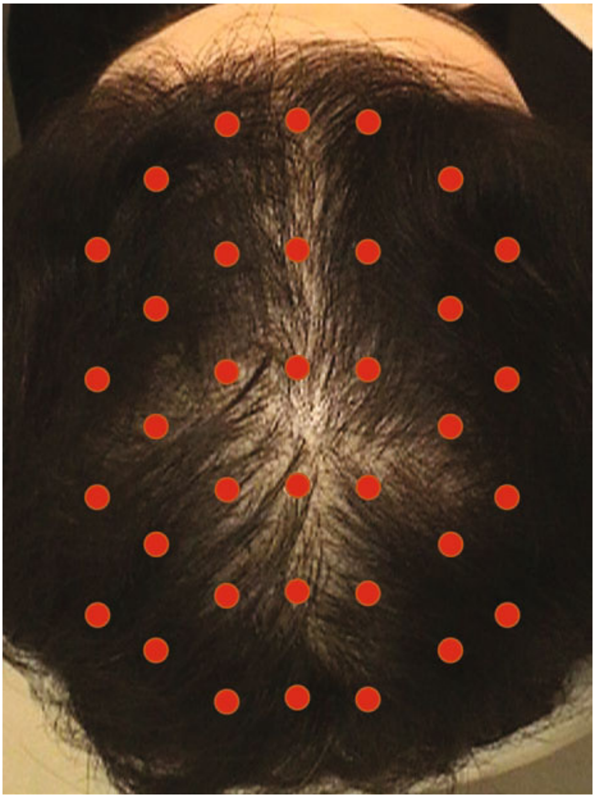

Fig. 9.3 Schematic view of injection points for PRP treatment along the frontal and vertex scalp

9.2.2 Post-procedure Care and Side Effects

Bleeding and PRP regurgitation are easily controlled by mild compression using gauze on the injection site. Prophylactically, oral antibiotics can be prescribed for 3 days. However, the prescription of systemic steroids or nonsteroidal anti-inflammatory drugs is not recommended, as they can theoretically reduce the effects of PRP. Patients can gently wash their hair 12 h after the PRP injection.

In regards to side effects, pain during the procedure is generally tolerable for most patients. Transient posttreatment edema and tenderness, mild itching sensations, and desquamation have also been reported [2, 10]. Other potential side effects, including progression of pattern hair loss, accompanying telogen effluvium or alopecia areata; secondary bacterial, viral, and fungal infections; and post-therapy scarring are not common.

9.2.3 Effects of Platelet-Rich Plasma Therapy on Pattern Hair Loss

Early after treatment, the injected PRP supplies growth factors and nutritional elements directly to hair follicles. In later phases, increased angiogenesis and vascularization enhance the supply of cells, growth factors, and nutritional elements from distant areas. As a result, PRP treatment awakens dormant hair follicles in the scalp and improves the efficiency of follicular formation [1]. In a study by Schiavone et al., two sessions of leukocyte-rich PRP treatments were performed with the addition of concentrated plasmatic proteins as a biologically active scaffold for slower and more efficient release of growth factors at 3-month intervals in 64 patients with pattern hair loss [3]. To do so, 60-mL peripheral blood was obtained from each patient and processed through the GPS III Platelet Separation System (Biomet, Warsaw, IN, USA) to produce 6–8 mL of leukocyte-rich PRP using a 1-spin PRP system at the first injection and a 2-spin PRP system at the second [3]. According to the Jaeschke rating scale, two evaluators in the study determined that the mean

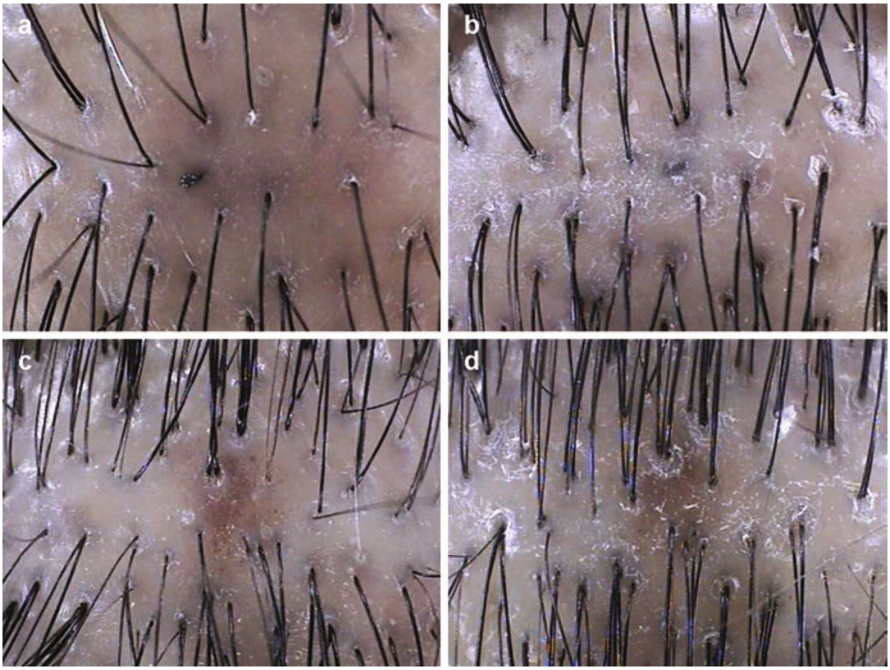

Fig. 9.4 Effects of PRP therapy on pattern hair loss. Digital images of hairs along the vertex scalp in patient 1 (**a**, **b**) and in patient 2 (**c**, **d**) with male pattern hair loss before (**a**, **c**) and 1 week (**b**, **d**) after the last session of combined treatment with injections of leukocyte-rich PRP containing intra-perifollicular CD34+ cells (single session) and of polydeoxyribonucleotide (12 sessions, 1-week intervals)

clinical rating increased by 3.2 and 3.9 (+3, somewhat better and +4, moderately better); the proportion of patients showing clinically remarkable improvement comprised 40.6 and 54.7%, respectively [3].

In a previous report, patients with female pattern hair loss treated with a single session of PRP and 12 sessions of polydeoxyribonucleotide (PDRN) injection demonstrated statistically significant clinical improvements in both mean hair counts (23.2 ± 15.5%) and mean hair thickness (16.8 ± 10.8%), compared with baseline values (Fig. 9.4) [6]. Additionally, comparison analyses revealed that combination therapy with PRP and PDRN exerted significantly greater effects on improving hair thickness than treatment with PDRN alone [6]. Another clinical report demonstrated that patients with pattern hair loss show clinical improvements in mean numbers of hairs (20.5 ± 17.0%) and mean hair thickness (31.3 ± 30.1%) at 3 months after an initial PRP treatment, compared with baseline values [10]. After an additional 3 months after a second PRP treatment, the patients exhibited clinical improvements in mean hair counts (29.2 ± 17.8%) and mean hair thickness (46.4 ± 37.5%), compared to those at baseline [10]. Also, in the same study, leukocyte-rich PRP treatment offered significantly greater clinical improvement in hair thickness and overall clinical improvement than placental extract injection therapy [10].

In a randomized, evaluator-blinded, placebo-controlled, half-head group study, researchers performed three sessions of PRP treatment at 30-day intervals in 20 patients with male pattern hair loss, injecting 9 mL of a PRP preparation using a 30-gauge, 1-mL Luer-lock syringe [17]. After three treatment cycles, the mean number of hairs in the target area increased by 33.6 hairs, and the mean total hair density increased by 45.9 hairs/cm^2, compared to baseline values, without remarkable side effects [17]. Also, no remarkable relapse in pattern hair loss was observed within 12 months, although some patients showed progressive hair loss after 16 months [17].

9.3 Conclusions

Although laboratory and clinical research data may not definitively prove the therapeutic efficacies of PRP in the treatment of pattern hair loss, intra-perifollicular injection of autologous PRP improves hair thickness and density in patients with pattern hair loss. Thus, standardization of PRP preparation and injection methods may help facilitate wider use of PRP treatment for pattern hair loss. Nevertheless, further prospective studies with a controlled/split human scalp design are warranted to confirm the clinical efficacy and safety of autologous leukocyte-rich PRP treatment in patients with pattern hair loss.

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Chapter 10
Holding Solutions, Conditions, and Additives to Optimize Hair Follicle Viability and Function

William D. Ehringer and Kristyn H. Smith

10.1 Introduction

The purpose of this chapter is to provide an overview of hair follicle storage solutions and the conditions that impact the viability of transplanted tissue for hair restoration surgery. At this time, there is no perfect storage solution and no conditions or additives that can preserve 100% of transplanted tissue since the process of tissue dissection leads to inevitable loss in viable cells from a variety of physical and biochemical factors. What can be addressed is how to best preserve the remaining cell populations that compose the hair follicle (i.e., epithelial, connective, muscle, and nervous tissues). It is important to note that each tissue has different metabolic demands, thus the optimized storage solution must take into account how to balance the differences between cell types. In some ways, the successful preservation of hair follicles is not drastically different from the preservation of a solid organ, except that the hair follicle lacks a pedicle for perfusion (of preservation solutions), and there is an obvious size difference. Due to the fact that there has been limited published information on optimal preservation conditions for hair follicles, some of the information presented will draw upon the more heavily studied areas of composite tissue and organ preservation as a model of how to optimize follicular unit (FU) viability.

Hair transplant operations rarely exceed 12 h in duration, and typical FU graft out-of-body times are between 2 and 8 h. While this time period pales in comparison to some solid organ transplant times (>24 h), using the wrong FU graft holding solution, and in the wrong manner, can lead to complete graft failure [1]. For example, a preservation solution that was designed for use at 2–8 °C does not perform as well at normothermia (37 °C) [2, 3]. In many cases, the preservation solution was

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specifically developed for certain types of organs or tissues, and using a preservation solution that works well in heart transplant procedures may not bold well in hair transplant procedures. Furthermore, since there is no specific preservation solution that was designed for hair transplantation, surgeons have been forced into relying on solutions that are at best suboptimal. This chapter will explore most of the current preservation solutions used in HRS in order to shed light on which preservation solution, additives, and conditions approach optimal preservation of hair follicles.

The biochemical and physiologic challenges that occur in hair follicles during preservation is the key to understanding how to best optimize and select a graft preservation solution. Hair follicles use aerobic glycolysis for 90% of ATP production, and this fact suggests that hair follicles require a large amount of ATP for survival and function [4]. During the process of FU isolation, the blood flow to the FUs is stopped, and as a result the tissue from this point onward suffers from hypoxia. Hypoxia leads to decreased cellular ATP production and an increase in the ATP degradation product hypoxanthine. Once normal oxygen tension is restored by neovascularization (typically 2–3 days post-op), the hypoxanthine in the cells of the follicle is converted into xanthine, and in the process a free oxygen radical is formed (e.g., IRI) leading to destruction of proteins, lipids, and DNA/RNA [5]. Thus, additives that boost intracellular ATP, prevent hypoxanthine buildup, or help reduce oxygen radicals are imperative in maximizing viability during hypoxia.

10.2 Hair Follicle Graft Holding Solutions

There is certainly not much consensus on which graft holding solution to use for either FUE or FUT procedures. The most widely used holding solutions are normal saline, Ringer's lactate, and Plasma-Lyte A [6]. Surprisingly, none of these solutions are considered tissue preservation solutions but rather were designed for IV irrigation and hydration [7–9]. In contrast, transplantation of composite tissues and organs is approached with more specialized preservation solutions specifically designed for maintaining maximum viability of the cells/tissue ex vivo. A good example is the University of Wisconsin (UW) solution that was designed for the preservation of the liver, kidney, and pancreas. This section will examine the most commonly used graft holding solutions used in HRS and the strengths and weaknesses of each solution.

10.2.1 Normal Saline (NS)

The popularity of NS (0.9% NaCl in water for injection) is not attributed to the composition of the NS but to the fact that it is inexpensive and "others" have used NS successfully. While it is understandable that NS can lead to a "successful" transplant, it can also lead to significant graft failure [10, 11]. The major issue with NS is that it is not buffered and does not address the biochemical and physiological effects of tissue survival during hypoxia and hypothermia. NS has a pH near 5.0, which is significantly lower than the intracellular pH of 7.39. The increased level of protons from the NS leads to a significant decrease in intracellular pH. A decrease in intracellular pH from 7.39 to 6.8 will lead to induction of pro-apoptotic pathways and thus a loss of viable cells in the FU.

In addition to the pH issue, NS does not have any substrates that can be used to produce ATP. Without glucose, or some substrate to produce intracellular ATP, all of the ATP-requiring pathways are significantly decreased in activity. While cells do have some reserves of glycogen, the taxing effects of time reduce these stores and thus lead to cell apoptosis or necrosis. In vitro culture of cells and tissues with normal saline leads to immediate changes in cell morphology and cell function, suggesting that the effects of NS could be equally detrimental to hair follicle cells [12].

Also of significance is the lack of an impermeant when using NS in hypothermic preservation. *In vivo*, the cells of our body use extracellular proteins and other impermeant molecules to control the flux of water and ions through the cell membrane. Hair follicle cells preserved in NS will swell as a result of the lack of these impermeants, leading to cell depolarization and likely cell death [1, 13]. So, why do hair follicles survive in NS? The answer is a decrease in metabolic demand due to the reduced temperature effects on the follicular tissue and hence preservation of sufficient pluripotent stem cells to survive the hypoxia. This idea is supported by the research of Beehner, who allowed grafts to dehydrate on a Telfa pad for 16 min prior to placement. Although the FU was brittle when implanted, 60% of one-hair FU survived, and 82% of two-hair FU survived [14]. Similarly, Limmer found that 88% of FU grafts survived an 8 h storage in saline [15]. This may explain why NS is successful in HRS and also may explain the delay of hair growth from the insult of NS.

10.2.2 Ringer's Lactate (RL)

Ringer's solution was modified to contain lactate to help treat metabolic acidosis. Since its invention, it has been used as an IV hydration solution and, to a lesser extent, irrigation solution. The composition and properties of Ringer's Lactate (RL) are shown in Table 10.1. RL is composed of nearly the same levels of sodium, potassium chloride, and calcium as are found in a human cell. These important ions help maintain the membrane potential of all cells, and thus RL decreases the issues with ion imbalances associated with NS. However, RL has several attributes that do not make it a good choice for FU preservation.

RL uses sodium lactate as a buffer for pH, which, given sufficient time and assistance by cells, can turn into bicarbonate and absorb proton. The conversion of lactate to bicarbonate occurs primarily in the liver, and thus in FU the conversion is slow, and the buffering capacity of lactate has been drawn into question [16]. RL has a pH of ~6.2, which is significantly below the intracellular pH of hair follicle cells,

Table 10.1 Composition of Ringer's lactate

Ingredient	Amount/1000 mL	Concentration (mmol/L)
Sodium lactate	3.10 g	25.4
Sodium chloride	6.00 g	102
Potassium chloride	0.30 g	4.02
Calcium chloride	0.20 g	1.80
Water for injection	Add 1000 mL	–

and thus acidification of the cell's cytoplasm occurs, potentially leading to apoptosis. In addition, RL has an osmolality of ~274 mOsm-kg. This is slightly less than the plasma osmolality reference range of 285–295 mOsm-kg, which can lead to passive leakage of ions and cell swelling, especially at hypothermic temperatures where ion pump activity is significantly decreased.

RL does have an energy source in that lactate can be used by cells to generate pyruvate via the Cori cycle. However, the level of lactate (28 mM) in RL is sufficient to produce less than 10% of the ATP needed by the hair follicle cell [4].

10.2.3 Plasma-Lyte A (PL)/Normosol

Plasma-Lyte A/Normosol (PL) has several unique advantages compared to normal saline and Ringer's lactate as an FU graft holding solution. First, Plasma-Lyte A uses acetate and gluconate as buffers; both are intended to raise the bicarbonate ion level [9, 17]. PL has a pH of 7.4, which is very close to intracellular pH, and as such, PL is considered to have an alkalinizing effect on cells which should decrease acidosis in hypoxic follicle cells. However, the alkalinizing effect of gluconate has been called into question [17] and is dependent upon the metabolism of the cells, and this is often compromised under hypoxia and hypothermia. PL has an osmolality of 295 mOsm-kg, which is also very close to cellular osmolality. PL also uses acetate, which can be converted to pyruvate as an energy source. Because of these factors, PL is clearly the better of the three crystalloid solutions in helping maintain FU cell viability.

While PL was designed for IV hydration and irrigation and not for preserving cells and tissues, there is evidence to support its role in tissue preservation. PL was demonstrated in a recent study by Wise et al., in which Plasma-Lyte A was found to be equally effective in preserving saphenous vein graft function compared to University of Wisconsin solution, Celsior solution, and glutathione-ascorbic acid-L-arginine solution (GALA) [16].

10.2.4 HypoThermosol (HT)

HypoThermosol (HT) was specifically developed for the preservation of cells and tissues under hypothermic, and its components and physical properties are very different from the three crystalloid solutions reviewed above (Table 10.2). HT has a

Table 10.2 Composition of HypoThermosol

Ingredient	Concentration	Units
Inorganic		
Na^+	100.0	mM
K^+	42.5	mM
Ca^{2+}	0.05	mM
Mg^{2+}	5.0	mM
Cl^-	17.1	mM
pH buffers		
H_2PO_{4-}	10.0	mM
HCO_{3-}	5.0	mM
HEPES	25.0	mM
Impermeants		
Lactobionate	100.0	mM
Sucrose	20.0	mM
Mannitol	20.0	mM
Glucose	5.0	mM
Colloid		
Dextran-40	6	%
Metabolites		
Adenosine	2.0	mM
Glutathione	3.0	mM

significantly high potassium concentration and contains impermeants, making it an intracellular-type solution [7, 10]. Both the potassium and impermeants aid in reducing passive leakage of ions and thus decrease cell swelling. HT contains adenosine and reduced glutathione as metabolites. Adenosine can be used by cells via adenine nucleotide salvage pathways to make ATP, ADP, and AMP and is a common element in stem cell metabolism [18]. Glutathione is the most predominant water-soluble free radical scavenger in cells, which is important in reducing cell damage from hypoxia-induced oxygen radical production. In addition, HT uses a HEPES buffer that contains phosphate and bicarbonate and is adjusted to pH 7.6. This buffer strategy creates a slightly alkaline environment, which allows for any excess protons produced by the metabolizing tissue to be absorbed without significantly affecting pH. In addition, HEPES is a very strong buffer with a pKa of 7.5 and is able to absorb significant levels of proton without a change in pH. The high osmolality of HT decreases potassium leakage and thus decreases cell swelling, changes in membrane potential, and ATP consumption.

Beehner performed a study in which HT was compared to NS and found that FU survival was increased using HT after 2 h of storage. After 5 days, the survival of grafts stored *ex vivo* was nearly threefold greater in HT compared to NS [19]. In another study by Perez-Mesa et al., HT was superior to Custodiol solution in preserving hair follicles after 24 and 48 h *ex vivo* [20]. While most HRSs do not use FUs that are stored for these long periods, it does suggest that the FU cell population was better preserved which may affect the hair transplant outcome.

10.2.5 Culture Media: Williams E (WM) and DMEM Media

The use of culture media in FU preservation would seem like an obvious choice given the plethora of publications using culture media to support cell and tissue viability *ex vivo*. A number of physicians have reported excellent results using Williams E media (WM) during graft isolation and preservation [21]. WM is an extracellular-type preservation solution in that the components are created to mimic the extracellular environment. Unlike other preservation media, WE contains all of the essential amino acids, essential vitamins, and inorganic salts. It contains both glucose and pyruvate for cellular energy production and glutathione as a free radical scavenger. WM has shown to increase hair growth in conditioned keratinocyte cells, and thus it would appear that WM is a good choice for HRS [22]. However, these studies were conducted at normothermia, and the effects of WM at hypothermia are unknown. What is known is that low concentration of impermeants and low potassium during hypothermic preservation can lead to cell swelling and loss of membrane potential as described previously.

Dulbecco's Modified Eagles Media (DMEM) have been successfully used by hair researchers focusing on *ex vivo* hair follicle culture [23, 24]. DMEM supplemented with iNOS inhibitors was shown to decrease post-transplant shedding [25]. Wnt1-conditioned DMEM was used in a study by Dong et al., to activate dermal papillae cells and promote hair follicle regrowth [26]. However, DMEM was designed for use at normothermia, and when used at reduced temperatures, it has shown to be much less effective at FU viability compared to HT [7].

10.3 FU Storage Conditions

FUs experience a variety of biochemical and physiologic challenges that impact viability and function. The most important are changes to pH, osmolality, and temperature [1, 27]. Cells exist in a state of homeostasis that resists (under normal conditions) any changes from the optimum biochemical environment. However, there are a number of examples in which the process of graft isolation and implantation results in suboptimal conditions. As an example, a decrease of the intracellular pH by 0.5–1.0 is sufficient to send most cells into apoptosis [28, 29]. Thus, the use of unbuffered solutions, such as normal saline, can lead to apoptosis as a result of intracellular proton accumulation and decreased sodium proton antiport function [30]. This section will examine how pH, osmolality, and temperature shifts affect FU survival.

10.3.1 pH and Graft Survival

The cells of the human body have an intracellular pH of ~7.39 under normal conditions. During conditions of hypoxia or ischemia, the intracellular accumulation of protons increases as a result of a number of metabolic cascades. As the intracellular pH decreases below 7.39, the function of a number of cytosolic and membrane-bound proteins is affected leading to alterations in function. If the cell has sufficient ATP, it can use a number of enzymes to decrease proton accumulation, such as carbonic anhydrase, sodium proton antiport, lactate/proton antiport, and buffers [30]. If the intracellular proton level is not controlled, the survival of the cells of the FU will most likely decrease.

There are a number of ways to prevent pH changes in HRS. The most obvious is to use a buffered graft holding solution. The optimal pH buffer will maximize the buffering capacity of the graft holding solution. Buffering capacity is the amount of strong acid or base (in gram equivalents) that must be added to 1 L of the solution to change its pH by one unit. The buffering capacity is optimal when the pH = pKa of the buffer. In the case of NS and RL, the pKa is either absent or significantly lower than the cell pH. HypoThermosol uses HEPES which has a pKa of 7.5 and thus can absorb a larger number of protons compared to other physiologic buffers. However, there is a limit to how much HEPES buffer can be used as studies have shown that concentrations in excess of 25 mM can be toxic to cells [31].

Another factor that can decrease the pH of graft holding solutions is hemolysis of RBCs. When hemolysis occurs, there is a release of hemoglobin and hemin, which leads to increased oxidative stress and also intracellular signaling that decreases cell metabolism [32, 33]. The increased oxidation of membrane-bound proteins and lipids leads to significant alterations in intracellular pH. Thus, when FU are isolated, they should be initially washed in excess graft holding solution to remove RBCs in order to prevent the damaging effects of hemolysis. In addition, the replacement of graft holding solution has an additional effect on FU survival. It is well known that static storage of tissue leads to accumulation of metabolites, especially CO_2, lactate, and ammonia [34], and thus the FU graft storage solution should be changed until there is no evidence of blood.

10.3.2 Osmotic Shock

The osmolality of a graft holding solution plays a critical role in FU survival. Cells have an internal osmolality of ~290 mOsm-kg, and changes in this value will affect a number of important factors such as cell permeability and increased intracellular calcium [35]. Many of the intracellular graft holding solutions (e.g., HypoThermosol, UW solution) have a high osmolality of 340–370 mOsm-kg, which is significantly higher than osmolality of the cell. The purpose of the increased osmolality is that it decreases potassium and other intracellular ion leakage, thus decreasing the chance of depolarizing the cell which can lead to apoptosis. When using two different graft holding solutions or a rinsing solution (e.g., NS and HypoThermosol), one should take into account the potential for osmotic shock.

10.3.3 Variances in FU Temperature

The consensus among most surgeons is that hypothermic storage results in better graft survival. This is certainly true as hypothermic storage decreases ATP consumption of the tissue. However, it is also known that storage of tissue at reduced temperatures can lead to significant issues that may affect graft viability and function. For example, hypothermic preservation leads to protein denaturation [36], increased cell membrane permeability after reheating [37], and decreased membrane potential [38]. Current research suggests that the best scenario for preservation of tissues is to keep them at normothermia; however, this requires specialized equipment and a method to maintain tissue ATP levels, such as oxygenation [39]. Unfortunately there is no current normothermic preservation protocol for FU grafts, and further research in this area is needed.

In addition to the effects of hypothermia on FU grafts, another issue is the temperature shifts that occur during FU processing. During FUT slivering and FU isolation, saline is usually used to keep the grafts hydrated during the dissection process. If the temperature of the hydrating solution is not the same as the graft holding solution, there is likely to be a temperature change that could decrease graft function or viability. This is supported by the finding that a slight temperature shift from 37 to 30 °C results in changes in cell cycle from S phase to G1, decreasing cell growth rates [40]. These "slight changes" can obviously affect the number of viable FU grafts, and/or delay graft growth, and thus need further consideration.

10.4 Additives and Treatments in HRS

There has been considerable interest in the use of various additives and treatments that affect the implantation of the FU and can potentially increase graft survival. The most studied of these treatments is the use of platelet-rich plasma (PRP), which is typically used by applying it to the scalp via injections or emersion of the grafts in PRP prior to placement. While it is not debatable that platelets contain a number of growth factors as well as extracellular matrix proteins, what is debatable are the effects of these factors and the repeatability of activation of the platelets in terms of tissue healing. ACell and other decellularized extracellular matrices increase cell attachment and cellular proliferation and have been successfully used to treat wounds. However, the extracellular matrix of human cells varies depending upon location and function in the body, which can lead to absorption of the decellularized matrix and increased scar formation. Finally, we discuss the role of additives that increase intracellular ATP levels during graft storage and also how this may impact the healing of implanted FU grafts.

10.4.1 Platelet-Rich Plasma (PRP)

Platelet-rich plasma (PRP) is an autologous concentrated platelet suspension in plasma that has been used to enhance wound healing [41–43]. PRP is prepared by taking a small volume of the patients' blood and centrifuging the sample to obtain a concentrated sample of platelets 3–5 times the baseline concentration [44, 45]. Once prepared, some protocols call for PRP to be activated (or stimulate platelet degranulation) prior to application. There are several methods for activating PRP including the addition of thrombin or calcium chloride. Alternatively, some protocols call for the injection of PRP without activation which relies on the platelet activation upon exposure to collagen native to the extracellular matrix [46]. Lubkowska et al. showed that platelet activation can even occur during the collection, processing, and storage of the platelets which can result in a loss of growth factors [47] (Tables 10.3 and 10.4).

Table 10.3 Composition of Williams E media and DMEM

Ingredient	Williams E media concentration (mg/L)	DMEM concentration (mg/L)
Inorganic salts		
Calcium chloride dihydrate	265.000	265.000
Copper sulfate pentahydrate	0.0001	–
Ferric nitrate nonahydrate	0.0001	0.100
Magnesium sulfate anhydrous	97.700	97.720
Manganese chloride tetrahydrate	0.0001	–
Potassium chloride	400.000	400.000
Sodium chloride	6800.000	6400.000
Sodium dihydrogen phosphate	122.000	–
Zinc sulfate heptahydrate	0.0002	–
Amino acids		
Glycine	50.000	30.000
L-Alanine	90.000	–
L-Arginine hydrochloride	60.300	84.000
L-Asparagine anhydrous	16.540	–
L-Aspartic acid	30.000	–
L-Cysteine dihydrochloride	64.070	–
L-Cystine	20.000	–
L-Cystine dihydrochloride	–	62.570
L-Glutamic acid	44.500	–
L-Glutamine	292.000	584.000

(continued)

Table 10.3 (continued)

Ingredient	Williams E media concentration (mg/L)	DMEM concentration (mg/L)
L-Histidine hydrochloride	18.580	
L-Histidine hydrochloride monohydrate	–	42.000
L-Isoleucine	50.000	105.000
L-Leucine	75.000	105.000
L-Lysine hydrochloride	87.460	146.000
L-Methionine	15.000	30.000
L-Phenylalanine	25.000	66.000
L-Proline	30.000	–
L-Serine	10.000	42.000
L-Threonine	40.000	95.000
L-Tryptophan	10.000	16.000
L-Tyrosine disodium salt	43.500	103.790
L-Valine	50.000	94.000
Vitamins		
Ascorbic acid sodium salt	2.270	–
Calciferol	0.100	–
Choline chloride	15.000	4.000
D-biotin	0.500	–
D-Ca-Pantothenate hemicalcium	1.000	–
D-Ca-Pantothenate	–	4.000
Folic acid	1.000	4.000
Menadione sodium bisulfite	0.010	–
Niacinamide	1.000	
Nicotinamide	–	4.000
Pyridoxal hydrochloride	1.000	4.000
Retinol acetate	0.100	–
Riboflavin	0.100	0.400
Thiamine hydrochloride	1.000	4.000
Vitamin B12	0.200	–
Myo-inositol	2.000	–
i-Inositol	–	7.200
Others		
D-glucose	2000.000	4500.000
Glutathione reduced	0.050	–
Methyl linoleate	0.030	–
Phenol red	10.700	–
Pyruvate acid sodium salt	25.000	–

Table 10.4 Summary of graft holding solutions

Graft holding solution	pH	Osmolality (mOsm)	Recommended temperature (°C)
Normal saline	5–7	270–280	37
Ringer's lactate	6.2	270–280	37
Plasma-Lyte A	7.4	290–295	37
HypoThermosol	7.6	340–370	4–10
Williams E	7.4	310–330	37
DMEM	7.4	310–330	37

Table 10.5 Platelet content and actions[a]

Platelet content	Biological actions
Growth factors	PDGF (stimulates mitogenesis for mesenchymal cells, regulates collagenase secretion and collagen synthesis, stimulates macrophage and neutrophil chemotaxis) [48] IGF (chemotaxis for fibroblasts, stimulates protein synthesis) [47] VEGF (angiogenesis, increased vessel permeability, stimulates mitogenesis for endothelial cells) [48] PDAF (induce angiogenesis, chemoattractant for monocytes and capillary endothelial cells) [49] TGF-β (induce angiogenesis, chemoattractant for monocytes and capillary endothelial cells) [49]
Hemostatic factors	Fibrinogen, fibronectin, vitronectin (form platelet endothelial adhesions) [41]
Proteases	MMP2 (amplifies the platelet aggregation, proangiogenic mediator) [41, 50] MMP9 (inhibitor of platelet aggregation. MMP9 may play an important role as a negative feedback regulator during platelet activation, proangiogenic mediator) [41, 51]
Necrotic factors	TNFα (enhances platelet activation) [52]
Chemokines	CXCL4 (induce neutrophil adhesion and degradation, activates monocytes) [41] CXCL7 (induces neutrophil chemotaxis and adhesion to endothelial cells) [41]

[a]Table 10.5 is an abbreviated list of platelet content and biological actions

PRP contains a myriad of wound healing constituents including growth factors, cytokines, and cell adhesion molecules (see Table 10.5). Growth factors released include platelet-derived growth factor (PDGF), insulin-like growth factor (IGF), vascular endothelial growth factor (VEGF), platelet-derived angiogenic growth factor (PDAF), and transforming growth factor-beta (TGF-β). Platelet degranulation causes the release of these growth factors that in turn bind to its specific cell receptor increasing the mitogenic response of the target cells. This response leads to actions crucial to wound healing such as angiogenesis, mitogenesis, chemotaxis, and collagen synthesis to name a few [48].

Table 10.6 ECM content and actions[a]

ECM content	Biological actions
Fibronectin	Forms structural fibrils and fibrin-integrin interactions encourage cell-ECM adhesions and induce signaling that affects the formation of the cytoskeleton [56]. Stimulates the adhesion and migration of fibroblasts [55]
Proteoglycans	Promote leukocyte adhesion, cell proliferation and migration, and angiogenesis [55]
Thrombospondins	Binds to fibronectin, laminin, collagen, and other ECM proteins [60] Promotes assembly of collagen fibrils [60]. Regulates angiogenesis [60]
Collagen	Promotes rigidity, tensile strength [56, 61], and structure [56, 62, 63] and links cells and ECM components [56, 63]

[a]Table 10.2 is an abbreviated list of ECM content and biological actions

While PRP is an excellent choice for the enhancement of wound healing in hair transplantation, there are several drawbacks. PRP protocols and results vary widely with methods of platelet activation [41]. Secondly, the methods used result in varying platelet numbers, platelet activation rates, and concentrations of growth factors released [47]. Martineau et al. showed that higher concentrations of calcium and thrombin trigger an immediate and significant increase in TGF-β1 and PDGF-BB which remained generally constant over a period of 6 days. This is in contrast to lower concentrations of calcium and thrombin which resulted in a reduction and delay of growth factor release [53]. Platelets have also been shown to prevent tumor hemorrhage and enhance tumor vessel stability [54]. Ho-Tin-Noé et al. showed that tumor bleeding in response to the deficiency of platelets may be independent from the tumor type as they saw similar results in subcutaneous LLC tumors, B16F10 melanoma, and in lung metastasis [54]. It is hypothesized that the proangiogenic factors contained in platelets promote the development of the tumor's blood supply, although the exact components that promote tumor stability still remain to be identified [41, 54].

10.4.2 ACell/MatriStem

The extracellular matrix (ECM) plays a significant role in the wound healing process [55, 56]. The ECM contains a multitude of components including fibronectin, proteoglycans, thrombospondins, and collagen [55, 56] (see Table 10.6). The complex fibrillar network forms a scaffold or matrix that (in combination with interstitial fluid) cannot only resist tensile and compressive stresses but mechanical changes to the ECM and surrounding cells, and results in a conversion of chemical signals that promote cell adhesion and migration during the healing process [55–57]. In addition to providing structural support, ECM constituents promote the healing process by recruiting enzymes to remove cellular debris, releasing inflammatory mediators, and binding to platelets and growth factors to stimulate angiogenesis, migration, and proliferation of fibroblasts, glycosaminoglycans, and collagen [55, 58, 59].

MatriStem (ACell, Columbia, MD, USA) is a dehydrated ECM medical device made from porcine bladders that comes sterile in either meshed sheets or in powdered form [64]. The processing of MatriStem allows for the removal of all cells leaving the collagen structure, which enables tissue remolding and eventual integration and reabsorption into the wound bed [64, 65]. The process of decellularizing the matrix also provides benefit in that it reduces the concern for an adverse immune response to the xenograft tissue [66]. The use of MatriStem in wound healing applications has been demonstrated with partial and full-thickness wounds such as burns, diabetic ulcers, pressure ulcers, and even open pilonidal wounds [65, 67]. Cooley et al. demonstrated the benefits of using MatriStem in hair transplant surgery where his cases showed a reduction in fibrotic scarring [68].

The use of MatriStem meshed sheets may cause issues if pressure to the wound area (e.g., in the case of hair transplantation, the strip closure sites) causes the sheets to be dislodged which could result in the formation of a fistula [69]. While the processing of the ECM reduces chances for allergic reactions, it does not completely remove risk. MatriStem's instructions for use state that any patients with known sensitivities or allergies should not use the product [69]. Finally, MatriStem's use may pose issues with religious, cultural, and moral objections due to its porcine origins.

10.4.3 ATP and Hair Follicle Cell Survival

It is well known that cells experiencing ischemia or hypoxia have a decreased cellular energy supply [70]. Adenosine triphosphate (ATP) is the major energy currency utilized by cells which plays a crucial role in protein and lipid synthesis, signal transduction, cell mitosis and migration, and membrane permeability [70–73]. ATP is made predominately in the presence of oxygen via the citric acid cycle (or Krebs cycle), electron transport, and oxidative phosphorylation [74] but can utilize glycolysis to generate ATP during anaerobic conditions. Unfortunately, glycolysis only yields 1/16 the ATP supply that the aerobic processes produce [70], and hair follicle cells rely predominantly on aerobic production of ATP [4]. The lack of blood flow following implantation of FU results in a dependency on glycolysis and thus an ATP deficiency, with subsequent increases in lactic acid [73, 75].

In addition to serving as an energy supply, ATP functions a signaling molecule by binding to purinergic receptors (P_2X and P_2Y) [76–79]. ATP is contained within cells at concentrations in the mmol/L (mM) range, while concentrations outside cells are on the scale of nmol/L (nM) [79]. When a hair follicle cell is damaged, it subsequently releases its internal ATP concentrations which signal a cascade of events by binding to P_2X and P_2Y receptors, which results in platelet aggregation [80], chemotaxis of inflammatory cells [78], cell proliferation [81], and angiogenesis [82]. ATP has also been shown to stimulate caspase-1 activity leading to cell apoptosis via P_2X receptors [83]. While the effects of P_2X stimulation and subsequent caspase-1 activation seem unfavorable, these actions promote the recruitment of immune cells which release inflammatory mediators, scavenge cellular debris, and release growth factors such as vascular endothelial growth factor (VEGF) to promote angiogenesis [82].

During the process of hair transplantation, isolated grafts pending transplantation are removed from their blood supply which results in decreased ATP production [8]. Once the grafts are implanted, it takes days to reestablish their own blood supply [8]. Due to the nature of cellular energy demands and the need for wound healing and tissue remodeling after surgery, there is a significant demand by the tissue for ATP. There are several solutions on the market that contain ATP or its metabolites (ADP, AMP, and adenosine) such as ATPv, HypoThermasol, and University of Wisconsin (UW) Solution. These solutions provide the benefit of providing either ATP directly (ATPv) or adenosine to create ATP (HypoThermasol, UW Solution, IGL-1 Solution). ATPv (Energy Delivery Solutions, Jeffersonville, IN USA) is a solution that encapsulates ATP within highly fusogenic liposomes that rapidly bind and fuse to cells delivering ATP to ischemic cells and tissues. This delivery of ATP is unique in that free ATP cannot pass through cell membranes in quantities to meet the demands of the cell [84]. The addition of ATP or adenosine provides benefit in that it helps prevent ischemic reperfusion injury that occurs when ATP is broken down to hypoxanthine during ischemia [73]. While the addition of adenosine greatly benefits ischemic tissues, the benefit is voided when the energy stores are drained and there is no energy left to phosphorylate adenosine to ATP.

10.5 Summary

Approximately 85–95% + of all implanted FU grafts will regrow a hair shaft within 1 year. This fact is proof of the talent of trained hair transplant surgeons and surgical team, as well as an abundant stem cell population to regenerate FUs. However, this also means that 5–15% of the transplanted follicles do not survive, and the choice of a graft holding solution can help decrease loss of viable FU; conversely the use of the wrong holding solution can decrease viable FU. A review of the most widely used graft holding solutions in HRS clearly suggests that either Plasma-Lyte A or HypoThermosol is likely to increase graft survival. The use of NS and RL can both have a negative effect on FU survival and should be avoided.

In addition to graft holding solutions, the physical parameters of temperature, pH, and osmolality can play a significant role in decreasing FU survival. Slight changes in any of these parameters will lead to graft failure. Surgeons should avoid changes in pH and osmolality of graft holding solution and rinsing/hydrating solutions. It is suggested that FU be washed to remove residual blood and that graft holding solutions be changed during the graft storage period to decrease metabolite buildup.

There are several additives and treatments that may help increase FU survival and function. Activated PRP applied topically, dermal rolled, or injected puts a high localized concentration of growth factors, cytokines, metalloproteases, hemostatic factors, and other cellular mediators in close proximity to implanted FU grafts. PRP should thus increase FU graft survival, but unfortunately, potential variations in activation of PRP can lead to increased variability in the timing and concentrations of these factors. In addition, the high localized concentrations of growth factors could increase the potential for tumor formation. Additional clinical studies are needed to further clarify the benefits and risks of PRP in HRS.

The use of MatriStem in both the donor and recipient site wounds increases the extracellular matrix scaffold allowing wound border cells to proliferate. This is clearly an advantage to newly implanted hypoxic FU grafts, as it decreases ATP consumption needed for extracellular matrix protein production. Conserving ATP, or strategies to help increase cytosolic ATP in FU during graft isolation until post-op day 2–3, is critical in preventing reperfusion injury. There are two major strategies in helping maintain ATP levels during this critical period, including use of ATP precursors or by encapsulating ATP in liposomes. Additional clinical research on both MatriStem and ATP preservation strategies will help better define how these impact FU graft survival and function.

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Part II
Instrument

Chapter 11
Dermoscopy

Chinmanat Tangjaturonrusamee

11.1 Basic Principles

There are two types of dermoscopic devices—(1) a handheld unit and (2) a digital dermoscopic system. The handheld dermoscope is more popular among physicians since it is less expensive and user-friendly when compared to the digital system. However, the handheld dermoscope is less advantageous since its maximum magnification power is limited to only 20×, even though the zoom function of the digital camera or mobile phone can be employed to enlarge the images. On the other hand, the digital dermoscopy system provides better image quality because of the higher magnification power up to 200×, and the pictures can be stored in sequential order to review and compare them with subsequent pictures obtained during follow-up visits. There are several brands of handheld dermoscopy devices available in the market today, including DermLite, Handyscope, DermScope, Dino-Lite, and Delta. Digital dermoscopic instruments include FotoFinder, Dermoscope, EasyScan, Medical-Scope, VideoCap, and Videoderm.

The magnification properties associated with dermoscopic procedures aid physicians in interpreting (1) follicular openings, (2) skin findings including vascular and pigmentary changes, and (3) hair characteristics. Evaluation of any observed abnormal findings provides information otherwise not easily and quickly obtainable and, when combined with the patient's clinical presentation, allows for more accurate diagnosis.

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11.2 Practical Use in the Medical Field

There are a number of instances in which patients experiencing hair loss request transplant surgery when in actuality they might only need pharmacological therapy. Therefore, it is important to be able to recognize important hair diseases in order to provide patients with proper clinical options. In such scenarios, dermoscopy enables physicians to establish a precise diagnosis better than with unaided visual examination alone. The dermoscopic findings in each common hair and scalp disease are as follows (Table 11.1).

11.2.1 Non-scarring Alopecia

Follicular openings (orifices) in non-scarring alopecia present differently from scarring alopecia (Fig. 11.1a, b). Various dermoscopic findings depend upon individual hair loss conditions and are shown below.

Table 11.1 Characteristics and common features in dermoscopy of common hair disorders

Disease	Characteristic features	Other common features
Alopecia areata	Exclamation mark hairs	Black dots, yellow dots
Trichotillomania	Coiled hair, flame hairs	Black dots, V-sign, tulip hairs, hair powder
Tinea capitis	Comma hairs	Black dots, Morse code-like hairs, zigzag hairs
Androgenetic alopecia	Hair diameter diversity >20%	Peripilar sign, yellow dots
Telogen effluvium	Empty hair follicles, short regrowing hairs	–
Lichen planopilaris	Peripilar casts	White patches, blue-gray dots
Frontal fibrosing alopecia	Peripilar casts	White patches, perifollicular erythema
Discoid lupus erythematosus	Follicular red dots, follicular plugs	White patches, blue-gray dots
Traction alopecia	Hair casts	White patches
Central centrifugal cicatricial alopecia	Peripilar white halo	Pinpoint white dots, asterisk-like brown patches
Folliculitis decalvans	Tufting of ≥6 hairs	White patches, pustules, perifollicular scaling, vascular abnormalities
Dissecting cellulitis	–	Broken hairs, yellow dots, white patches
Seborrheic dermatitis	Arborizing vessels, atypical red vessels	Twisted loops
Psoriasis	Red dots	Twisted red loops, red globules

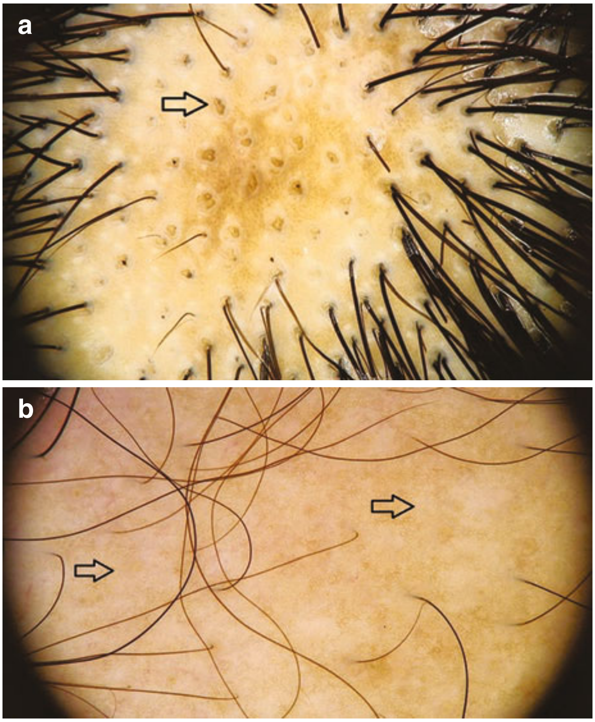


Fig. 11.1 Follicular opening. An area showing follicular opening in non-scarring alopecia (**a**) and an area of lacking follicular opening (*white patch*) in scarring (cicatricial) alopecia (**b**). (Original magnification: ×20)

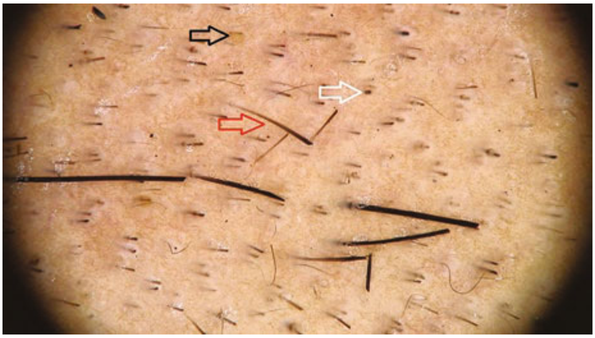


Fig. 11.2 Alopecia areata: exclamation mark hair (*red arrow*), black dots (*white arrow*), yellow dots (*black arrow*). (Original magnification: ×20)

11.2.1.1 Alopecia Areata (AA)

Common findings include exclamation mark hair, black dots, and yellow dots [1, 2] (Fig. 11.2). Exclamation mark hair is the characteristic found in this condition and cannot be seen in any other types of alopecia [3]. Black dots which are the broken or damaged hairs remaining on the scalp are not specific to AA, as they are also found in trichotillomania, tinea capitis, and early stage of dissecting cellulitis.

Yellow dots which correspond to keratin debris or sebum at the follicular opening can be seen in the advance stage of androgenetic alopecia, trichotillomania, and dissecting cellulitis [1, 4, 5].

11.2.1.2 Trichotillomania

The diagnosis of trichotillomania can be difficult due to the broken hairs and black dots it shares with common findings seen with alopecia areata. The broken hairs and black dots are the result from hair pulling, leaving broken hairs at the superficial level of the scalp. One specific finding of coiled hair results from broken hairs due to the pulling force, causing the distal end of broken hairs to curl down [1] (Fig. 11.3). Flame hair is the other specific finding, which presents as broken hairs with wavy ends due to excessive hair pulling (Fig. 11.4). Other common findings associated with hair pulling include V-sign, tulip hairs, and hair powder [6] (Fig. 11.4).

11.2.1.3 Tinea capitis

When considering this condition, tinea capitis is readily diagnosable and confirmable using potassium hydroxide (KOH) examination. Dermoscopy aids in making such diagnoses faster by characterizing hair curved and fractured, which is named

Fig. 11.3 Trichotillomania: coiled hairs. (Original magnification: ×20)

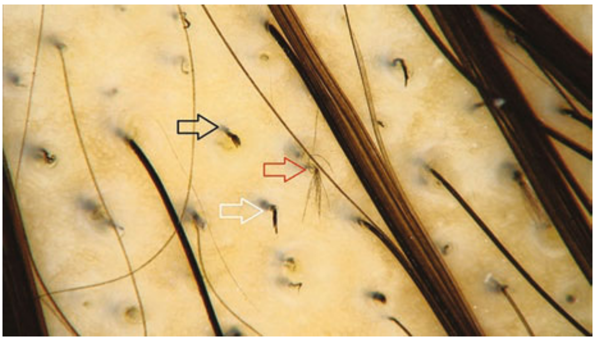


Fig. 11.4 Trichotillomania: flame hair (*red arrow*), V-sign (*white arrow*), tulip hair (*black arrow*). (Original magnification: ×30)

Fig. 11.5 Tinea capitis: comma hairs (*red arrow*). (Original magnification: ×20)

Fig. 11.6 Tinea capitis: Morse-code hairs (*red arrow*) and zigzag hairs (*white arrow*). (Original magnification: ×20)

comma hair [1] (Fig. 11.5). Corkscrew hair is typically seen in African American patients [7]. Morse code-like hair presenting with empty bands from fungal invasion on the hair shafts and zigzag hair due to hair breakage are also reported [8] (Fig. 11.6).

11.2.1.4 Androgenetic Alopecia (AGA) or Pattern Hair Loss

AGA is the most common cause of hair loss in both men and women [9]. Although dermoscopy utilization is not necessary in the majority of such cases, its application in situations where the clinical presentation is not certain is helpful in arriving at a correct diagnosis [10]. The characteristic dermoscopic finding in androgenetic alopecia is hair diameter diversity greater than 20% [11] (Fig. 11.7a). Hair diameter diversity is related to hair miniaturization, since this process affects all hair follicles individually at the same time [11]. Other usual dermoscopic findings include perifollicular hyperpigmentation (peripilar sign) and yellow dots, both of which vary according to various studies from 10 to 66% [2] (Fig. 11.7b, c). Peripilar sign is explained by perifollicular inflammation in this condition [12].

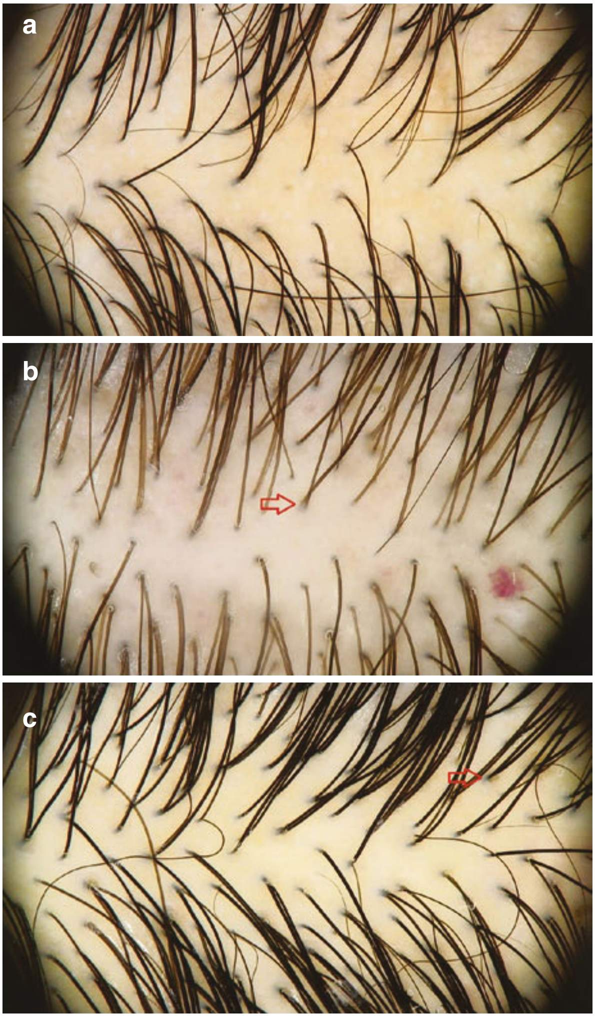
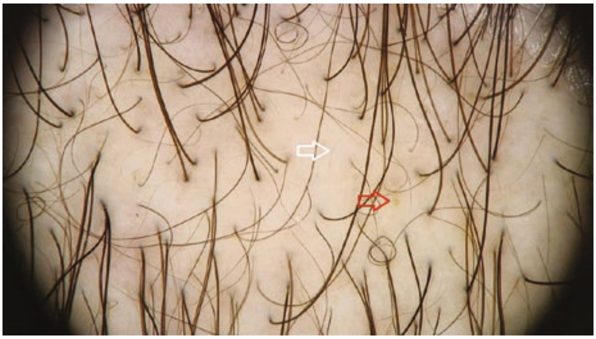


Fig. 11.7 Androgenetic alopecia: hair diameter diversity >20% (**a**), peripilar sign (**b**), and yellow dots (**c**). (Original magnification: ×20)

11.2.1.5 Telogen Effluvium (TE)

Diffuse hair loss is a challenging diagnosis, and dermoscopy can provide a rapid method to refine the differential diagnosis between telogen effluvium and AGA (diffuse unpatterned alopecia type). Telogen effluvium does not have hair diameter diversity more than 20% compared to AGA [13]. Instead, dermoscopy in conditions of both acute and chronic TE presents empty hair follicles and many regrowing hairs [13] (Fig. 11.8). It is also important to recognize that both TE and AGA can occur simultaneously. In those cases, the duration of hair shedding and the location

Fig. 11.8 Telogen effluvium: empty hair follicles (*red arrow*) with short regrowing hairs (*white arrow*). (Original magnification: ×20)



of positive pull test evaluations may prove to be beneficial in differentiating between these two conditions.

11.2.2 Scarring (Cicatricial) Alopecia

Dermoscopy increases the likelihood of early diagnosis and prompt treatment of scarring alopecia prior to the receipt of a pathology report. The dermoscopic findings of scarring (cicatricial) alopecia are white patches or white dots with the loss of follicular orifices [1, 2] (Fig. 11.1b). In cases with severe inflammation covering the fibrotic areas, whitish areas might be hard to observe. Milky-red areas are also a common finding related to inflammation surrounding scarring tissue [14]. Although each type of cicatricial alopecia shares similar dermoscopic findings, cicatricial whitish patches differ from other conditions in the following ways.

11.2.2.1 Lichen Planopilaris (LPP) and Frontal Fibrosing Alopecia (FFA)

LPP and FFA, subtypes of lichen planopilaris with predilection for scarring on the frontal hairline, show similar dermoscopic findings. The characteristic dermoscopic findings of both conditions are perifollicular scaling (peripilar cast) (Fig. 11.9a) and interfollicular or perifollicular violaceous areas around the white dots (blue-gray dots) [15] (Fig. 11.9b). Other findings similar to cicatricial alopecia include cicatricial white patches, loss of follicular orifice, and milky-red areas [1, 2, 15] (Fig. 11.9c).

11.2.2.2 Discoid Lupus Erythematosus (DLE)

Dermoscopy shows the presence of follicular keratotic plugs, follicular red dots, and blue-gray dots in DLE [15–17]. Follicular plugging is the widening of follicular ostia filled with keratin materials [16]. Similar to yellow dots, follicular plugging is a perifollicular yellowish round structure, but the latter is larger and darker [2] (Fig. 11.10).

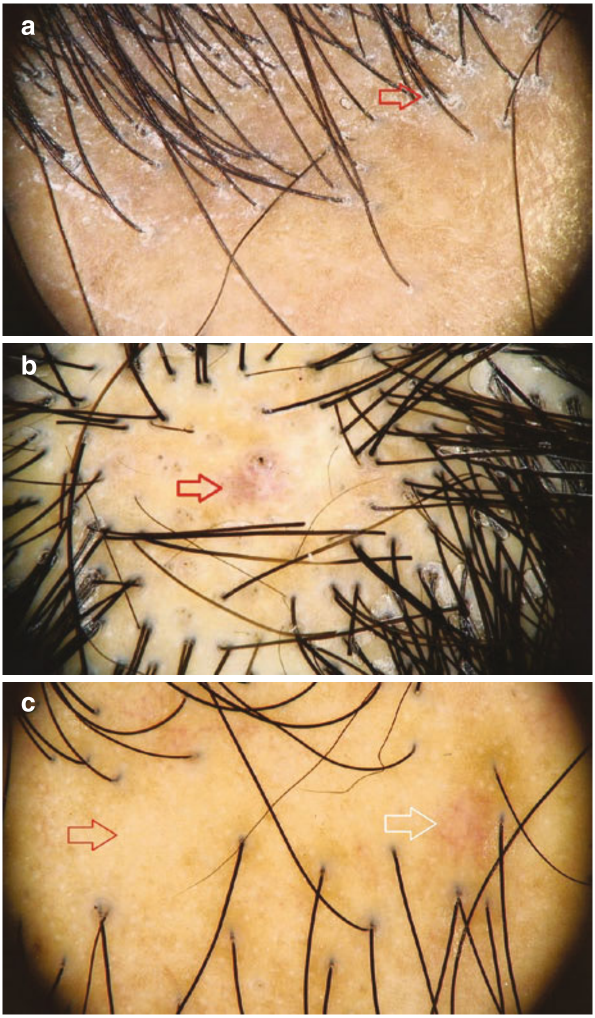


Fig. 11.9 Lichen planopilaris (LPP) and frontal fibrosing alopecia (FFA): peripilar casts (**a**), blue-gray dots (**b**), and white patches (*red arrow*) with milky-red area (*white arrow*) (**c**)

Fig. 11.10 Discoid lupus erythematosus: follicular plugging. (Original magnification: ×20)

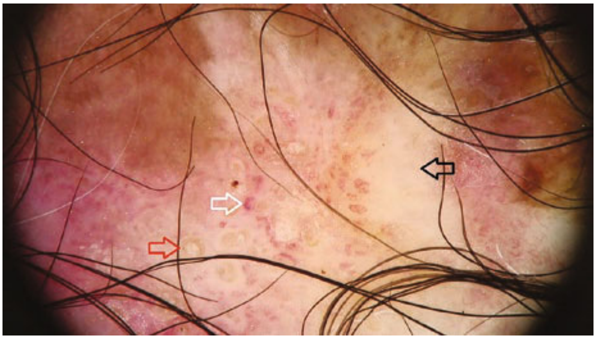


Fig. 11.11 Discoid lupus erythematosus: yellow dots (*red arrow*), red dots (*white arrow*), and white patches (*black arrow*). (Original magnification: ×20)

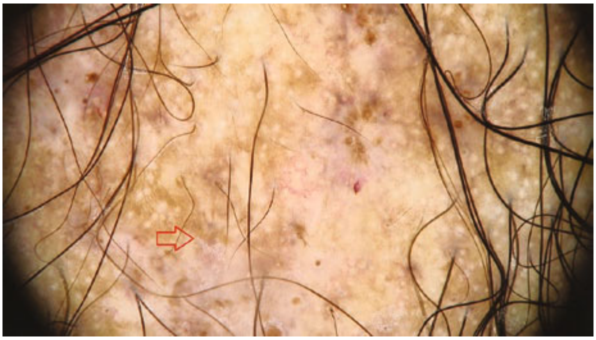


Fig. 11.12 Discoid lupus erythematosus: blue-gray dots. (Original magnification: ×20)

Follicular red dots are correlated to dilated blood vessels and extravasation of red blood cells around the follicular ostia [17] (Fig. 11.11). Blue-gray dots can be observed in both DLE and LPP resulting from melanophages responding to epidermal injury due to basal vacuolization [15] (Fig. 11.12). Other common findings include white patches and loss of follicular orifices like other cicatricial alopecias [16].

11.2.2.3 Traction Alopecia

The clinical presentation of traction (marginal) alopecia is similar to FFA, AA, and trichotillomania. The dermoscopy of this condition shows features found in other forms of scarring alopecic conditions, including white patches and loss of follicular orifices. However, hair casts which are white cylindrical materials around the proximal hair shaft are the most common dermoscopic findings in patients with traction alopecia [18]. This is different from peripilar signs associated with FFA which presents perifollicular scales, not white cylindrical structures.

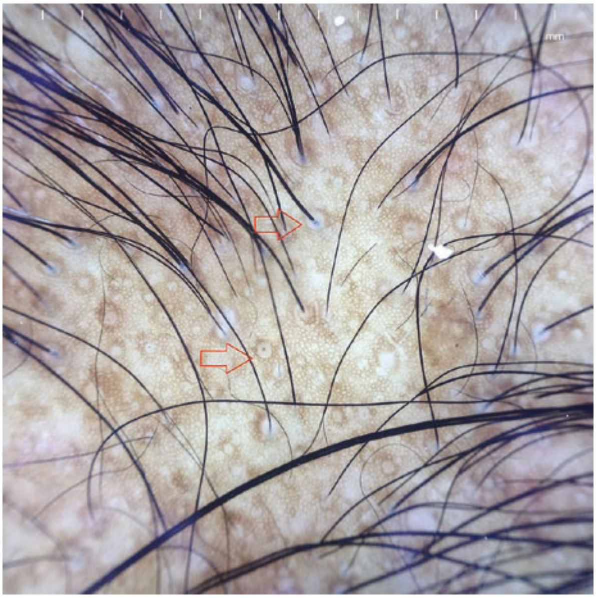


Fig. 11.13 Central centrifugal cicatricial alopecia: peripilar white halo. (Original magnification: ×10)

11.2.2.4 Central Centrifugal Cicatricial Alopecia (CCCA)

This condition presents pathognomonic dermoscopic findings differentiating it from other forms of cicatricial alopecia. Dermoscopy of CCCA is characterized by peripilar white-gray halos corresponding to lamellar fibrosis around hair follicles in histopathology (Fig. 11.13). Other dermoscopic findings include numerous pinpoint white dots on the background of honeycomb pigmented networks and asterisk-like brown blotches. White patches, erythema, and scales are also observable.

11.2.2.5 Folliculitis Decalvans

Tufted hairs containing six or more hairs are the most common dermoscopic finding in this condition (Fig. 11.14). Although tufted hairs can be seen in other forms of cicatricial alopecia such as LPP, there are less than six hairs which are characteristic with hair tufting in folliculitis decalvans [1]. Other common dermoscopic findings include pustules, perifollicular scaling, and vascular abnormalities due to neutrophilic inflammation [1, 14].

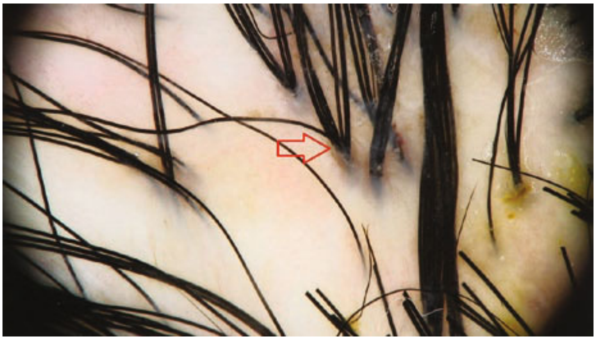


Fig. 11.14 Folliculitis decalvans: tufted hairs. (Original magnification: ×20)

11.2.2.6 Dissecting Cellulitis

Dermoscopy of dissecting cellulitis varies depending upon the stage of this condition. During the early stage, yellow dots intermingling with broken hairs are present [1, 14]. These findings are indistinguishable with AA except for exclamation mark hairs which are associated with AA [1]. Clinical presentation of boggy masses helps exclude AA from the dermoscopic findings in dissecting cellulitis. In the late stages, cicatricial white patches are observed as in other forms of cicatricial alopecia [14].

11.2.3 Inflammatory Scalp Disorders

11.2.3.1 Seborrheic Dermatitis

Dermoscopy is a useful method to differentiate seborrheic dermatitis from scalp psoriasis [19]. Dermoscopy of seborrheic dermatitis shows arborizing blood vessels and atypical red vessels correlated to dilated capillaries from inflammation in the upper dermis [19] (Fig. 11.15). Since inflammation in seborrheic dermatitis distributes on the upper dermis, but rarely involves blood vessels perpendicular to the upper dermis, seborrheic dermatitis does not show fewer red dots and globules than scalp psoriasis [19]. Under dermoscopic evaluation, when light enters through the upper dermis, it shows linear branching vessels (arborizing vessels) instead of red dots and globules.

11.2.3.2 Psoriasis

Scalp psoriasis is characterized by multiple red dots and globules corresponding to tortuous blood vessels in the dermal papillae [19]. Twisted red loops and glomerular vessels are also commonly observed in this condition [19] (Fig. 11.16). The tortuous blood vessels are seen as red dots when the light from dermoscopy perpendicularly

Fig. 11.15 Seborrheic dermatitis: arborizing vessels. (Original magnification: ×70)

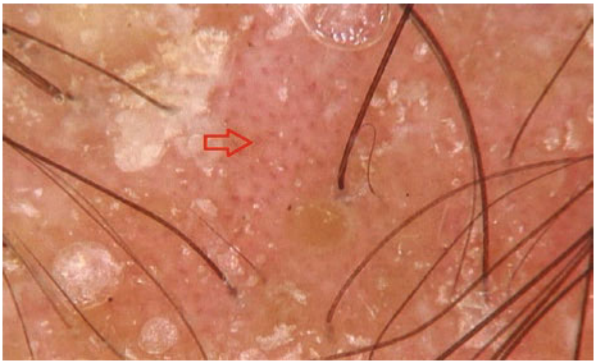


Fig. 11.16 Psoriasis: red dots. (Original magnification: ×70)

shines on the upper dermis, revealing twisted red loops and glomerular vessels pointed tangentially on the scalp.

11.3 Practical Use in the Surgical Field

Dermoscopy is extremely useful for surgeons not only for excluding alopecia that can be treated by medication but also in assessing hair density and hair quality before hair transplantation. Depending on the surgeon's choice, either the digital dermoscopy system or handheld dermoscopy allows numerous ways to attain follicular unit counts.

Digital dermoscopy encompasses more useful functions than handheld dermoscopy such as hair counting programs and phototrichogram. The function of hair counting programs provides the ability to count hair follicular units individually and in several donor areas, respectively (Fig. 11.17), thereby limiting any potentially confusing counting determinations by surgeons and their assistants when dealing with multiple donor areas.

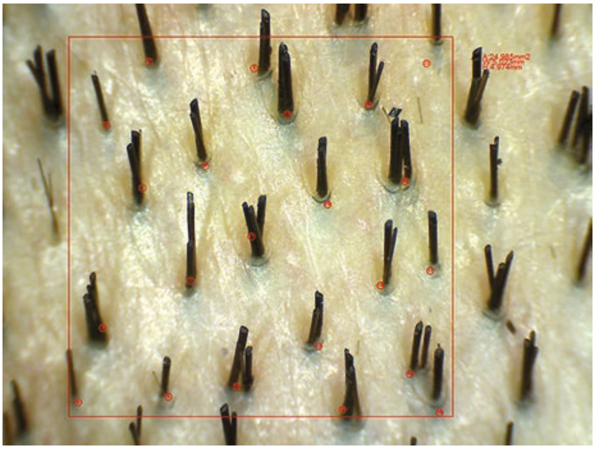


Fig. 11.17 Dermoscopic picture on the donor area with hair counts. (Original magnification: ×40)

Handheld dermoscopy is more user-friendly due to its portability, lower maintenance, and cost. Although present handheld dermoscopic instruments do not incorporate a hair counting function, surgeons can still count hair follicular units by using a precut 1 cm square block to lay on top of the donor area or a 1 cm square block pattern drawn on the donor area prior to the use handheld dermoscopy. This method simulates determinations made with the widely used densitometry method.

From dermoscopic pictures, surgeons can readily evaluate hair quality, hair grouping, large hair diameter, as well as the number of desirable two to three hair follicular units available to surgeons for transplantation. Dermoscopy helps surgeons plan ahead for cutting when they see hair miniaturization and a lot of one-hair follicular units. It also helps surgeons predict expected results in terms of hair quality.

11.4 Conclusion

Many hair transplant surgeons do not regularly use dermoscopy in their practice as they usually see more patients with AGA than other forms of alopecia. However, it is undeniable that they will still come across patients with cicatricial alopecia and non-scarring alopecia other than AGA during their patient encounters. And, in such scenarios, dermoscopy is a most useful clinical apparatus for establishing accurate diagnoses and rapid treatment regimens by providing substantial advantages over other instrumental procedures in the areas of preoperative evaluations and follicular hair counts.

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Part III
Different Hairline in Asians

Chapter 12
Hairline Design in South Asians

Sanjiv Vasa

12.1 Introduction

Hairline design consists of three elements: (1) frontal hairline, (2) temple triangles, and (3) parting line.

12.2 Philosophy of the Hairline

All over the globe in all five different continents, hairline variations are extreme. Countless variations are observed, and so it is very difficult to establish one design for every human due to variable sizes and shapes of the skull and forehead.

To make the whole process simple, the author observed the evolution process of human.

The first predecessors were monkeys, where the hairline starts from the eyelids below the eyebrows (Fig. 12.1).

In chimpanzees, the hair starts growing just above the eyebrows covering the whole forehead and scalp (Fig. 12.2).

In orangutans, the hairline appears receded further up and begins at the end of the forehead (Fig. 12.3).

The human hairline begins at the attachment of frontalis muscle for the frontline and temporalis muscle for the temple triangle.

This anatomy is very easy to understand and can be applied to any human being male or female in any part of the world. It avoids the necessity for a ruler or calculation of complicated measurements. The only tool required for hairline design is a marking pen.

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Fig. 12.1 Demonstration of different levels of the hairline of the monkey

Fig. 12.2 Demonstration of different levels of the hairline of the chimpanzee

Fig. 12.3 Demonstration of different levels of the hairline of the orangutan

12.3 Designing the Frontal Hairline

The attachment of frontalis muscle is in a zigzag fashion, and so the frontal hairline should never be drawn as straight line. It should also follow a zigzag, wavy, or step ladder pattern.

12.3.1 Step 1: Old Photo

If possible, observe an old photo of the patient showing the frontal hairline. If a photo is not available, there is no cause for concern, as anatomical landmarks of the frontalis and temporalis muscles will be visible for marking.

12.3.2 Step 2: Surprise Test

Ask the patient to give a surprise look by:

1. Rolling the eyeballs upward, keeping the head straight (Fig. 12.4a, b).

Fig. 12.4 Surprise test: front view (**a**, **b**) oblique view (**c**, **d**). (**a**) Normal, (**b**) surprise, (**c**) normal, (**d**) surprise

Fig. 12.5 Contacting forehead muscles: front view (**a**, **b**) oblique view (**c**, **d**). (**a**) Normal, (**b**) surprise, (**c**) normal, (**d**) surprise

2. Asking the patient to bend the head downward from the neck, and then while keeping the head in the same position, ask them to roll eyes upward to look straight toward you (Fig. 12.4c, d).

   These maneuvers will make the upper border of frontalis visible for marking as shown in the photograph above.
3. Contracting forehead muscles (Fig. 12.5a–d).

12.4 Designing the Temporal Triangle

12.4.1 Step 3: Clench Test

Ask the patient to clench teeth by compressing the lower jaw against the upper jaw. This movement will make the attachment of the anterior border of temporalis muscle visible. The hairline of the temple triangle should be marked where the slope of the muscle attachments ends (Fig. 12.6a, b).

Temple triangle result (Fig. 12.7a, b)

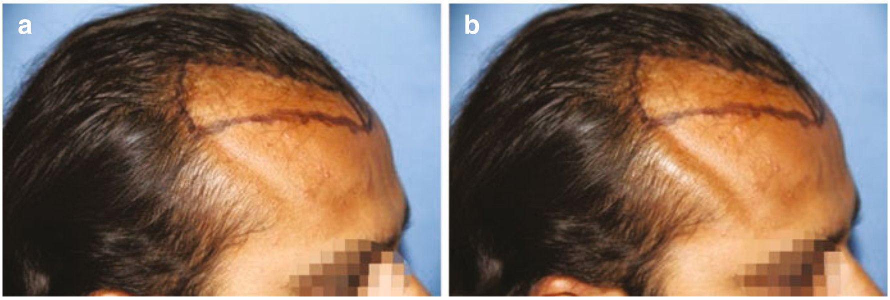

Fig. 12.6 Clinch test. (**a**) Normal. (**b**) Clinch

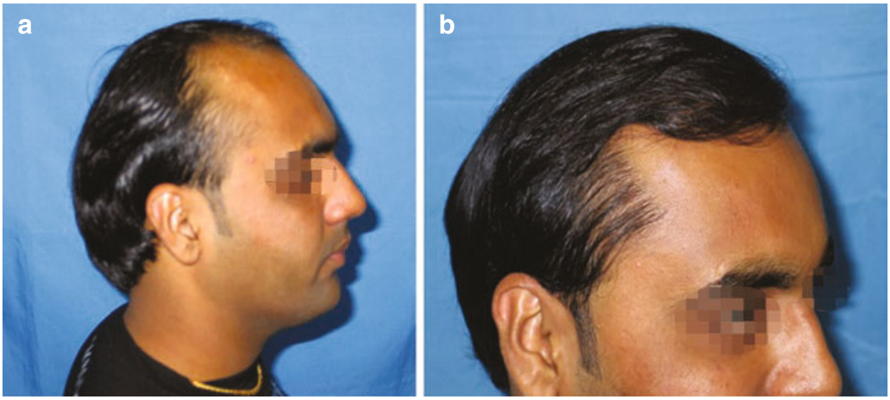

Fig. 12.7 Temple triangle result. (**a**) Before. (**b**) After

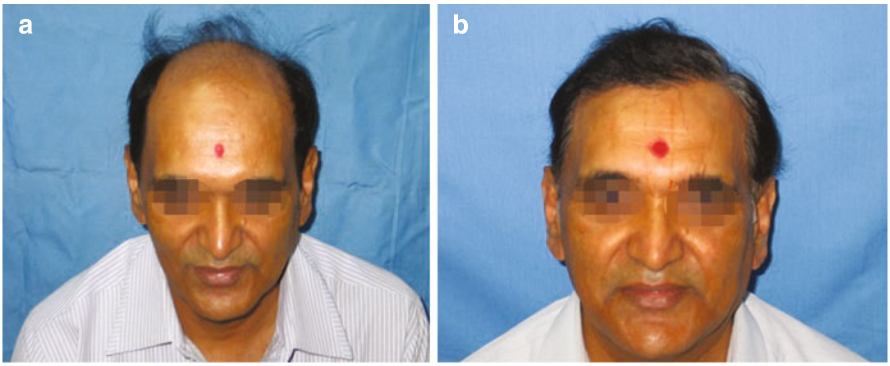

Fig. 12.8 Parting line design. (**a**) Before. (**b**) After

12.5 Designing the Parting Line

The starting point of parting line can be placed on the marked frontal hairline as per the patient's choice or by examining an old photo. Implantation can be made with slight deviation on either side of the parting line (Fig. 12.8a, b).

Chapter 13
Hairline Design in West Asians

Bessam K. Farjo

13.1 Introduction

Understanding and mastering the frontal hairline design is one of the most important aspects in hair transplant surgery determining the essence of the natural appearance of the result. It is often said that restoring one's hairline frames the face resulting in a softer and a more youthful appearance. Patients would like the result to be noticeable that way, with the hair looking like it has always been there and not have a "transplanted" look [1, 2].

13.2 Design

The hairline can be divided into two regions, anterior and temporal. The anterior hairline can be horizontal or slightly convex across the middle. It connects laterally on either side to the temporal hairline, which runs vertically down joining the sideburns. The two combine to form the "frame" around the face.

The hairline "zone" from the anterior hairline backward can be 1–3 cm deep, with the front 3–5 mm reserved for the intricate feathering zone of one-haired grafts in an irregular pattern. This feathery area is assigned after agreeing on the actual hairline with the patient and drawing it on the scalp [2–4].

There are three aspects to design when drawing the hairline on the patient: location, shape and symmetry. While we always strive for symmetry, the other two

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factors can be influenced by race, current stage of hair loss, donor availability, and the patient's age.

The first thing to do is determine the position of the trichion. This is the central point of the anterior hairline, which usually also forms the lowest point. There are different methods to determine this location, and experienced hair surgeons will usually use a combination of these [4, 5].

The classical method is the concept of the rule of thirds. Although widely accredited to classical artists like Da Vinci, it is a rule very commonly used in a variety of art forms and not just that of faces. In my experience, it is not always helpful but nevertheless a reasonable starting point in determining the central point of the anterior hairline. Basically, you measure the distance between the menton (lower end of the chin) and the base of the nose. This then should be equivalent to the distance between the base of the nose and the glabella and again between the glabella and the trichion. In Caucasian males this will normally range between 7 and 8 cm, but can be lower in Asians and Africans.

The above method should be combined with another measurement, which I find far more reliable. In this method, you determine the meeting point of the vertical plane over the forehead with the horizontal plane over the scalp. This can be viewed most clearly from the side profile of the patient, but can also be felt by sliding your thumb upward along the forehead until it suddenly slips and gives way as described by Sandoval calling it the shingling point (Fig. 13.1). A final check is to notice the position of the trichion you settled on in relation to the front end of the temporal point. They should closely match or the trichion be ever so slightly forward of that [2–5].

If the patient favors a lower position against your better judgment, one useful maneuver is to draw in a central widow's peak slightly lowering the central point but

Fig. 13.1 The meeting point of the vertical plane over the forehead with the horizontal plane over the scalp

not the remainder of the hairline. This is more suited to a narrow-shaped head and higher hairline than a rounded head.

Once this central point is settled on, you need to determine two more points on each side of it. The first is the lateral anterior point in line with the mid-pupillary point and represents the point at which the horizontal anterior line begins to curve upward. Beyond this the line takes a steeper upward curve and ends at the higher placed frontotemporal point which meets the vertical temporal hairline in line with the outer canthus of the eye. To determine the height of the frontotemporal point, I recommend the following. Draw a vertical line through the trichion and the midline high up into the upper scalp. Follow this by drawing vertical lines from the lateral canthus of each eye parallel to the midline and again into the upper scalp. This technique helps draw parallel lines more accurately and avoid skewing. From the lateral anterior point, you should curve the hairline upward so that it gradually meets and blends into the outer vertical line rather than go across it. It is important to perform these measurements and drawings while you are facing the patient rather than standing behind or above them [4].

Next thing to look at after the hairline position is shape. Generally speaking you can have a classic bell-shaped hairline commonly seen in long or narrow-shaped heads or the more rounded hairline more commonly seen in rounded heads. The bell shape allows for a higher positioned hairline and requires fewer grafts, while a rounded hairline is more common in smaller foreheads and generally needs more grafts. The rounded hairline maintains relative convexity throughout the length of the line. The classical bell-shaped hairline is convex at the front until the lateral anterior point where it begins to curve the other way into a concave shape. Variations of these themes will need to be customized depending on the particular individual circumstance (Figs. 13.2 and 13.3).

Fig. 13.2 Frontal view of Middle Eastern patient hairline restoration result

Fig. 13.3 Frontal view of Middle Eastern patient hairline and temporal point restoration

The point at which the anterior hairline meets the temporal hairline can either be conservatively angled as described above, or the anterior line can have a downward curving flare producing a softer and more forward transition into the temporal hairline. As a general rule, a downward flare should not be drawn if the surgeon anticipates significant potential future hair loss at the temporal hairline. Imagine planting hairs in front of this temporal line only for it to recede posteriorly giving the patient a bald column behind his side hairline. While the patient is young or vulnerable to look like this, he should be advised that covering this area with hair should be achieved with styling rather than a transplant until a later point in the future. For the reason of the above complication and the experience required to make these judgments, transplanting in the frontotemporal angle should not be attempted by the novice surgeon.

The final element in designing the hairline is symmetry. It is important to view the patient with your hairline design from a variety of different angles to ensure realistic proportions. When it comes to symmetry, you need to check on this in the frontal three-dimensional view while you are drawing in the lines, but also importantly in the mirror of the two-dimensional view which is what the patient actually sees. You do this sitting the patient in front of a large mirror while you stand behind them looking at them through the mirror. The first is what other people see while the second is what the patient sees in the mirror. Both views are important of course, and often the two views can show different degrees of symmetry due to the common unevenness of the scalp curvature. A compromise between the symmetries in the two views will give the best solution. Other than the surgeon's own skill and experience, there are a couple of design aids previously described that can help in achieving symmetry. Pathomvanich and Ng helped design a red laser pointing device for the purpose, while Cole designed a plastic template to be used as a measuring tool to aid design and symmetry [6, 7].

Once the whole hairline is drawn, the surgeon then demarcates the remaining circumference of the area to be treated behind the hairline and clearly demonstrates the extent of this to the patient. This is done by holding a mirror above the patient's head, while they look into another mirror in front of them.

In cases of advanced baldness, or in patients who show the potential for it, it may be wise to place the hairline at a higher point than described here. This will minimize the total area of baldness to cover with hair, and they can always grow their hair and let it fall forward to simulate a lower hairline. This strategy may appeal to the older patient, but younger men may think it looks unrealistic or unfashionable and elect to shave their head instead with or without the help of scalp micropigmentation.

In Middle Eastern men, the variations in head and hairline shapes can be similar to Caucasians. Some will have narrow heads and bell-shaped hairlines especially in countries like Iraq, Syria, and Egypt. In the more southern-placed countries in the region, you may find that a more rounded head and rounded hairline is more common. Similar design rules will apply to what has been described here already (Fig. 13.4). Afro-Caribbean men exhibit a lower and more straight anterior line that meets the temporal hairline in a rectangular-shaped frame. Women generally exhibit a convexly curved hairline that is rounded laterally with no frontotemporal angles. They also can have a small widow's peak with a small lateral mound on each side of it. Some women also have a hairline whorl or cow's lick near the center of the anterior hairline. The final thing to note is that the hair caliber in this ethnicity can be larger. Therefore, more care needs to be undertaken in keeping the frontal hairline natural and feathery, perhaps with a deeper zone of single hair grafts than otherwise (Fig. 13.5).

Fig. 13.4 Profile view of Middle Eastern patient hairline and temporal point restoration

Fig. 13.5 Immediate post-op view

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Chapter 14
Naturally Occurring Hairlines in Non-balding Oriental Men of East and Southeast Asian Origin

Damkerng Pathomvanich and Tyng Yuan Tan

14.1 Introduction

The commonest cause of male pattern baldness (MPB) is androgenetic alopecia (AGA) [1]. The clinical onset of baldness in both men and women generally occurs at around the age of 30–40 years [2]. Norwood (1975) reported a prevalence of 45.6% in Caucasians [3]. Hamilton found that approximately 30% of Caucasians have hair loss by the age of 30, while 50% of white men have hair loss by 50 [4].

In East Asia, the incidence of male pattern baldness varies depending on region and is generally lower compared to their Caucasian counterparts, but is also increasing with age. In the early 1980s, Takashima et al. studied MPB in Japanese and found that the incidence was about one-fourth that in whites, increasing to one-third in later years [5].

However, by 2002 in Thailand, Pathomvanich et al, found the prevalence to be 38.52%, approaching that of Europeans [6]. In Korean men, the prevalence of MPB is 14.1% [7]. The prevalence of AGA in Taiwanese men was compatible to the Korean men [8]. In Shanghai, China, the prevalence is 19.9% [9]. In cosmopolitan Singapore, the prevalence was much higher at 63% due to the diversity of ethnic groups (Malays, Indians, and others) [10].

Not surprisingly, more Asians are seeking a permanent solution to their hair loss by means of hair transplantation. The creation of a natural hairline is possibly one

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of the most important steps of a successful hair transplant and reflects on the surgeon's aesthetic and artistic flare. Knowing the trend of hairlines as they change with age helps the surgeon to plan ahead of time and design a hairline that is most natural for the patient.

14.2 Hairline in East and Southeast Asian Men

To create a good hairline, understanding the anatomical differences between Caucasian and Asian hairline is essential. East Asian men tend to have brachycephalic or round skulls, while Caucasians tend to have dolichocephalic or ovoid skulls (Fig. 14.1). East Asian scalps tend to be wider and flatter, with rounded frontotemporal angles, and most patients of East Asian origin seek a flatter hairline that mimics this nature [11]. This also means that a larger number of grafts are needed to restore the East Asian hairline.

There is limited literature on the characteristics of the naturally occurring hairline in Orientals. We studied the changes to the hairline with age in Chinese males and its common characteristics for better application to Asian patients seeking hair restoration surgery.

Fig. 14.1 Comparative anatomy of typical Asian and Caucasian skulls (*top view*). The typical East Asian male has a round skull (*left*), while the average Caucasian male have an ovoid skull shape (*right*). (Photos courtesy of DHT Clinic, Thailand)

14.3 Methods

A total of 209 Oriental men from East and Southeast Asia origin (Singapore, Malaysia, Indonesia, China, and Brunei) without AGA (Norwood Type I–II) were included in this study. Subjects between 18 and 85 years old were recruited from outside major shopping malls and train stations, bus stations and interchanges, community centers, and Chinatown in Singapore. We looked at the impact of age on the hairline, as well as other potential risk factors (smoking, family history, diet).

Patients age 18 years and above were recruited in the study as androgenetic alopecia becomes clinically apparent after the onset of puberty [10]. The hairline in the absence of AGA in the majority of the population in the specific age group is the desired hairline that we would want to recreate in hair transplant patients.

Hairline characteristics were examined, including the direction of the hairline, the density, and the hair count at the first 1 cm of the frontal hairline and peaks. The mid-frontal point (distance between the interception of a horizontal line between the eyebrows and a vertical line drawn from the glabella to the most anterior part of the hairline) and frontotemporal point (distance between the lateral canthus and the most anterior point of the temporal hairline) were also calculated.

The presence of a widow's peak or cowlick was noted, as well as the natural direction of the hairs at the hairline, the frontotemporal angle (round/straight), the hair direction at the temples, and the width and relationship between the sideburns to the tragus were investigated.

14.4 Results

14.4.1 Risk Factors and Hair Loss

85.7% of the 209 subjects had no family history of hair loss, emphasizing the significance of genetics in androgenetic alopecia (AGA). 49.75% were of Norwood I classification and 50.25% of Norwood II. 46.9% of the participants were smokers, and majority (84.7%) of them were on a mixture of eastern and western diets.

14.4.2 Density

Hair density decreases as men ages (Table 14.1). The average frontal hairline density in men is 77.8 FU/cm^2 and 110 hairs/cm^2. This translates to 1.4 hair/FU in the first 2 cm of the hairline. At the temporal region, the average density is 69.6 FU/cm^2 and 97.6 hairs/cm^2. This also translates to 1.4 hairs/FU.

Table 14.1 Hairline density of non-androgenetic alopecia men between the ages of 18–85

Age	Density frontal hairline (FU/cm^2)	Hairs/cm^2	Density temporal hairline	Hairs/Cm^2
18–29 (n = 41)	85.2	120.0	77.1	110.9
30–39 (n = 35)	83.2	127.3	76.4	114.2
40–49 (n = 29)	79.3	118.2	72.3	100.5
50–59 (n = 33)	74.7	105.8	71.1	96.6
60–69 (n = 36)	76.8	103.0	65.8	86.7
>70 (n = 35)	66.3	84.7	57.3	75.3
Average (n = 209)	77.8	110.0	69.6	97.6

n, number of subjects

Table 14.2 Height of hairlines in Chinese men age 18–85

Age	Frontal hairline to glabella height (cm)	Rt Frontotemporal hairline height	Lt Frontotemporal hairline
18–29 (n = 41)	6.7	8.8	8.8
30–39 (n = 35)	6.7	8.9	8.8
40–49 (n = 29)	7.2	9.2	9.2
50–59 (n = 33)	6.6	8.9	8.8
60–69 (n = 36)	6.7	8.9	8.8
>70 (n = 35)	7.0	9.0	8.9
Average (n = 209)	6.8	8.9	8.8

Fig. 14.2 An upsloping hairline

14.4.3 Height of Hairline

The height of the hairline in non-AGA men does not change or recede significantly with age (Table 14.2).

14.4.4 Shape of Hairline

55.5% of the hairlines were upsloping (Fig. 14.2), 35.4% were straight (Fig. 14.3), and only 9.1% were downsloping (Fig. 14.4).

Fig. 14.3 Straight hairline

Fig. 14.4 Downsloping (juvenile) hairline

14.4.5 Hair Direction/Widow's Peak/Lateral Mounds

The hair direction flows from the left to right in 59.8% of the cases, right to left in 15.8%, was radial in 10.5% and anterior flowing in 13.9%. The presence of a widow's peak was found in only 47.4% of men, and most Asian men did not have any lateral mounds (66%). A cowlick was present in only 1% of the participants.

Due to the fact that all the patients in the study had non-shaved hair, the patterns that we found may have varied from the literature, and we were unfortunately unable to assess the exit angle of the hair from the scalp due to the weight of the hair, which is misleading.

14.4.6 Frontotemporal Angle and Hair Direction of the Temples

The average frontotemporal angle is round in 62.2% and straight in 37.8% (Table 14.3).

The temples recede gradually with age but maintain a convex shape.

Table 14.3 Temple hair directions

Temple direction	Inferiorly	Posteriorly	Anteriorly
Right (%)	22.0	**71.3**	6.7
Left (%)	**38.8**	**38.8**	22.4

14.4.7 Sideburns

The average sideburn width is 1.43 cm and is at the level of the tragus in 45.5% on the left and 46.4% on the right. Knowledge of the norm is important in the recreation of sideburns in hair transplant patients.

14.5 Discussion

As the patient ages, lesser hairline density if required for patient satisfaction as density declines progressively with age even in non-AGA men. The average height of the MFP remains low at 6.8 cm. It may be prudent to create a hairline higher than this so that the hairline continues to look natural as the patient ages.

Common shapes of the hairline seen in Orientals include slight upsloping of the hairline or straight.

AGA can be inherited from both maternal and paternal sides of the family. From the study, more and more patients are exposed to risk factors such as smoking and a westernized diet [6, 12]. Patients with AGA are also more informed of their surgical options, and patients are also presenting for surgery at a younger age [6], and knowledge of the naturally occurring hairline will help both the surgeon and the patient to decide and design a suitable hairline during hair restoration surgery. The anticipated future hair loss and limitations of the donor reserves have to be factored into the planning of a surgical hairline.

Conflict of Interest We have no conflict of interest to declare.

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Chapter 15
Hairline Design in East and Southeast Asians (ESEA)

Damkerng Pathomvanich

15.1 Introduction

One of the challenging areas in hair restoration surgery is hairline placement [1–3]. The majority of patients already have their preferred design in their minds ranging from very low to very high, from flat hairline to U-shaped, with or without flare or temple restoration.

The skull and facial bones differ between ESEA and Caucasians. ESEA have short and round skulls (brachiocephalic) and therefore shorter faces compared to Caucasians, who have long skulls (dolichocephalic) and thus long faces. In other words, ESEA have broad and wide faces with less frontal projection and sometimes an almost flat shape, making the hairline design more challenging [4]. In addition, uneven skulls pose more difficulty in achieving symmetrical hairline design.

15.2 Material

I believe majority of surgeons use only a mirror attached to the wall or a handheld mirror to show the hairline to the patient after it is drawn [5]. The room should have good lighting, and it's preferable to use a large mirror with side panel mirrors that can be folded 180° so the patient can see both front and side views after the hairline is completely drawn (Fig. 15.1). It's also good to have a back mirror placed about 2 m away so the patient can have a posterior view of the hairline as well.

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Fig. 15.1 Large three-sided mirror

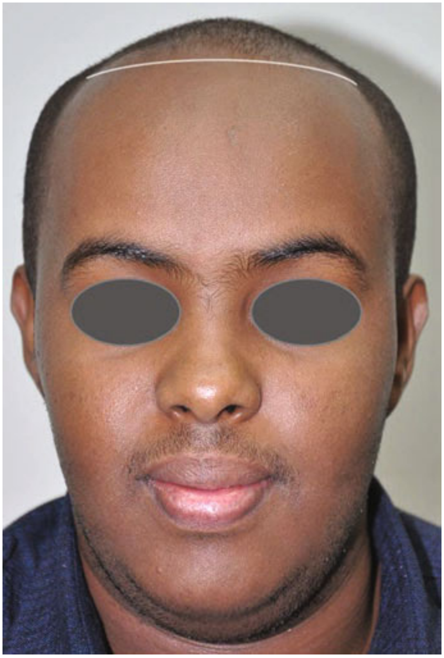

Fig. 15.2 White pencil to draw the hairline on patient who has dark skin

15.3 Method

The tools to draw the hairline are of utmost importance. An eyeliner pencil for drawing should clearly mark on the skin with the lines not being too wide. Since the forehead is oily, it is helpful to clean and degrease the skin so the drawing pencil will easily mark. I prefer black color for the majority of my patients since the color stands out well except in very dark skin. For dark skin I use a white-colored pencil which shows good contrast (Fig. 15.2). Prepare to have cotton pads and cotton buds soaked with alcohol or water to wipe off unwanted lines.

I start by having the patient sit on an adjustable comfortable chair, positioned at a height on par with the surgeon. I think it is very important that the patient's head be at the same level as the surgeon. If the patient's head is too low or too high, it is more difficult to achieve a symmetrical hairline. I have seen many surgeons draw the hairline while standing higher than the patient's head and observed difficulty in assessing if the hairline is symmetrical. I always ask the patient about his idea for his new hairline and ask him to draw the line first so I will understand what he needs. I then discuss with the patient if his initial design is unrealistic and looks unnatural, be it either too high or too low.

15.4 Steps in Drawing the Hairline

First, the mid-frontal point (MFP) is marked along the mid-frontal line (MFL). There is no magic number for the hairline position as some would like to believe. A distance between 6 and 9 cm from the mid-glabellar line, with an average of 7 cm, seems to frame the ESEA face well. This hairline height is much lower than that of Caucasians [6]. Placing the hairline at the single point as described by Arturo Sandoval might be considered if the frontal projection is not too flat [7].

Next, a point along the lateral canthal line is marked at a position above the brow line determined by the shape that I want to design (V, U, or straight hairline). The opposite lateral canthus is also marked in the same plane to try to achieve symmetry. The three points are joined to complete the arc and is extended laterally to end at the temporal fringe on both sides. However, if the temporal fringe is very low, the line needs to curve down to reach the temple fringe. In ESEA the majority desire a flat hairline.

Rapid laser hair line design device that I invented with Dr.Bertram Ng (Fig. 15.3). First, the mid-frontal point is marked, and the lateral canthal line point is marked on

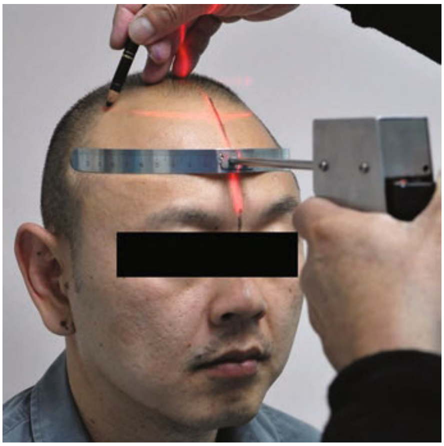

Fig. 15.3 Rapid hairline placement with laser device

Fig. 15.4 Laser placed upside down to achieve symmetry for frontotemporal angle

one side. Then, the laser is turned on, and the marking pencil follows the laser beam to achieve a symmetrical hairline in less than a minute. Most of the time, I use only the MFP and move the laser beam up and down to change the shape till I think it frames the patient's face very well.

The frontotemporal angle can be either drawn with a flare or without a flare. To achieve symmetry, I turn the laser device upside down to rapidly outline both frontotemporal angles as well as achieve a symmetrical flare (Fig. 15.4).

15.5 Hairline Tips for Different Face Shapes (Table 15.1)

For patients with a *round* or short face, I like to place the hairline higher so the face will have more exposure and better proportion, minimizing the shorted appearance (Fig. 15.5).

For *square faces*, a flat hairline will make it more square; hence, I modify a U or V shape to better frame the face (Fig. 15.6).

Table 15.1 Hairline tips for different face shapes

Round face	• Place the hairline higher to expose more facial skin, making it longer
Square face	• Create a modified U or V shape to soften the sharp angles of a square face • A flat hairline will accentuate the "squareness" of the face
Long (oblong) face	• Create a low hairline • Note donor hair availability and degree of baldness
Triangle face	• Inverted U-shaped hairline fits well • A widow's peak (V-shaped hairline) will make the patient look like a vampire • Flat hairline will accentuate the triangle face shape

Fig. 15.5 Short face with high hairline

For patients with a *long face*, a high hairline will make the face look even longer. The surgeons should therefore lower the hairline according to donor hair availability and extent of baldness (Fig. 15.7).

For *triangular faces*, if the surgeon creates a V-shaped hairline, the patient will look like a vampire. A flat hairline will accentuate the triangle shape of the face; thus, an inverted U might look better (Fig. 15.8).

To check the symmetry of the frontotemporal angle, have the patient bend his head down, giving the surgeon a clear view of both sides (Fig. 15.9).

Fig. 15.6 Square face

Fig. 15.7 Long face

Fig. 15.8 Triangular face

Fig. 15.9 His head bend down so surgeon can see the clear view of both sides

15.6 When Should We Restore the Temple in ESEA and at What Age?

I decide this on a case-by-case basis. In the young age group with extensive hair loss, it is advisable to use grafts for the front and top only, and not restore the temples. One can then reassess his hair loss a year later and determine if his face is properly framed without temple restoration. If his face is not properly framed and the forehead appears large, then it might be reasonable to partially restore his temples based on his donor availability. In the older age group with enough donor hair, it would be safe to restore the temples since the graft number is small compared to the grafts being used for the front and top. Patients must be informed that temple hair may recede further posteriorly as hair loss progresses, and thus implanted temple hair grafts might become an island of hair in the future (see Chap. 37).

Once the hairline is completely drawn, I stand behind the patient in front of the mirror and check for myself, and then I ask the patient to look at the finished hairline to see if it is appropriate, symmetric, and to his satisfaction. Any corrections are made until both of us agree, then I let him sign the consent.

15.7 Summary

Hairline design in ESEA is different from that of Caucasians due to ethnic characteristics (see other chapters), different facial features, and contour of the skull. ESEA have less frontal projections than Caucasians, and the hairline appears more flat. Creating a hairline too high in ESEA will not frame the face properly, unlike in Caucasians.

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Part IV
Pre- and Post-operative Care

Chapter 16
Peri- and Intraoperative Care

Kuniyoshi Yagyu

16.1 Introduction

Safety of a patient is of upmost importance in hair transplantation surgery. Unexpected complications may occur in every surgery. Among many complications, cardiovascular complications and cerebrovascular events are serious and sometimes become fatal. Even though we try to avoid patients with past history of cardiovascular diseases, some patients may have latent stenosis in the coronary artery and cerebral artery. The author summarizes the clues to prevent cardiovascular events during hair restoration (Table 16.1). The author also addresses the possible cardiovascular complications and how to avoid unexpected cardiovascular events during surgery. Several guidelines are referenced in this article.

16.1.1 Past History

Interview of patients' precise past history is the first step to achieve safe surgery. Past history of heart attack, stroke, and valvular heart disease should be checked.

Patients with systemic arteriosclerosis may have latent stenosis in the coronary artery and cerebral artery [1]. Risk factors of systemic atherosclerosis include diabetes mellitus, hypertension, obesity, smoking habit, hypercholesterolemia, hypertriglyceridemia, and hyperuricemia. Among them, combination of diabetes, hypertension, hyperlipidemia, and obesity is called deadly quartet, and the addition of smoking to these risk factors is called deadly quintet. These words suggest high risk of ischemic heart disease even in a young patient [2].

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Table 16.1 Contraindication of operation

1. Heart rate <40 beat/min or >140 beat/min
2. Systolic blood pressure <90 mmHg or >180 mmHg
3. Anginal pain
4. Atrial fibrillation with extreme bradycardia or tachycardia
5. Acute myocardial infarction
6. Tachyarrhythmia, frequent ventricular arrhythmia
7. Chest pain at rest
8. Dizziness, syncope, nausea
9. Palpitation, shortness of breath, cold sweat
10. Fever >38 °C (100 F)
11. SpO_2 <90%

Disorders indicating systemic arteriosclerosis include obliterative arteriosclerosis, calcification in the coronary artery, and stenosis of the carotid artery. Patients over 60 years of age have possibility of latent coronary artery stenosis. Elderly patients with diabetes and hypertension should be considered as high-risk candidates for a heart attack.

Judging from the past history of the patients, we will be able to anticipate possible risk of cardiovascular and cerebrovascular events during surgery [3]. Then we will be able to prepare monitors, medicines, and equipment which are necessary for the treatment of cardiovascular events.

16.1.2 Monitor

Monitoring of electrocardiogram (ECG), blood pressure, heart rate, and pulse oximeter (SpO_2) is necessary during surgery. We should always check arrhythmia, hypotension, hypoxemia, and cardiac ischemia during surgery [4]. As for ECG monitor, the author prefers precordial ECG in lead II rather than lead I, because lead II provides us more information about myocardial ischemia than lead I. Blood pressure should be measured as often as possible. The author measures arterial pressure every 2–2.5 min.

16.2 Blood Pressure

16.2.1 High Blood Pressure

Antihypertensive drugs should be continued before surgery. They include calcium channel blocker, angiotensin II receptor blocker, angiotensin-converting enzyme inhibitor, beta-blocker, and diuretics. Beta-blockers are strong antihypertensive drugs and should not be stopped before surgery [5]. Guidelines recommend that we continue beta-blockers before surgery.

Systolic arterial pressure should always be checked. Diastolic pressure is not important during surgery. If the systolic arterial pressure is greater than 200 mmHg, we should postpone the operation. If the systolic arterial pressure is greater than 180 mmHg before surgery, we should give sedative drugs and a painkiller to the patient, and we should wait for several minutes. If the systolic arterial pressure becomes less than 170 mmHg, we can start the operation. If the systolic arterial pressure is still greater than 180 mmHg under sedation, we should postpone the operation. We should send the patient to a cardiologist and wait for several months until the blood pressure is controlled within normal range. Then we can perform safe surgery with continuation of antihypertensive medications.

In patients with well-controlled hypertension, it is not often that the patient has persistent high blood pressure during the surgery if you continue maintenance antihypertensive drugs before surgery.

In a patient without medical treatment for the hypertension, the patient may have high arterial pressure before and during surgery. The author usually uses 2 mg midazolam intravenously as sedative to reduce high arterial pressure. If you want to use calcium channel blocker, you can use per oral 2.5 mg amlodipine or 10 mg nifedipine before surgery. After 60–90 min, the drug will become effective.

Patients with chronic renal failure who are maintained on regular hemodialysis may have hypertensive emergencies with high arterial pressure of >180–220 mmHg (systolic) and >120–125 mmHg (diastolic), respectively. A single dose of 5 mg sublingual nifedipine may be used on the physician's own responsibility with careful monitoring of the side effects to treat the hypertensive crisis.

In most patients, the hypotensive effect of nifedipine is modest and well tolerated, but occasional patients may have excessive and poorly tolerated hypotension. On rare occasions, 10 mg sublingual nifedipine causes rapid and excessive fall in the arterial pressure in patients with severe hypertension, which can cause an uncontrollable decrease in the arterial pressure, reflex tachycardia, and a steal phenomenon in certain vascular areas. There have been many reports of serious adverse effects with sublingual nifedipine, which include cerebral ischemia, neurologic dysfunction, myocardial ischemia, complete heart block, and an increase in mortality. The FDA reviewed data regarding the safety and efficacy of sublingual nifedipine for hypertensive emergencies in 1995 and concluded that it should be abandoned. The FDA gives warnings on the website that sublingual nifedipine should not be used for the acute reduction of blood pressure.

Intravenous injection of nicardipine can be used carefully by a cardiologist or an anesthesiologist to control high arterial pressure.

It will be better for you to postpone surgery in patients with severe hypertension. You should send the patient to a cardiologist for treatment of the hypertension. After a few months, you will be able to perform safe surgery with well-controlled arterial pressure.

16.2.2 Low Blood Pressure

If the systolic arterial pressure is less than 100 mmHg, we should be careful. The systolic arterial pressure usually becomes lower after sedation. We should ask the patient if his daily blood pressure is low. In patients with low arterial pressure in daily life, we can begin the operation carefully. If the patient's ordinary systolic arterial pressure is within normal range, we should check the causes of low blood pressure. Volume replacement by transfusion of saline or lactated Ringer's solution is effective to treat hypovolemia. It might be better to postpone the operation for some days if hypotension persists. We can start the operation if the arterial pressure becomes normal and the circulatory status becomes stable again.

If the systolic arterial pressure becomes less than 90 mmHg during surgery, we should stop the operation and raise the lower legs of the patients. Sometimes we should put the patient in Trendelenburg position. Transfusion of lactated Ringer's solution and intravenous injection of ephedrine are effective to treat low arterial pressure during surgery. We can repeat intravenous injection of 4 mg ephedrine hydrochloride every several minutes up to two to three times. After injection of a total of 8–12 mg ephedrine, the systolic arterial pressure will become greater than 90–100 mmHg again. Then we can restart the operation. Ephedrine hydrochloride is a safe and effective vasopressor to treat low systolic arterial pressure during surgery. In order to achieve safe surgery, intravenous cannula should be inserted before surgery in high-risk patients and patients older than 60 years old. Prophylactic transfusion of lactated Ringer's solution is useful as volume replacement in patients over 60 years old. Oral intake of hypotonic drinks and sports drinks before surgery is recommended as volume replacement for a patient with possible hypovolemia.

16.3 Heart Rate

If the heart rate is faster than 140 beats per minute or slower than 50 beats per minute at rest, it is a warning sign of tachycardia or bradycardia. In patients with tachycardia or bradycardia, we should check the systolic arterial pressure [4]. If the systolic arterial pressure is in the normal range, systemic circulation is maintained, and we can begin operation carefully.

When the heart beats fast, cardiac diastolic time becomes shorter, and it causes insufficient diastolic filling in the cardiac chamber, which results in decrease in stroke volume and cardiac output. The heart pumps blood around the body less effectively, and the heart provides less blood flow to the heart itself, whereas tachycardia increases oxygen consumption in the myocardium. Tachycardia can disrupt cardiac function, and it may increase the risk of low arterial pressure, stroke, and myocardial ischemia.

If the systolic arterial pressure is less than 100 mmHg in patients with heart rate faster than 140 beats per minute at rest, we should stop the operation. Volume replacement by transfusion of saline solution or lactated Ringer's solution is usually effective to treat hypovolemia. We can restart the operation if the heart rate becomes

Table 16.2 Tachycardia, bradycardia, and operability

1. 50 < HR < 130, & normal sBP	Operable
2. HR < 50 or HR > 140, & normal sBP	Carefully operable
3. HR > 140, & sBP < 100 mmHg	Stop operation, volume replacement
4. HR > 140 after sedation and transfusion	Postpone operation
5. HR < 130, & sBP > 100 mmHg	Start operation
6. HR < 40	Postpone operation

HR heart rate (beat per minute at rest), *sBP* systolic blood pressure (mmHg)

slower than 120 beats per minute and the systolic arterial pressure becomes greater than 100 mmHg.

If the tachycardia prolongs and if the heart rate is faster than 140 beats per minute at rest after sedation and transfusion, we should postpone the operation for several weeks, and we should send the patient to a cardiologist. After the treatment by a cardiologist, the heart rate of the patient will become normal again, and we will be able to perform safe surgery.

If the heart rate becomes slower than 130 beats per minute and if the systolic blood pressure is kept greater than 100 mmHg, we can begin the operation. Heart rate around 120 beats per minute is normal, and safe operation is possible. Heart rate ranging from 50 to 130 beats per minute is normal in the usual daily life (Table 16.2).

If the heart rate is less than 50 beats per minute, the slow heart rate may be caused by overactivity of vagus nerve. Bradycardia may cause symptoms of fatigue, dizziness, and fainting. We should check blood pressure and ECG in patients with bradycardia. Does the ECG show sinus bradycardia or arrhythmia? If the arterial pressure is maintained in the normal range in a patient with sinus bradycardia, systemic circulation is maintained, and safe operation is usually possible. If the heart rate drops below 40 beats per minute, we should postpone the operation, and we should send the patient to a cardiologist. After the treatment for bradycardia, safe operation will become possible.

16.4 Arrhythmia

We sometimes encounter a patient with arrhythmia. Monitoring of ECG during surgery is mandatory in patients with arrhythmia [4].

Frequent supraventricular premature contraction and ventricular premature contraction are not very dangerous. We can perform operation carefully. We should check the arrhythmia on an ECG monitor during the surgery in patients with couplet or triplet of ventricular premature contraction. Short run of ventricular tachycardia is a dangerous arrhythmia, and we should not begin the operation. We should postpone the operation for several months, and after the treatment of arrhythmia by a cardiologist, we can perform surgery safely.

If the heart rate is more than 140 beats per minute, the patient may have persistent supraventricular tachycardia. Persistent supraventricular tachycardia may last longer than several minutes to 30 min or sometimes for about 1 hour. Sometimes systolic arterial pressure becomes low. If persistent supraventricular tachycardia prolongs, it would be better to postpone the operation. After the medical treatment of persistent supraventricular tachyarrhythmia by a cardiologist, safe operation will become possible. If persistent supraventricular tachycardia turns into normal sinus rhythm, and if the systolic arterial pressure becomes normal again, then we can begin the operation carefully under ECG monitoring. Persistent supraventricular tachycardia may reoccur during the surgery.

Dangerous arrhythmias include Brugada syndrome, ventricular tachycardia, and Wolff-Parkinson-White (WPW) syndrome with tachycardia and syncope. We should send the patient to a cardiologist before surgery. WPW syndrome and Brugada syndrome are classified into several subtypes. The cardiologist will make a diagnosis after precise examinations. If the subtype of the arrhythmia is a safe one, we can proceed to surgery. If the subtype of the arrhythmia is a dangerous one, the patient has the possibility of ventricular tachycardia and sudden cardiac death, even if the patient has no special past history of syncope or faintness. We should not proceed to surgery until the arrhythmia is controlled by a cardiologist.

16.5 Anti-arrhythmic, Anticoagulant, and Antiplatelet Drugs

If the patient has a history of atrial fibrillation (Af), tachyarrhythmia, and other arrhythmia, the patient is usually treated by a cardiologist, and the patient takes maintenance drugs for the treatment of the arrhythmia. If the patient takes anti-arrhythmic drugs including beta-blocker, anticoagulant drugs including warfarin, and antiplatelet drugs as maintenance drugs, all the drugs should be continued before surgery [5–10]. We should not stop beta-blockers before surgery. If beta-1 selective blocker is stopped before surgery, we may have uncontrollable arrhythmias or high blood pressure during surgery, which is much more dangerous for the patient. Usage of a beta-1 selective blocker is safe during hair transplantation even though epinephrine is used in the tumescence solution.

Anticoagulant and antiplatelet drugs can be stopped safely for 1 week, if the patient has no ischemic heart disease, Af or valvular heart disease. In patients with coronary artery disease, Af or mechanical prosthetic heart valve, anticoagulant and antiplatelet drugs should not be stopped before hair transplantation [11].

16.6 Other Symptoms

There are other symptoms which suggest hemodynamic instability. Palpitation may suggest tachycardia, arrhythmia, and increased sympathetic nerve activity. Cold sweat, nausea, and shortness of breath may suggest parasympathetic nerve hyperactivity, heart failure, hypotension, shock, and angina pectoris.

Dizziness and syncope may suggest Meniere's disease and arrhythmia. Fainting and nausea may suggest arrhythmia, hypotension, shock, and angina pectoris.

High body temperature may result in dehydration, hypovolemia, perfusion failure, renal failure, hepatic failure, and metabolic acidosis. High body temperature may cause increased oxygen consumption resulting in brain damage.

Hypoxemia may suggest pulmonary disease, which causes dyspnea, cyanosis, and ischemia in many organs including the heart, brain, liver, and kidney.

16.7 Oxygen Saturation and Myocardial Ischemia

16.7.1 Oxygen Saturation

Oxygen saturation in the peripheral vessels (SpO_2) should be monitored by pulse oximeter during surgery [6]. SpO_2 should be around 95–99% in the room air. If SpO_2 is below 94% during surgery, we should give 1.5–2 L/min oxygen to the patient through a nasal cannula. SpO_2 should be kept above 95% during surgery. SpO_2 level below 90% is unacceptable for a prolonged period of time, and we should not begin surgery.

Hypoxemia may cause cardiac ischemia and cerebral ischemia during surgery. Patients over 60 years of age may have latent coronary artery stenosis. Hypoxemia will cause myocardial ischemia in these patients. It is important to keep SpO_2 above 95% during surgery in elderly patients with chronic obstructive pulmonary disease, whose SpO_2 is usually low.

16.7.2 Myocardial Ischemia

Mental stress, hypovolemia, hypotension, and hypoxemia may cause myocardial ischemia during surgery in patients with latent coronary artery stenosis [6, 11]. Depression of ST segment on the ECG is a sign of myocardial ischemia. When we notice 0.5 mV depression on the ST segment on the ECG, nitroglycerine tape should be used. If the patient complains of chest pain or chest discomfort, sublingual nitroglycerine spray or tablet should be given. 1.5–2 L/min oxygen should be supplied to the patient through a nasal cannula. The combination of hypotension and hypoxemia is dangerous in elderly patients. If the systolic arterial pressure drops below 100 mmHg at rest in elderly patient with hypoxemia, the patient is at risk of angina pectoris and myocardial infarction. If the systolic arterial pressure drops below 80 mmHg, the patient is at risk of cardiac arrest.

16.7.3 Prevention of Cardiovascular Events

Hemodynamic stability is very important to prevent cardiovascular events during surgery. Hemodynamic stability includes stable blood pressure, heart rate, ECG, and SpO_2. If these parameters are kept within the normal range, we don't need to worry about the possibility of unexpected cardiovascular events during surgery [12]. We can perform safe surgery even in patients with underlying cardiovascular diseases. If some of these parameters are unstable, a cardiovascular complication may occur, and we should stop the operation [2, 6, 11].

In patients with a history of ischemic heart disease, special attention should be paid during surgery [2, 6, 11]. Hypovolemia, hypotension, hypoxemia, bradycardia, and tachycardia may result in myocardial ischemia and cerebral ischemia. If the patient has already been treated with percutaneous coronary intervention, coronary artery stenting, and coronary artery bypass graft operation, coronary blood flow is secured, and the patient is safer than the other patient without treatment for ischemic heart disease. Safe hair transplantation is usually possible in these patients, if the hemodynamic parameters are kept stable [2–6].

Removal of mental stress using sedative drugs is important for the safe operation. Prophylactic usage of a nitroglycerine tape is useful to prevent myocardial ischemia during surgery [6]. Transfusion of saline solution or lactated Ringer's solution is useful to treat hypovolemia and hypotension during surgery in elderly patients.

The author prefers to use a half size of 5 mg nitroglycerine tape, an ECG monitor, transfusion of lactated Ringer's solution, and nasal oxygen during surgery in patients over 60 years of age [4, 7].

16.8 Summary

Stable hemodynamic state is important for safe surgery. If hemodynamic parameters are unstable, we should postpone the operation, and we should send the patient to a cardiologist. After several weeks or several months, the patient will become stable again, and we will be able to perform safe surgery. If hemodynamic parameters are kept in a stable state, safe surgery will become possible even in elderly patients and high-risk patients with past history of cardiovascular diseases.

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Chapter 17
Anesthesia and Techniques of Administration

Steven C. Chang and Michael L. Chang

17.1 Hair Transplant Anesthesia

Hair transplant surgery has dramatically improved in the last 10 years, but anesthesia for hair transplant surgery remains a stressful and painful experience for many patients. Due to anxiety and pain from local anesthetics, some patients experience a vasovagal response, and some pass out from the experience. This problem can be minimized with proper anesthesia.

17.2 Objective

Our version of ideal anesthesia for hair transplantation includes seven expectations. First, we must exercise safety. Second, the procedure should be painless. Third, the anesthesia should be long lasting. Fourth, there should be minimal blood loss, since without a clear bloodless field, you cannot deliver the best possible transplant. Fifth, there should be no nausea and vomiting, and the patient must be wide-awake and be ready for discharge as soon as the surgery is finished. Sixth, stable vital signs must be maintained, and, seventh, there should be minimal forehead swelling postoperatively.

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17.3 Methods

The procedure of painless hair transplant anesthesia involves several steps (see Table 17.1). The patient is first hooked up to a vital sign monitor that displays a continuous pulse and oxygen saturation and measures blood pressure every 5 min. After the patient's vitals are determined, a heparin lock is started. The dorsum of the hand is cleaned with an alcohol pad; the skin then is pre-numbed with bacteriostatic 0.9% saline [1], using a 30G needle followed with lidocaine 1% with epinephrine. Then heparin lock is placed with a 22G IV cannula and secured. Bacteriostatic saline is a physiological saline solution containing the bacteriostatic agent benzyl alcohol as a 0.9% solution. It is used mostly for diluting and dissolving drugs for IV injection and as a flush for intravascular catheters. It also has local anesthetic properties. When injected intradermally, the duration action is only less than 5 min. Midazolam and fentanyl are then slowly pushed through the heparin lock. The fentanyl is optional, and if a patient is prone to motion sickness, only midazolam is used. The patient is given 1 mL (1 mg/mL) of midazolam and 1 mL (50 μg/mL) of fentanyl to begin, and the dose is repeated in 2–3 min. My maximum dose of fentanyl is 100 μg, so if the patient needs more sedation after 100 μg of fentanyl and 2 mg midazolam have been administered, then only 1 mg midazolam is given incrementally. Once the oxygen saturation has dropped 2–3 points, or the patient starts to close their eyes, or their language becomes slurred, the next step can begin. Every patient responds differently, and older patients and Asian patients are usually more sensitive to the medication and need less. If midazolam is given too much or too rapidly, the oxygen saturation might come down below 90%. At this point, we ask the patient to take a few deep breathes. If there is no response, then the chin has to be held to open the airway that may be blocked by a dropped tongue. Chest movement must be seen to confirm an open airway. It usually takes 10–12 min for the patient to reach the ideal level of sedation.

After the patient has been properly sedated, the first stage of the supraorbital block is given. The skin is pre-numbed with bacteriostatic saline with a 30G

Table 17.1 Steps of painless hair transplant anesthesia

1. Monitor vital signs
2. Heparin lock
3. IV sedation
4. Pre-supraorbital block
5. Donor site tumescent anesthesia
6. Donor harvesting
7. Real supraorbital block
8. Wound closure
9. Field block to confirm the block
10. Triamcinolone mixed with tumescent injected
11. Very superficial tumescent solution injected

needle because lidocaine pH is low and causes pain on injection. Then 1 mL of 1% lidocaine with epi is given on each side but only down to the subcutaneous tissue (no intention to block the nerve at this point) with a 27G needle because the nerve block is the most painful part and the sedation is light. The purpose of this shot is to inject to the superficial tissue only. Over the next 10–15 min, the medication will gradually infiltrate into the supraorbital nerve. It is important to inject the lidocaine into exactly the same spot as the bacteriostatic saline, and the injection is given very slowly to minimize discomfort. The second stage of the supraorbital block will be administered immediately after the removal of the donor strip.

17.3.1 Method to Numb Donor Site Tumescent Anesthesia [2]

First, we mark the planned anesthetic entry points by placing a dot with a permanent marker about 3 cm apart (a little shorter than needle) along the bottom of donor site. Next, we use bacteriostatic saline to numb the entry points, followed by 1% lidocaine with epi at the same points. Again the same entry points are used to inject tumescent solution (up to 2–3 mL/cm) to connect adjacent points, keeping the needle depth in the subcutaneous level to reduce pain sensation.

For strip surgery, just prior to the removal of the donor strip, tumescence is injected very superficially using a 1 mL syringe with a 25G 1 1/2” needle along the incision line to control bleeding. With this method, the field is extremely dry allowing a perfect view of the direction of the hair during the removal process. During the whole procedure, a vibrator is applied to distract the patient and disperse medication [3]. At this point, the donor site will remain anesthetized for an average of 10 h. The description sounds time-consuming, but from the start of the IV to the time the donor site is harvested is usually no more than 30 min.

For FUE surgery, epinephrine 1:100,000 is injected to different sections immediately before a punch is applied. For vasoconstriction purpose only, no lidocaine is needed.

17.3.2 Supraorbital Block

The second stage of the supraorbital block is delivered after the donor strip is harvested and before the wound closure. This time the needle is inserted along the previous route, advanced all the way to the bone, and then withdrawn slightly, and 1.5 mL 0.5% bupivacaine is injected with a 30G needle to each side. Because of the first-stage injection, the patient should not feel this usually painful injection. The supraorbital block does not extend to the frontotemporal area. After the block, return to the donor site for incision closure.

It will take 10–15 min for closure, just long enough for the bupivacaine to work. To supplement the block and provide anesthesia beyond the limit of the block, a field block is achieved with local infiltration of 3 mL of 1% lidocaine with epi to each side. 1 mg of midazolam is given intravenously before the field block. In order to reduce post-op swelling, after confirmation of the nerve block, a mixture of tumescent fluid and triamcinolone is injected into the recipient area deep to the subcutaneous level to prevent skin atrophy. The volume used is determined by the size of the recipient area, but the triamcinolone dose is limited to 40 mg. Just prior to making the recipient sites, additional tumescence is injected very superficially with a 1 mL syringe with a 25G 1 1/2 needle to control bleeding. This technique keeps the field extremely dry while the recipient sites are made. For procedures over 3 h, an additional dose of 1 cc bupivacaine 0.5% is given to reinforce the nerve block to ensure that the remainder of the procedure is painless.

17.4 Discussion

17.4.1 When Should Midazolam Be Used Without Fentanyl?

Midazolam is a benzodiazepine that produces relaxation and amnesia, but too much will cause airway obstruction. Fentanyl is a narcotic that reduces the sensation of pain but can cause nausea and vomiting. Ideally, both are used together, but we absolutely do not want nausea and vomiting during or after the surgery, and thus we screen each patient for narcotic intolerance. If the patient has had nausea and vomiting at any prior surgery or if the patient experiences motion sickness very easily, that is a contraindication for the use of fentanyl. Since we have adopted this approach, we have not incurred problems with nausea or vomiting.

If I only use midazolam, the patients might not remember the pain of injection, but they still feel it, and tachycardia and hypertension may occur. If this situation occurs, I always give a heavier sedation. In addition, I will inject the tumescent solution slower and sometimes even give medication to control the hypertension or tachycardia.

17.4.2 How Much Midazolam and Fentanyl Should Be Used?

This is a very difficult question to answer, because everyone's response is different and the dose range is huge. For midazolam, the dose is from 1 mg to 15 mg (very rare), with an average dose of 3–5 mg for the entire procedure. My maximum dose for fentanyl is never more than 100μg (2 mL). The point is not to rush. Take 10 to 12 minutes to induce sedation, then increase sedation until the oxygen saturation drop 2 to 3% or wait until the patient has closed his eyes and is slow to respond to your communications.

17.4.3 Why Not Heavily Sedate the Patient and Let Him Sleep During the Whole Procedure?

Heavy sedation increases the chance of airway obstruction, nausea, vomiting and aspiration, and it is very dangerous without adequate training and equipment. Additionally, hair transplantation is a very long procedure, and it's safer to have the patient awake to notify us of an uncomfortable position (especially the neck) so that corrective action can be taken. Therefore IV sedation is only for the beginning of the procedure. After the patient is completely numb, then there is no longer need for sedation.

17.4.4 How Is the Tumescent Solution Mixed?

The preparation consists of three stainless steel bowls. Two of the bowls have 100 mL of normal saline, 0.5 cc of epinephrine 1:1000, and 5 mL of 2% lidocaine (epinephrine 1:200,000 and lidocaine 0.1%). In the third bowl, 10 mL of tumescent is drawn from each bowl totaling 20 mL, and 20–40 mg of triamcinolone is added, depending on the size of the recipient area. All wrappers that need to be discarded are left on the table so that the technicians can confirm that the medication is mixed properly. The tumescent solution is kept as close to body temperature as possible to minimize discomfort and speed the effect.

17.4.5 When Do You Avoid IV Sedation?

About 20% of our patients go without IV sedation in order to be able to drive home by themselves. In this situation, the only change is at the donor site. First using bacteriostatic saline, followed by tumescent solution and then lidocaine, each 3 cm segment is fully anesthetized immediately before moving to the next injection site. With this method I stick the non-anesthetized donor skin only one time instead of several times for a 30-cm-long incision. This approach will slow me down a few minutes, and occasionally I will see a vasovagal reflex occur. When I use IV sedation, I never see this happen, and thus IV sedation is always encouraged in our office.

17.4.6 Can the Effect of Midazolam Be Reversed?

Romazicon (flumazenil) is the antidote for midazolam**.** The onset of action is rapid and usually the effects are seen within 1–2 min, but we have never used it in our office.

17.4.7 Can the Effect of Fentanyl Be Reversed?

Narcan™ (naloxone) is the antidote of fentanyl. But up to 100 μg fentanyl is too small dose to cause respiratory depression. We have never used it in the past 25 years of our hair transplant practice.

17.5 Conclusion

The combination of using conscious sedation, supraorbital nerve block, and local anesthetic helps provide a more dry, quick, and minimized pain procedure. The IV conscious sedation helps provide a painless nerve block and enforce our local anesthetic more effectively. The patient is always arousable throughout the procedure. Medication should always be administered slowly with monitoring of patient clinically and serial vitals.

In a previous survey done in our clinic over 100 patients, no patient scored over a 3 out of 10. With practice, a skilled hair transplant surgeon will be able to provide adequate anesthetic within 30 min. In my 25 years of practice, I have never had a complication or need for reversal agents such as Narcan or Romazicon.

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Chapter 18
Postoperative Care

Wen-Yi Wu

18.1 Postoperative Care

Patients are given 500 mg cephalosporin preoperatively. Immediately after the surgery, an antibiotic ointment is applied to the donor area, and a headband is applied (Fig. 18.1). We also provide some analgesics and sleeping pills to the patients as required. A loose-fitting baseball cap is also provided before patients leaving the clinic.

Patients are given written and verbal instructions to very gently wash the recipient area by light patting for the first week. The recipient area may be blown dry by cool setting only. At no time during the first 10 days, they are to rub the recipient area with a towel.

Patients are encouraged to return to the clinic the next day for hair wash. They may come back for a daily wash until they feel comfortable doing it themselves.

Patients are instructed to return to the clinic for suture removal 7–10 days. Occasionally some pustules may develop in the recipient areas. They will clear up spontaneously with an incision using a hypodermic needle and gentle drainage to expel the exudates.

18.1.1 Pain

Most of the discomfort from a hair transplant is limited to the evening of the procedure and the following day. Pain will come from the donor area and is caused by the tension created by the sutures and extra fluid applied to the area. Extra strength acetaminophen may be used; avoid aspirin and NSAID [1].

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Fig. 18.1 Headband after operation

18.1.2 Rest

Rest as much as possible for the first 2 days. It is recommended to avoid strenuous exercise, heavy lifting, and bending over at the neck or waist for 1 week.

18.1.3 Postoperative Antibiotics

Antibiotics are not routinely prescribed. The scalp has an abundance of blood supply, thus making infection less likely. However, should an infection occur, methicillin-resistant *Staphylococcus aureus* (MRSA) must be considered [2].

18.1.4 Bleeding

If bleeding is noted, one should place firm pressure over the area with a clean cloth or folded gauze for 10 min. If bleeding is brisk, call the office.

18.1.5 Swelling

Swelling is a natural phenomenon. If the recipient site is injected with tumescent fluid incorporated with steroid solution, swelling should be minimal or none at all. If not, the head should be kept above the level of the heart. Headband may be applied to the forehead.

18.1.6 Sleeping

Sleeping slightly elevated at a 30 degree angle, usually with an extra pillow behind the head, is sufficient. A travel pillow (U-shaped or neck roll) can be a more comfortable way to sleep, relieving some of the pressure in the donor area.

18.1.7 Coverings

A clean hat can be worn as long as it does not fit snugly or contact the grafted area. Hairpiece should not be placed for 5 days and, if needed, should be placed with caution.

18.1.8 Shampoo

Hair washing starts on the next day. Shampoo gently using the flat of the fingers lathered with a generous portion of shampoo. Most commercially available shampoos are safe to use. Dry off the hair with a towel. Blow-dry with a hairdryer on a low setting. Avoid scratching, bumping, or rubbing the grafted hair to prevent graft loss.

18.1.9 Scabbing

With gentle washing, the scabs are usually gone within 1 week to 10 days after the surgery.

18.1.10 Camouflaging Products

Toppik and other hair fibers can be used 3 days after the surgery.

18.1.11 Suture Removal

Return after 1 week for suture removal. If the donor area required a layered closure or was challenging to close due to previous surgeries, they are then removed 12–14 days postoperatively.

18.1.12 Shedding and Shock Loss

The transplanted follicles will shed their hair shafts and go into a resting phase before growing a new hair. Shock loss is temporary and will occur 2–6 weeks after the surgery. They will come back after 16–24 weeks.

18.1.13 Regrowth

It will be at least 6 months postoperatively before most patients see some substantial growth and up to a year for the full impact of the hair transplant procedure.

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Part V
Donor Harvesting: Strip Harvesting (FUT)

Chapter 19
Strip Harvesting (FUT)

Damkerng Pathomvanich

19.1 Introduction

Carlos Uebel from Brazil advanced modern hair transplant surgery in 1992 by advocating the excision of a linear donor strip in hair transplantation [1]. In 1994, Bobby Limmer described single strip harvesting using stereomicroscopic dissection of individual follicular units, known today as follicular unit transplantation (FUT) or the strip procedure [2].

19.2 Breakthrough Technique to Minimize Follicular Transection "Open Technique"

For the past 15 years, I have explored strip harvesting by direct visualization or what I called the "open technique" by using a simple method of cutting or dissecting with the aid of two skin hooks for traction. Since then, several devices have been developed to spread the incision, such as the tissue spreader by Haber [3] and Rose spreader [4], and Kamran reported using a clamp to simply spread the incision that was scored resulting in minimal transection and reportedly faster than cutting [5]. His technique might be a modification of Dr. Arturo Sandoval's "score and spread technique" using mosquito to spread the incision after scoring [6]. Brazilian dermatologist, Dr. Arthur Tykocinski, used his device to perforate the incision and noted minimum transection, but the device does not work well on scar tissues [7]. He subsequently used the skin hooks to help separate the skin layers while he perforates the incision. I have tried his device but it was not as successful as he had reported,

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so I have modified his technique with the aid of a sharp blade and added it to my armamentarium.

19.3 The Instrument for Strip Harvesting

The tools in strip harvesting are as follows: four skin hooks, #15 and #10 blades, small suction machine to clear the blood from the operative field, and small gauze rolls for packing the incision to stop the bleeding. High-powered loupes of at least 4.5× magnification are very helpful, though loupes of higher magnification than these are great but will slow down the process. Good lighting is very important and needs to be emphasized. I use an LED surgical light and found it to be great in visualizing the anatomy of the hair follicle.

19.4 Refined Technique

I have noted in the past that with cutting and pulling, there was profuse bleeding from cutting the small vessels despite the injection of tumescent fluid containing epinephrine. Higher concentration of epinephrine will cause less bleeding but might result in effluvium postoperatively. With the new dissecting technique, the bleeding is less. However, it might be more prudent to cauterize the bleeding vessel using a bipolar cautery machine to avoid damage to the hair follicle. I have a few patients who had copious bleeding 1 week later, and I suspected that bleeding was from the vessel that was not cauterized, hence resulting in blood accumulation and subsequently into an expanding hematoma ready to burst.

The technique is as follows:

1. The donor area is selected in the safe zone as described by Unger [8], and then the area is shaved leaving the hair stump roughly 4 mm in length, which is a bit longer compared to the past. These longer hairs make it easier for the assistants to see the hair direction after implantation and also for me to check the hair direction at the end of the procedure. If the graft sinks, it is also easier to pull it out. If there is lots of gray hair present in the selected donor area, it is prudent to color the hair with an instant hair dye. The shade that I use is dark brown. The hair color will help the assistants in placing the grafts more precisely as it is sometimes difficult to see and determine the root end of the hair if the follicle is all gray especially with one hair graft, since the top and the root look similar. The hair color also helps the physician to do a final check especially for buried grafts and wrong direction.
2. A videoscope is used to count hair density in different areas, including mid-occipital, parietal, and temporal. Mayer laxity is next measured. Strip length and width are then calculated [9] depending on the number of grafts needed, and the

strip location is marked with gentian violet. I usually mark the location of the occipital artery, so I will be careful when approaching this vessel upon harvesting on both sides. This is also helpful during layer closure as it will help to avoid ligating the neurovascular bundle hence avoiding pain postoperatively. The end of the strip is marked as an arrow or flag shape depending on the hair direction (refer to Chap. 22). Once the marking on the strip is completed, I use the laser to check whether the width is safe to excise (see Chap. 20). I then trim a narrow area of hair very short just outside the marked incision borders on both sides, so I can see the strip border of long hair in case the marker is accidentally wiped off during harvesting (Fig. 19.1).

3. The donor area is then scrubbed with 4% Hibiscrub for 5 min trying not to erase the gentian violet markings before I paint it with Betadine.
4. Local anesthesia is then injected. My preference is 0.5% lidocaine with a total of 6 cc more or less depending on the length of the strip, followed by tumescent fluid containing 0.1% lidocaine and epinephrine 1:300,000. An average of 40–120 cc is injected into the donor area to extend 2 cm^2 beyond the strip line to provide longer-lasting local anesthetic. For more information and details on the technique, please refer to Chap. 35.
5. The strip is scored superficially with a #10 blade with a forward pushing motion (Fig. 19.2), following the gentian marker; alternatively, one can also score toward the operator. Scoring should be kept to a minimum as going too deep will lead to blind cutting of the stem cells which are located between 1.0 and 1.8 mm from the surface of the skin [10].

Fig. 19.1 Strip with the hair trimmed about 4 mm. in length

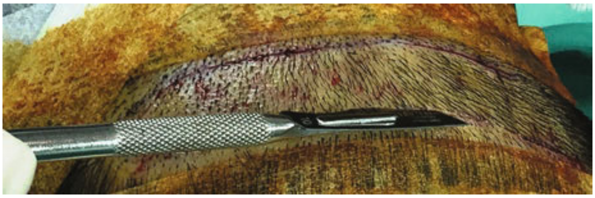

Fig. 19.2 Scoring should be shallow to avoid damage to stem cell which is located about 1.0–1.8 mm. from the epidermis

6. Personally, I prefer to use a double skin hook for retraction since it's more secure, while my assistant uses another double skin hook to grasp the other edge of the skin with the other hand holding the suction tip to clear the blood. The other assistant, if available, will insert a pair of single skin hooks about 1 cm away from my hook and gently lift the incision and pull once the blade cuts through the skin.
7. There are many maneuvers to dissect the strip:
   (a). The tip of #15 blade **stabs the incision line** while the skin hook pulls up the skin, a modification from Dr. Tykocinski (Fig. 19.3).
   (b). The belly of the blade can be used with a **lateral gliding** motion to gently push or tease the soft tissues sideways in between the follicles (Fig. 19.4).
   (c). The belly of the blade can be used to perpendicularly **push down** the soft tissues between the follicles when the dissection almost reaches the dermal papillae (Fig. 19.5).
   (d). The frontal third of the blade is used for **cutting** (Fig. 19.6).

Applying these maneuvers appropriately will help speed up the harvesting process, minimize transection, and reduce bleeding.

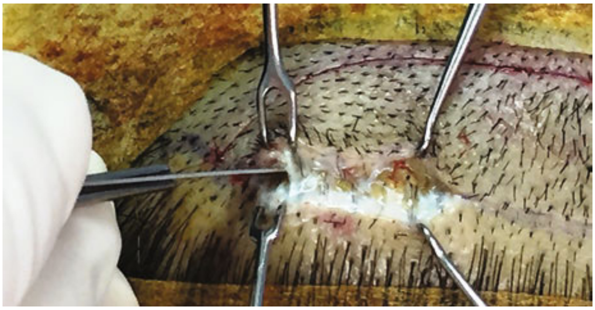

Fig. 19.3 Stab the incision between the follicles with #15 blade

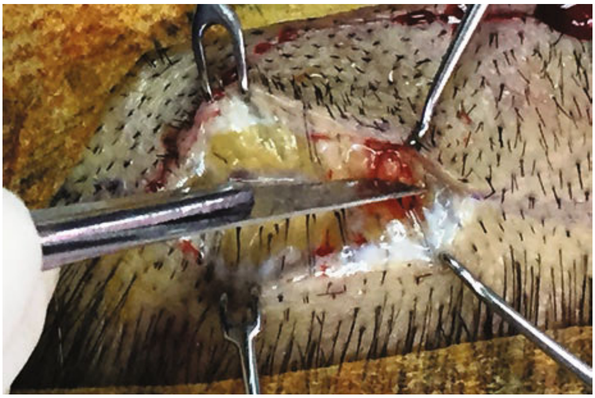

Fig. 19.4 Lateral gliding with belly of the blade

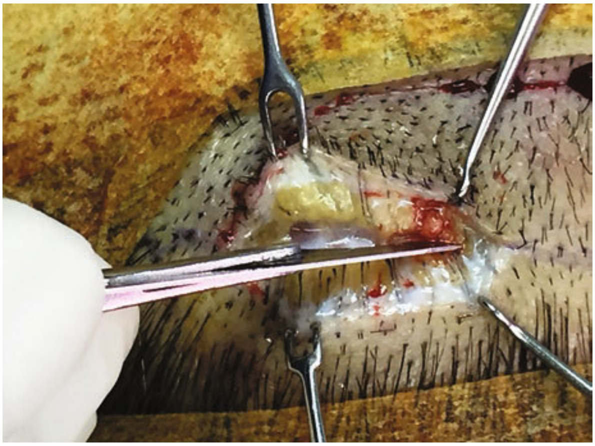

Fig. 19.5 Pushing: using the belly of #15 blade gently pressing between the follicles

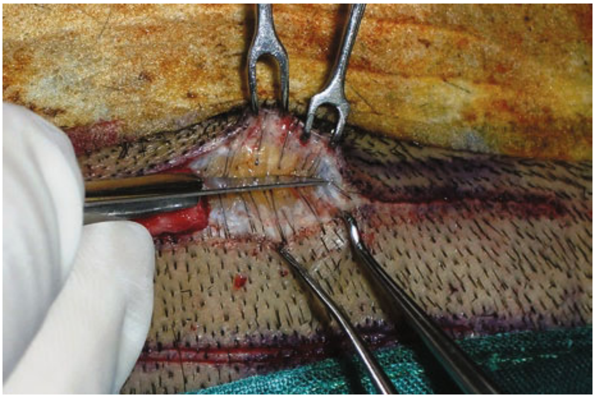

Fig. 19.6 Cutting: using frontal third of the blade cutting between the follicles

19.5 The Open Technique

The open technique procedure is as follows: score the skin about 1 mm deep, insert the four skin hooks up to the mid dermis, and then use the tip of the blade to make multiple small stab wounds between the follicles to help separate the incision. Sometimes there is a lot of soft tissue that is difficult to separate. One may use the blade to cut the tough tissue. Sometimes I do a second scoring to advance quickly along the dissection without applying pressure other than the weight of the handle. The sharpness of the blade will cut the tissue by gravity without transection. I then glide the blade or cut between the follicles laterally for half an inch until it reaches the lower third of the follicle, where the belly of the blade is used to gently push perpendicularly down on the follicles, which will then easily separate without transection. Alternately one can use the skin hook and pull on both sides to separate the incision. Some surgeons use a dissecting scissor to separate the incision after deep scoring [11]. The cutting is continued for about 10 cm on both sides, and then the first strip is removed.

The first strip is removed by using a towel clamp or skin hook to lift up the end of the strip. A #10 blade is used to cut the strip just below the dermal papilla. Try to preserve as much fat as you can since there are lots of stem cells in the fat [12], but care must be taken to avoid inadvertently cutting the dermal papilla. The dissecting plane for less bleeding and fast removal is just above the deep fascia. The surgeon can gently pull backward without cutting, and the strip can be quickly removed in a minute. However, a lot of soft tissues can also be removed which will be discarded by the assistant during graft cutting and slivering. I use James Arnold's modified towel clamps [13] to approximate the incision along the area where the strip is excised, about 1–2 cm^2 apart. Tension clamps arrest the bleeding as it creates a mechanical creep. It would be best to leave the clamps on for 5–10 min to increase mechanical creep.

19.6 The Technique to Divide the Strip

There are many techniques to divide the strip:

- Direct cutting at the edge (like slivering the strip) from the skin toward the dermal papilla till it reaches the other end (Fig. 19.7)
- Scoring across the divided strip and gently dissect from top to the bottom with the help of a pair of skin hook (Fig. 19.8)

I like these two maneuvers since it preserves the follicles better than direct cutting in a single stroke, which can lead to unpredictable transection.

Once the strip is removed, it is stored in a storage solution. My preference is ATP in Williams' E media (see Chap. 10 for holding solution). The strip is then ready to be slivered into multiple rows of narrow strips and subsequently cut down to follicular unit grafts.

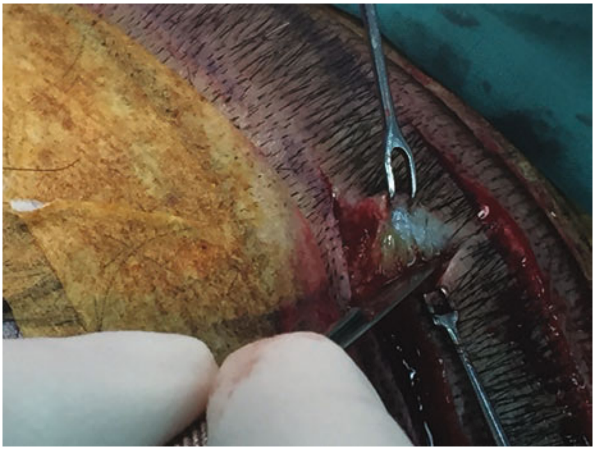

Fig. 19.7 Strip dividing, slivering technique start from the one side to the other side

Fig. 19.8 Strip dividing, scoring technique

19.7 Donor Wound Closure

Donor wound closure is still controversial as to whether a single or double layer closure should be used. Please refer to the chapters on alternative wound closure by Drs. Yamamoto and Dae Young Kim.

My preference is inferior trichophytic with or without excision of any redundant edge of the superior incision before the strip is excised, since the skin edge is stabilized by the retaining strip. I use Iris scissors trimming the inferior edge with the aid of two skin hooks for the tension. Dae Young Kim used bent razor blade to cut skin edge less than 1 mm deep to avoid the damage to stem cell [14]. I have been using retention sutures with 3/0 nylon for the past 10 years with good results in majority of my cases, and I like it because it's fast and does not leave any foreign body or nerve entrapment (which can result from layer closure). The retention stitches should not be tied so tight, just to approximate the subcutaneous tissues but not the skin (Fig. 19.9). Retention stitches create a mechanical creep and subsequently lay down the biological creep. I like to leave the retention stitches longer for 7–10 days instead of 5 days like in previous years of my practice and 2 weeks for subsequent session. The skin is then closed with 4/0 Vicryl Rapide, and I have not found any tissue reaction with this kind of suture. Many surgeons advocate that fast absorbable stitches should not be used for skin closure. However, this might be one exception for scalp repair considering it is thick with an abundant vascular supply. The disadvantage of deep retention sutures is pain and increased incidence of shock loss if tied too tight. On the other hand, if the retention is tied loose to snug, it will minimize pain and shock loss. See Fig. 19.10. For the past few months, I have modified the stitches with the needle bite just below the dermis, deep enough to create a

Fig. 19.9 Retention suture

Fig. 19.10 Before and 1 year after strip harvesting, 2 cm. wide at the mid-occiput

mechanical creep but lessening the strangulation effect on the follicles, and I found that majority of the patients have less pain and shock loss. The scar looks as good as regular retention stitches. See Fig. 19.11.

Trichophytic closure during the first session can make subsequent sessions more difficult if the surgeon chooses to use the same scar.

19.8 An Alternative to Trichophytic Closure

For the past few months, I have modified the technique by not cutting the skin edge for trichophytic. During strip harvesting, I dissect and leave some follicles close to skin edge instead of including it into the strip, so it will act like placing hair graft in the center of the wound once it is closed, when the incision is closed. It can be done either at upper or lower edge of strip. The isolated follicles that are attached to the skin edge when the incision heals look more natural since there are no graft

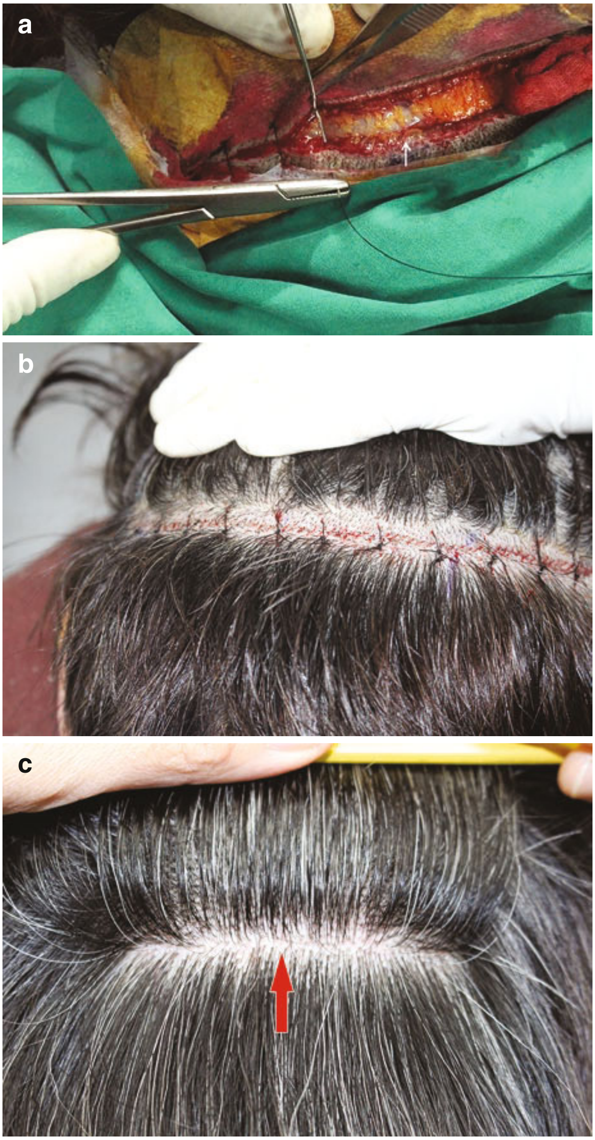

Fig. 19.11 (**a**) shows the small bite at the deep dermis (*white arrow*); (**b**) completed wound closure; (**c**) 8 months after the procedure

rotations. The disadvantage of trichophytic closure is once it heals it appears like the hairs from upper and lower incision crisscrossed like ridgeback and looks unnatural. In the patient who wears the hair short, some complain of pain during sleeping from the hair stump poking the skin. Nevertheless, the long-term result remains to be seen (Fig. 19.12).

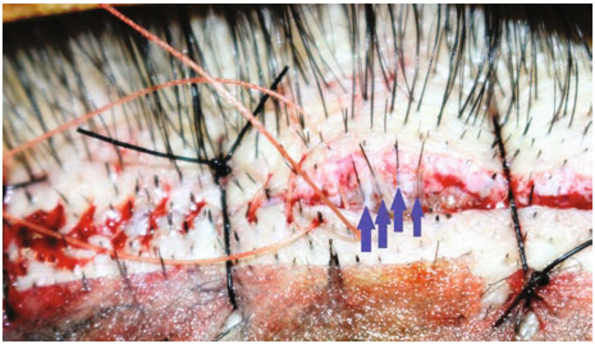

Fig. 19.12 Non-trichophytic closure with few islands of hairs (*blue arrows*) left along the edge

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Chapter 20
Laser Lax for Donor Closure

Chinmanat Tangjaturonrusamee

20.1 Laser Lax or Cross Beam Laser

Scalp laxity depends on elasticity and gliding ability of the scalp skin in each person. Evaluation of scalp laxity can be achieved by using several different techniques at the surgeon's choice [1–5]. Proper measurement is critical for each individual nature especially in the ones with tight scalp. Laser Lax (cross beam laser) is a newly invented device for measuring scalp laxity developed from a laser-assisted hairline drawing instrument [6, 7]. This handheld tool is equipped with a class IIIA horizontal beam laser utilizing a 3volt battery pack to produce a maximum power of 5 mW at a wavelength of 650 nm (Fig. 20.1). To determine vertical scalp laxity, Laser Lax projects a steady laser line on the scalp horizontally over the donor area for accurate scalp laxity determination [8].

20.1.1 Laser Lax and Mayer's Elasticity Scale (MES)

Our research study [6] evaluated the efficacy of the Laser Lax (LL) and attempted to corroborate the accuracy of LL in assessing scalp laxity by comparing its measurements to those obtained with the most commonly used Mayer's elasticity scale technique. We did not compare LL with Wong's method which is another vertical measurement because there were not enough reference numbers recorded and it was not used by many surgeons. Also, Wong's method is more like a freehand instant measurement that can be varied by individual performer strength.

Both the LL and MES techniques were utilized by Dr. Damkerng Pathomvanich to assess each patient's scalp laxity measurements. Starting with MES, two vertical

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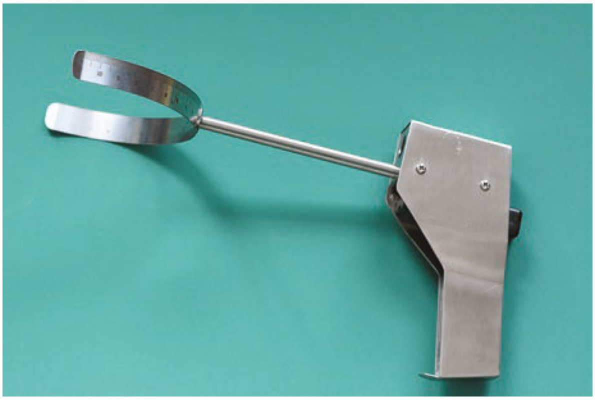

Fig. 20.1 Laser Lax (cross beam laser) device

Fig. 20.2 Laser Lax is being held firmly against a patient's neck and laser beam is projected over the donor area

lines were drawn 5 cm apart on the back of the patient's scalp as close to the center as possible. Applying full strength with both thumbs, the lines were pushed inward and measurements taken between the two lines. The measurement thus obtained provided the 5 cm reference number used in calculating the percentage of scalp laxity for maximum donor width.

In contrast, the LL procedure provides rapid donor strip width determination absent the need for calculation. The LL instrument has a curved arm which is held firmly against the patient's neck by the surgeon (Fig. 20.2). A horizontal laser line is projected over the donor area and serves as the first reference line (Fig. 20.3). While maintaining the LL in position, the skin above the line is pressed downward against the occipital bone as far as possible, and a mark is made, establishing the second (upper) line (Fig. 20.4). The same procedure is employed starting below the first line and pressing the skin upward for marking the third (lower) line (Fig. 20.5). These manipulations are also performed on the left and right lateral areas, using the first line as the reference mark (Figs. 20.6, 20.7, and 20.8). The distance between the second and third lines represents the maximal donor strip width, and once the center and lateral lines are linked together and closed at both lateral ends, a perfect size

Fig. 20.3 The first line is marked as a reference line

Fig. 20.4 The scalp skin above the reference line is push downward towards the neck, and the second line is marked where the laser beam appears on the skin

Fig. 20.5 The skin below the reference line is push upward to mark the third line where the laser beam appears

donor strip is thereby marked for maximal donor harvest (Fig. 20.9). A final confirmation is performed by moving the scalp skin up and down along the whole donor strip to make sure the lines drawn on the scalp properly coincide with the laser beam (Fig. 20.10 and 20.11).

Fig. 20.6 Laser Lax is being used with the same procedure on the left side of the scalp to find the reference line

Fig. 20.7 Marking of the extended second line on the left side of the scalp

Fig. 20.8 The third line is being marked on the left side of the scalp. (This patient has poor scalp laxity, so the third and reference line are so close together)

Referring to our research study published in Dermatologic Surgery Journal [6], Table 20.1 illustrates the comparison of the maximum donor strip width measurement performed by MES, LL, and real width (RW). RW is the total number of the actual width and the additional width combined that we used as our reference value.

Fig. 20.9 The donor strip drawing is complete

Fig. 20.10 The third line (lower line) is being checked for the correct marking by pulling up the skin

Fig. 20.11 The second line (upper line) is being checked by pushing down the skin

"The actual width" is the width of the donor strip we took from the incision. After the donor strip removal, we inspected the looseness of the skin before closing the incision by pulling both edges of the wound close together with tension clamps to check for an overlapping. If the overlaps existed, we measured the amount and

Table 20.1 Comparison of the measurement data between MES and LL to RW [6]

	Mean width ± SD (cm)			Paired *t*-test *p*-value		
	MES	LL	RW	MES vs. RW	LL vs. RW	MES vs. LL
Overall						
Center	1.90 ± 0.03	1.97 ± 0.02	1.90 ± 0.03	0.97	0.008	0.006
Lateral	1.35 ± 0.02	1.55 ± 0.02	1.58 ± 0.02	<0.001	0.22	<0.001
First session						
Center	2.10 ± 0.02	2.03 ± 0.02	2.00 ± 0.03	<0.001	0.26	0.003
Lateral	1.49 ± 0.01	1.58 ± 0.02	1.62 ± 0.02	<0.001	0.08	<0.001
Subsequent session						
Center	1.49 ± 0.05	1.83 ± 0.05	1.70 ± 0.04	<0.001	0.003	<0.001
Lateral	1.06 ± 0.04	1.50 ± 0.04	1.49 ± 0.03	<0.001	0.51	<0.001
Need maximum*						
Center	1.80 ± 0.05	1.92 ± 0.04	1.95 ± 0.04	<0.001	0.471	0.006
Lateral	1.28 ± 0.04	1.51 ± 0.02	1.57 ± 0.02	<0.001	0.009	<0.001

Note: *Patients who need maximum number of grafts

called it "additional width." After both LL and MES techniques were performed on patients during either first or subsequent sessions, the results appeared to be that both techniques appeared to be compatible, though LL had an advantage due to its rapid and accurate measurement enough to be real-time draws of donor strip without other needs of measurement and calculation.

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Chapter 21
Follicular Transection in Strip Harvesting

Tyng Yuan Tan

21.1 Introduction

There are a limited number of donor hairs that a patient can donate in their lifetime for hair transplantation. Hence, every effort should be made to minimize transections so as to obtain the maximal yield each surgery.

In the past, donor hair was harvested using either a single-blade excision, multiple-blade excision, or punch grafting. With the development of follicular unit extraction (FUE) in recent years, there has been increasing patient demand for the procedure, from 30% in 2013 to 48.5% in 2014 [1, 2]. However, strip harvesting or follicular unit transplantation (FUT) remains the more common technique (Fig. 21.1) [2].

FUE transection rates vary from surgeon to surgeon, as the subdermal course of the follicles does not follow the angle of hair emergence. Hence, FUE is a blind technique and transection rates may be higher. Using the SAFE system (Surgically Advanced Follicular Extraction), a motorized FUE using a dull punch, Harris reported a transection rate of 6.14% (ranging from 1.7 to 15%) [3]. Similarly, the introduction of robotic surgery produced comparable results with a transection rate of 6.6% (range, 0.4–32.1%) [4].

From personal communication with Dr. Pathomvanich, a renowned FUT surgeon, who spoke at an ISHRS meeting, the transection rate of FUT ranges between 10 and 15%. For FUT, the majority of surgeons use a single blade although some are still using multiblade, which increases transection rate if there is no depth control [6]. Bernstein and Rassman (2001) also quoted a 30% greater yield with single-blade strip harvesting as compared to multibladed knife [5]. The usage of high-magnification loupes and stereomicroscopes helped improve transection rates.

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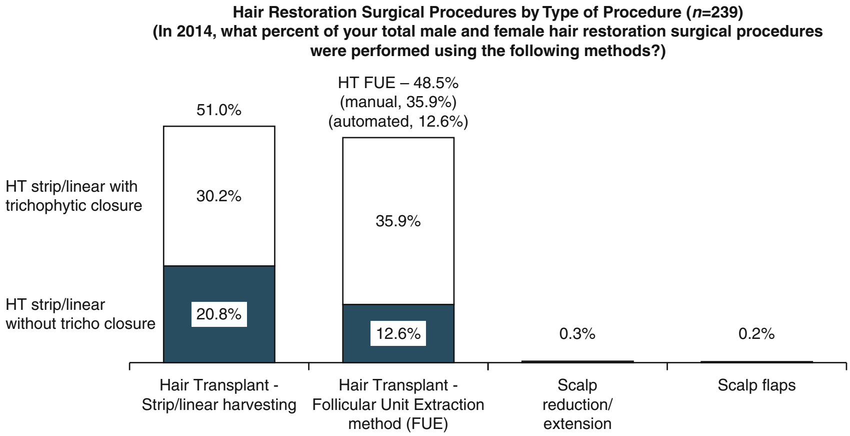

Fig. 21.1 Percentage of FUE and FUT carried out in 2014 by 239 hair surgeons who are members of the International Society of Hair Restoration Surgery

Pathomvanich (2000) described the use of a pair of skin hooks during donor harvesting in FUT. Carefully opening up the donor ellipse allowed better visualization of the field, and he was able to achieve a transection rate of 1.9%. He calls this the "open technique in donor harvesting" [6]. It is very important that while harvesting the donor area, the blade remains parallel to the direction of the hair so that the roots are not damaged [7].

Asian hair tends to be straight and dark, with a bigger contrast between scalp and hair color hence leading to the illusion of thinner hairs. The average caliber of Asian hair is 100 μm in diameter, compared to 70 μm in Caucasians [8]. Asians have an average hair follicle depth (from the epidermis to dermal papillae) of 5.0–6.0 mm compared to 4.0–5.0 mm in Caucasians [8].

Although some transected hair does continue to grow, the quality of the hair is often poor and finer in nature [9]. This is because hair follicle stem cells reside, crucially, in the bulge area (located in the outer sheath close to the arrector pili muscle near the midportion of the follicle) and move downward toward the bulb area [10, 11]. Transected hair follicles with preserved bulge areas are capable of generating follicular hair regrowth of good quality [11].

21.2 Methods: "A Refined Technique to Donor Harvesting"

(For more details on donor harvesting, please refer to Chapter 18 of this textbook.) Below is a summary of the technique that is recommended for donor harvesting.

The donor area is first shaved to 1 mm and marked using Gentian Violet solution. Donor density is calculated using video microscopy. The area is anesthetized using 0.5% lidocaine with epinephrine followed by tumescent fluid (0.1% lidocaine with 1:300,000 adrenaline) to achieve hemostasis.

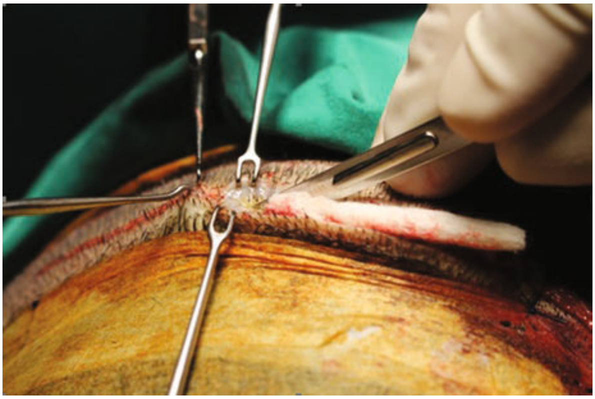

Fig. 21.2 "Open technique in donor harvesting" using four skin hooks (Photo courtesy of DHT Clinic, Bangkok)

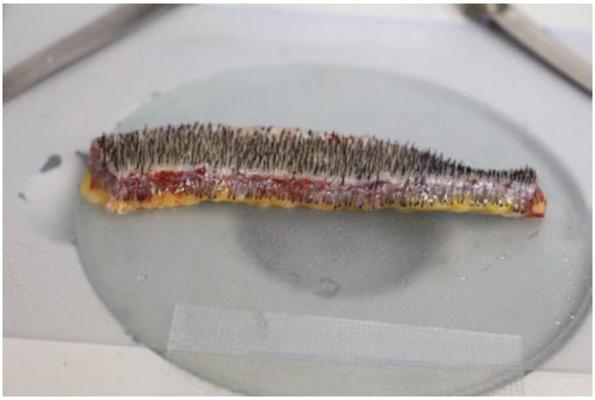

Fig. 21.3 The donor ellipse is examined for transection (Photo courtesy of DHT Clinic, Bangkok)

The donor area is first scored superficially using a #10 Swann-Morton blade. Four skin hooks are then applied, as pioneered by Dr. Dow Stough, to the exposed superficial dermis, two on each side, for fast and "open" dissection [12]. The hair follicles are directly visualized using this technique. Constant traction of the skin hooks is maintained while the surgeon dissects the donor area using a #15 Personna blade down to the dermal papillae (Fig. 21.2). Pathomvanich (2010) calls this the "refined open donor harvesting" technique, which minimizes follicular transection.

The surgeon uses ×4.5 magnification loupes. The skin hooks are constantly repositioned as the dissection continues. If a hair follicle is encountered during the dissection, the follicle can be pulled up and tipped to one side with the dull part of the blade. The bottom of the strip is wrapped in wet gauze to prevent desiccation and is then cut using a #10 blade while being held by the surgeon with the nondominant hand [12]. This technique also avoids cutting of the neurovascular bundle. By marking the neurovascular bundle, the surgeon is aware not to excise too deeply at this marking.

Once the donor ellipse is taken out, it is wrapped in wet gauze and handed to the first assistant for slivering. The difference between virgin scalp and scar tissue is shown in Figs. 21.3, 21.4, and 21.5.

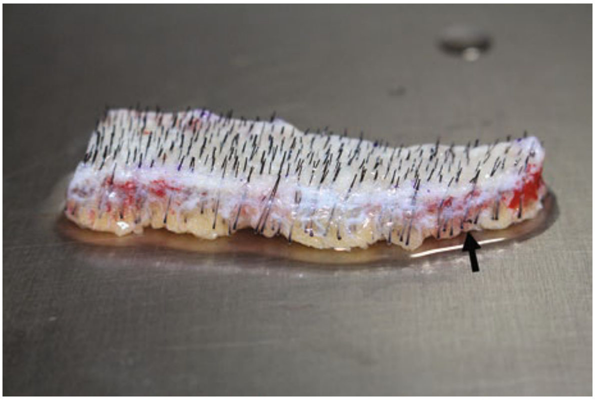

Fig. 21.4 Transection along the donor ellipse (*arrow*) (Photo courtesy of DHT Clinic, Bangkok)

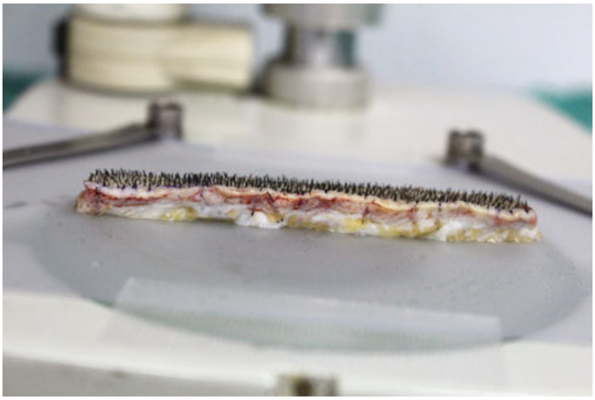

Fig. 21.5 The donor ellipse from a second hair transplantation incorporating part of the original scar tissue (Photo courtesy of DHT Clinic, Bangkok)

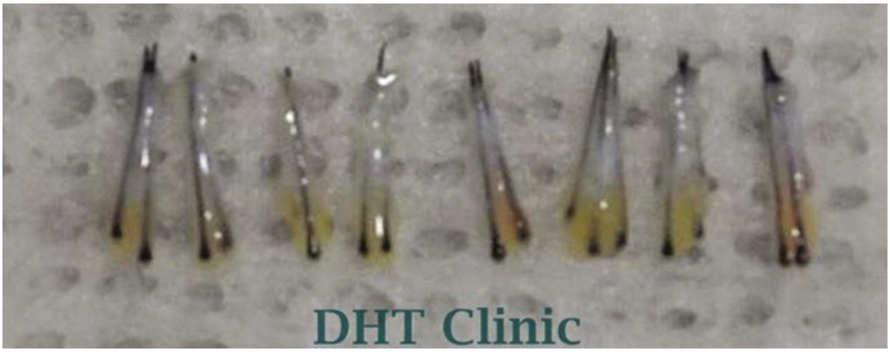

Fig. 21.6 Follicular unit grafts from FUT harvesting (Photo courtesy of DHT Clinic, Bangkok)

The donor ellipse is then fixed to the slivering tray using two 23G needles. Slivering is carried out using a #10 Swann-Morton blade to 1–2 rows of follicular units. The slivers are then cut down to follicular units by surgical assistants using the Meiji stereo microscope (×10 magnification) (Fig. 21.6).

21.3 Common Factors Influencing Follicular Transections in Strip Harvesting

To investigate more into our transection rates, a study was carried out at the DHT clinic, Bangkok, from March to Nov 2015, and ten Asians undergoing FUT were recruited for follicular transection rates.

Our findings are as follows:

21.3.1 Location of the Transection Along the Hair Follicle

From a study conducted by DHT clinic, Bangkok (2015), the lower one-third (dermal papilla) is the commonest site of follicular transections during donor harvesting and slivering (74%). Scoring too deeply (2 mm) can result in transection at the proximal one-third of the follicle. The average transection rate of FUT in Asians in this most recent study is 1.2% [13].

21.3.2 Deep Roots

Transection rates tend to be higher during donor harvesting and slivering for patients with deep roots (5.5–6.0 mm).

21.3.3 High Donor Density

Higher transection rate occurred at the level of graft cutting during the cutting of grafts into basic follicular units by the surgical assistants on patients with a virgin scalp with and high hair density (above 90 follicular unit/cm^2) [13].

21.3.4 Location of the Strip

Transections are more common at the ends of the ellipse as the incision changes from linear to curvilinear [12].

21.3.5 White Hairs

White hairs are the hardest to harvest and cut, as the roots are deeper and harder to visualize. Transection rates at every stage level (donor harvesting, slivering, and graft cutting) are usually higher in these cases.

21.3.6 Scar Tissue

It is now more common to encounter patients who are undergoing a second or more hair transplantation. Transection rates are generally lower in these patients although it was initially anticipated that there would be a higher transection rate near previous scar tissue, as the hair direction is unpredictable and hair follicles are harder to visualize. The lower transection rate is likely due to the low density in the area of the previous scar, which is frequently partially included in the harvested donor ellipse in a second hair transplant to create only one linear scar.

21.3.7 Inexperienced Team

There is a steep learning curve for hair transplantation. Lack of training in the hair transplant team will result in higher transection rates at all stages of the process initially. It is important to take more time and effort in donor harvesting, slivering, and graft cutting at the beginning until the team becomes proficient.

21.4 Conclusions

Follicular Unit Transplantation remains the most popular form of hair transplantation as it allows bigger sessions to be performed at a shorter time, with experience.

In the hands of an experienced team, the transection rate can be very low (1–1.2%) [13, 14], compared to the estimated 6% in FUE surgeries in similarly well-trained hands, which is also more time-consuming.

Potentially, transections at a higher level (with the distal two-thirds of the lower follicle intact) can be transplanted. From the study of Yang et al. (2010) and JC Kim, the rate of regrowth of transected follicles is good, but other studies have found that the quality of the hair is thinner in nature [9, 11]. Ergin et al. hence recommended not implanting partially transected hair follicles [10].

With the increasing number of patients undergoing more than one hair transplant and the demands for a single scar, it is important to know how scar tissue impacts the transection rate of donor follicles. Despite the difficulty in visualizing the scar tissue due to the fibrotic tissue, our findings are that transection rate is lower at every stage of harvesting, slivering, and graft cutting in the scar tissue. This is likely due to the low density of scar tissue.

The "refined open donor harvesting" technique allows for direct visualization of the donor site hair follicles and minimizes the transection rate of donor harvesting. Achieving the lowest possible transection rate is important as it preserves more intact hair grafts for patients. This is crucial as conserving every available follicle should be a priority for the hair transplant surgeon who carefully plans for the possibility of future surgeries.

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Chapter 22
Hair Alignment in Donor Closure

Chinmanat Tangjaturonrusamee

22.1 Factors Associated with Misalignment

Misalignment of hair direction at the donor area following FUT hair transplantation can occur due to several reasons, including the size of the donor strip (too large), location (near the neck/ears), and individual characteristics of hair follicles in each patient [1]. It is important to recognize the hair directions on both upper and lower edges after harvesting the donor strip since they are of surgical importance prior to wound closing in order to prevent or minimize misalignment [2]. Misalignment of the hair is especially a concern when performing FUT hair transplantation requiring a large donor strip, as the difference in hair direction increases as the strip width increases.

The natural hair pattern of each patient is unique and is of utmost importance when determining the location of the donor strip. Hair direction originates from the hair whorl in the form of a spiral, sometimes known as the cowlick. Generally, hair on the back of the scalp grows in a circular pattern either clockwise or counterclockwise. On the top of the scalp, hair grows toward the forehead, while on the back of the scalp, it grows from the top to the nape. On the side of the scalp and behind the ears, hair growth points toward the hairline. At the middle of the occipital scalp, hair misalignment normally is not significant because hair direction is straight downward. However, hair misalignment issues become a concern on the sides of the scalp and the area near the end of hairline (neck/ear), where the acute divergence of hair direction develops (Figs. 22.1 and 22.2). Most hair transplant surgeons try to align hair direction by sliding and stretching the upper and lower wound edges to match, but this method does not usually allow for a good outcome.

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Fig. 22.1 Hair direction at the middle of the back of the head is straight downward

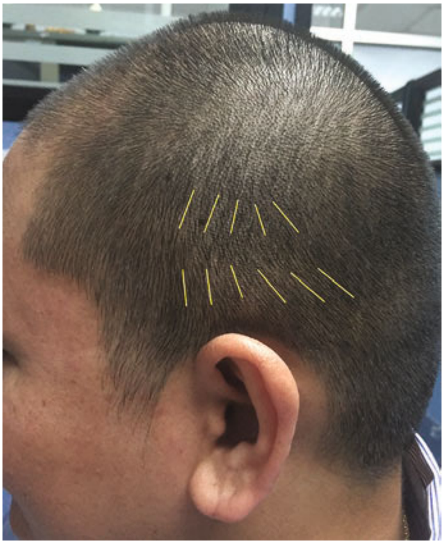

Fig. 22.2 Hair direction on the sides of the scalp is curved down until reaching the area near the end of the hairline (neck/ear) where it is usually straight or diverts to the other direction

22.2 How to Improve Misalignment

A new strip tip design, the triangular flag-shaped designed (TFD), was developed at DHT Clinic in 2014 and utilized on 157 hair transplant patients and compared to the original common elliptical designed (CED) [3, 4]. The main differences were at both donor strip tips where misalignment was seen the most. With CED, the upper and lower edges of the tip are the same length, while with TFD the upper edge is longer and points downward at both ends while the lower edge is almost a straight line (Figs. 22.3 and 22.4). The advantages of TFD result from the longer incision of the upper edge combined with the gliding characteristics of the scalp skin, thereby providing a better opportunity to match hair direction between the upper and lower edges. Tangential retention stitches are the best choice for closing the wound when combined with absorbable running stitches to better secure the wound edges, maintain hair direction, and achieve proper hair alignment (Figs. 22.5 and 22.6). Both suture types are important for successful hair alignment. Even though CED is the more common incision technique, TFD maybe a better choice for cases in which hair direction appears difficult to match.

Fig. 22.3 Drawing shows the pattern of triangular flag-shaped designed (TFD) with longer upper edge and end of the tip pointing down

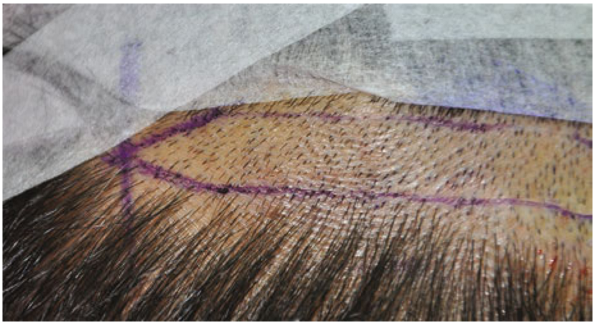

Fig. 22.4 CED has even length on top and bottom with arrow-shaped tip

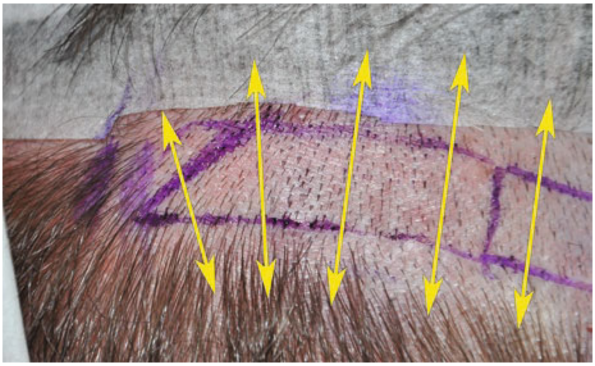

Fig. 22.5 TFD with longer incision of the upper edge together with the gliding characteristics of the scalp skin which provide a better chance to match hair direction between the upper and lower edges especially near the donor tips

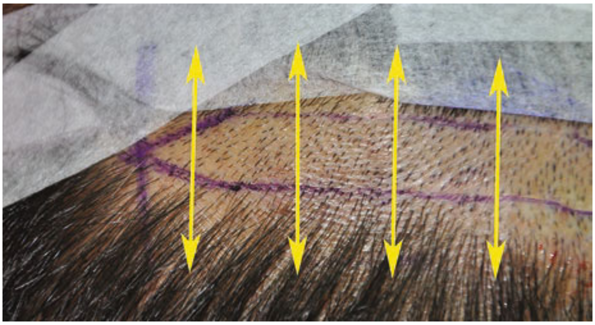

Fig. 22.6 Closing the wound of CED strip is done by simply stitching the upper and lower edges of the wound directly together, leaving no room to align the hair direction between top and bottom

Following donor strip removal, close attention is given to the hair direction near the tips of both upper and lower edges prior to closing the wound. After donor tissue is removed, the hair direction of the upper and lower wound edges usually points outward due to the loss of the skin's tissue tension. This change of hair direction can be even more pronounced when the scalp laxity at the upper edge is greater than at the lower edge due to tissue adherence to the scalp in some patients. This causes the hair direction at the upper wound edge to point outward more than the hair at the lower wound edge. However, with TFD, the longer incision creates extra vectors to match the hair direction between the upper and lower wound edges, especially when the hair direction at the upper wound edge and the lower wound edge is different. With the CED technique, wound closure is accomplished by simply pulling the upper and lower edges directly together with normal stitches, since the use of tangential retention stitches cannot be applied to help match hair direction on the top and bottom edges. Selection of either the CED or TFD strip technique for donor harvesting requires recognition of the natural hair direction for each individual patient.

22.3 Natural Hair Direction

The hair direction pattern originates from the hair whorl of the cowlick [5] and keeps changing until entering the lateral area and varies depending upon the location on the scalp. We have observed a rapid change in hair direction in some small areas of the lateral region. Therefore, hair direction at the upper and lower wound edges has a tendency to be disoriented especially when a wide donor strip is taken. Furthermore, mismatched hair direction can also occur after the loss of tissue tension on the side from which the strip is excised causing an absence of the tissue's ability to hold the hair follicles. The remaining tissue then possesses a greater tension which manifests itself by affecting hair direction to be diverted on both upper and lower wound edges.

Based on our observations [3, 4], we categorize the hair directions over the upper and lower edges of the donor strip tips into three types: outward (O), straight (S),

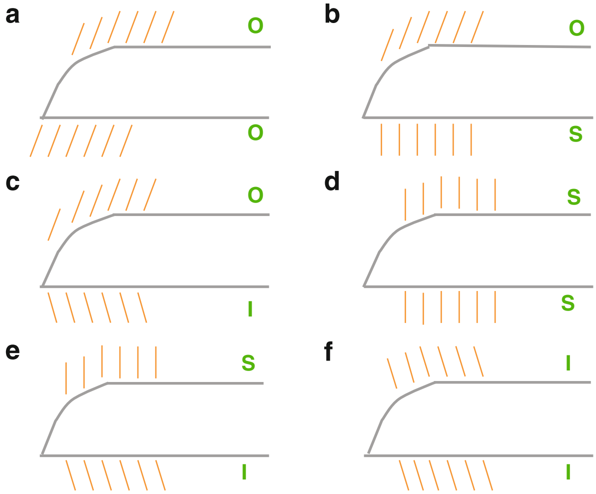

Fig. 22.7 The six combinations of hair alignments perceived in the study. (**a**) Hair direction outward on both upper and lower wound; (**b**) hair direction outward on upper wound and straight on lower wound; (**c**) hair direction outward on upper wound and inward on lower wound; (**d**) hair direction straight on both upper and lower wound; (**e**) hair direction straight on upper wound and inward on lower wound; (**f**) hair direction inward on both upper and lower wound

and inward (I). Thus, there are nine different possible combinations of hair alignment following wound closure, i.e., OO, OS, OI, SO, SS, SI, IO, IS, and II. However, only 6 combinations of alignment were actually detected in this 157-subject study: OO, OS, OI, SS, SI, and II (Fig. 22.7). At the lateral region (preauricular and auricular areas), the most common hair alignment is OS (56.8 and 49.5%), while the majority of SS is found in postauricular and center areas (32.9 and 100%, respectively). Thus, the lateral region has the greatest potential to be the location where a different hair direction pattern between upper and lower wound edges would occur. In our study [3, 4], two blind evaluators independently assessed the outcome of hair alignment using a 5-point visual analog scale (VAS) on photographs that were taken of wounds immediately after closure by retention stitches and running stitches. We found that TFD provided a better overall outcome than CED among all different types of hair directions. For the rare SI pattern found in the auricular area (1.9%), the TFD incision permits the diverting of hair direction on the upper edge when closing the wound. In contrast, the CED incision is beneficial to the II pattern which is found in all locations except the center area, because a change in hair direction is not necessary. However, based on experience gained in this study, the SI and II patterns delivered the worst outcomes, so it is essential to avoid an inward hair direction at the lower edge, making it difficult to align with the upper edge hair direction. Interestingly, patients more than 60 years old allowed easier alignment than seen in the younger age group.

This study provides experimental evidence establishing TFD as the proper donor strip design at the preauricular and auricular areas, since hair direction at the lower

Fig. 22.8 Before TFD incision, hair direction on both upper and lower edges is almost the same

Fig. 22.9 After TFD incision, hair direction on both upper and lower edges would have changed, but with TFD incision, proper hair alignment can be achieved

Fig. 22.10 Before CED incision, similar hair direction is shown on upper and lower edges

and upper wound edges rarely points in the same direction (Figs. 22.8, 22.9, 22.10, and 22.11). The CED technique does not allow proper hair alignment between the upper and lower wound edges in these areas.

Fig. 22.11 After CED incision, both hair directions on upper and lower edges are not properly aligned

Due to individual patient variation, TFD may not be the best solution for all misalignment issues. Also, differences in hair direction between upper and lower edges of the wound in some cases might be too great to match up. Nevertheless, for the majority of patients in this study, the TFD strip technique did, in fact, improve hair alignment at the incision site after the donor strip was removed. Another benefit afforded by TFD is that the scar associated with TFD surgery is minimal in both first and subsequent session patients because with the TFD technique, the design of the donor tips points slightly downward following the contour of the scalp. In contrast, the CED technique may result in more donor tip scarring during subsequent surgeries. By improving hair alignment, the TFD technique enhances the cosmetic appearance of the donor area.

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Chapter 23
Upper and Lower Trichophytic Closure with Wavy Two-Layered Closure for Optimal Hair Transplantation Scar

Kazuhito Yamamoto

23.1 Main Points of This Method

In this chapter, I describe the method currently carried out in detail, but it is necessary to pay attention to the following main points [1–5]:

1. It is necessary to minimize follicle transection and to leave intact hair follicles on the outer excision wound not to contain more follicles in the inner excision strip when donor density is relatively low in Asians. In addition, Asian hair follicles are long, and the scalp is thick and sometimes tight, so donor excision based on the open technique by Dr. Damkerng Pathomvanich [6, 7] is more effective than a blunt technique to avoid transection [8].
2. Trichophytic strips should be very thinly excised depending on individual differences to gain complete protection of the bulge area of the follicles and sebaceous glands [9]. Donor scars also become less visible by maintaining a very shallow excision area in the triangular strips that are cut by scissors. The outline of donor scars becomes vague on the irregular shallow excision area of the apex of the triangular strips.
3. In superficial-layer suture at the intraepidermal and upper intradermal level, the needle enters as perpendicular as possible, not an obtuse angle, to the wound plane, and approximately parallel to the skin surface so that the donor wound becomes wavy eventually. This technique reduces wound tension by dispersing lateral dynamic tension in a longitudinal direction. In addition, the needle should reach a depth no more than 1 mm from the skin surface in the intraepidermis and upper dermis to avoid damage to follicles and reduction of blood flow. Necessary care should be taken to prevent the suture from strangulating the follicles below the upper dermis.

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23.1.1 Donor Excision

The patient lies prone and donor excision is performed by one surgeon and one assistant. The instruments used are two skin hooks, a 2.5× magnifying loupe, and no. 15 blades. This procedure is performed with a field block using 1% lidocaine with 1:100,000 epinephrine (local anesthesia) and dilute local anesthetic including 0.25% lidocaine with epinephrine (tumescent anesthesia) in the subcutaneous and dermal plane.

The donor excision area is scored by superficially incising the skin with a no. 15 blade to a depth of less than 1 mm. A surgeon with a 2-prong skin hook and an assistant with a 1-prong skin hook secure each hook in the epidermis or upper dermis and add countertraction to the incision while lifting each hook upward. This makes it possible to safely incise and peel between follicles without transection. As shown in Fig. 23.1, it is necessary to carefully split each follicle in the same follicular units and groups in parallel along the hair shaft without transection.

23.1.2 Deep-Layer Closure

In deep-layer suturing after donor excision, no additional undermining is performed so as not to impair blood supply. Deep-layer suturing is also used to stop bleeding without leaving any dead space as an electric cautery is not usually used; this prevents donor scars from widening after surgery at the subcuticular level, and the vertical angle distortion of hairs in the scars can slightly decrease although the change in angle of the hairs on skin surface by trichophytic technique cannot be prevented. Deep-layer suturing also simplifies superficial-layer suture further because the distance between the upper and lower wounds will decrease. The up and down side of galea aponeurosis is folded inwardly to match the anatomical structure, while care is taken to avoid vascular injury using continuous or interrupted sutures with 3/0 polydioxanone (Fig. 23.2). Continuous running sutures are used when the strip width is less than 1 cm. Interrupted sutures with triangular or horizontal mattress sutures are used in the case of closure under severe tension, such as subsequent sessions and a strip width of more than 1 cm.

23.1.3 Upper and Lower Trichophytic Technique

The trichophytic strip is divided into two types according to the uniformity on strip width and depth. The ledge trichophytic closure is the method excised with the uniform strip width and depth [2, 10]. I excise the trichophytic strips with the irregular width and depth using scissors so as not to straighten the wound scars.

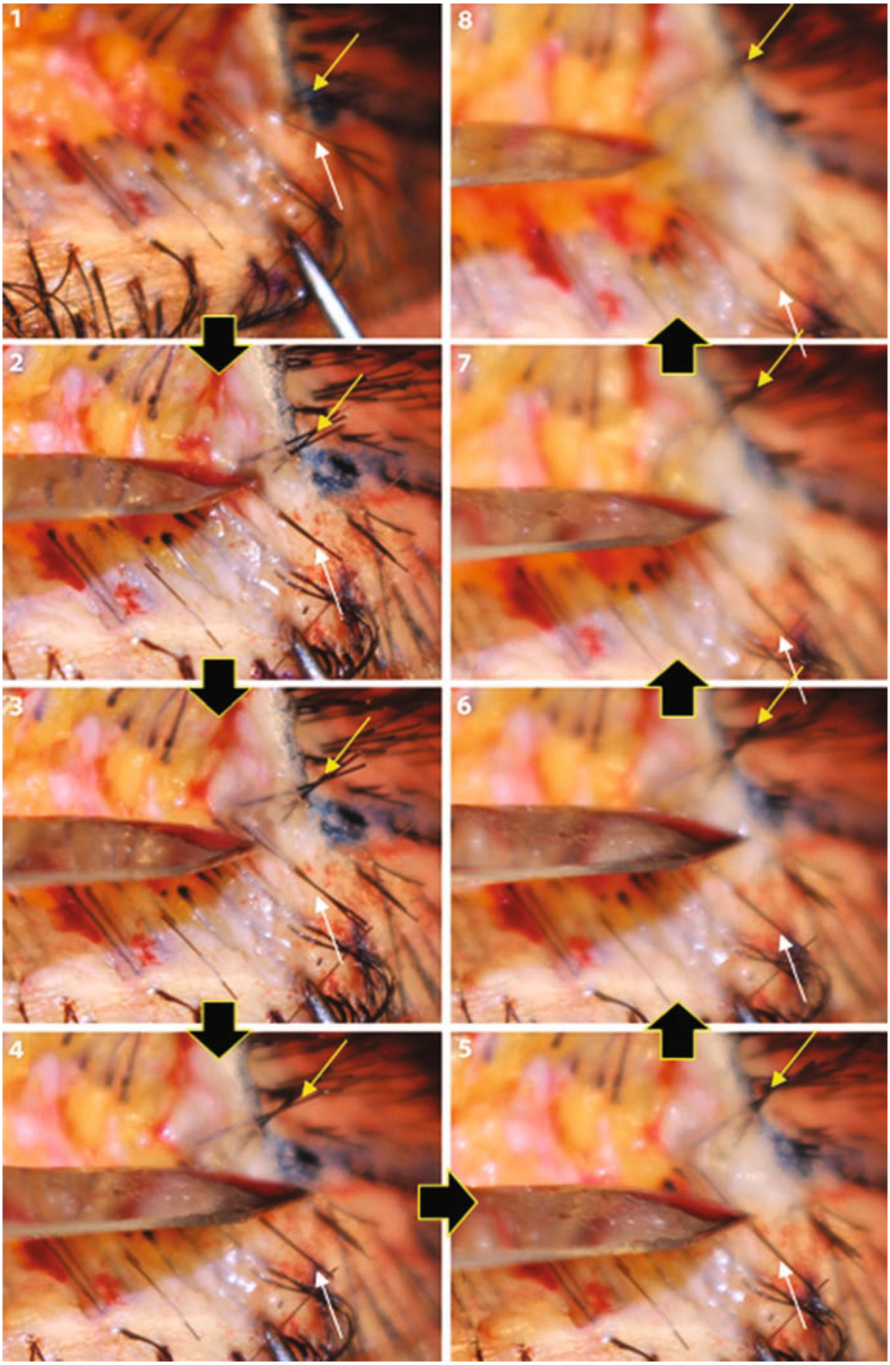

Fig. 23.1 Donor excision. Five follicles in the same follicular group are divided into three follicles and two follicles without transection

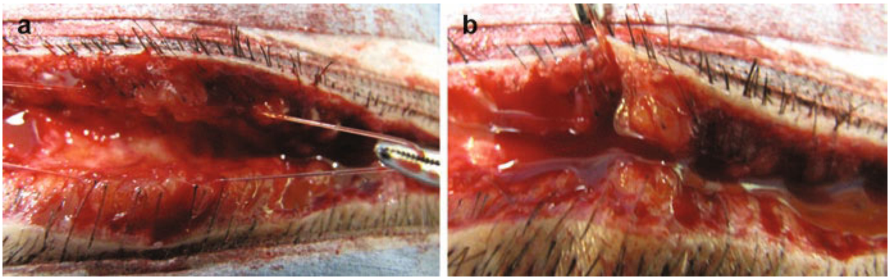

Fig. 23.2 Deep-layer suture. (**a**) An interrupted suture with horizontal mattress suture without injury to follicles and vessels. (**b**) The galea is folded inside

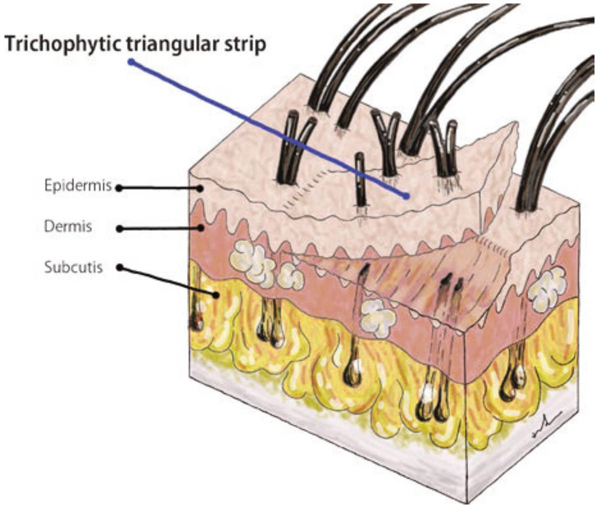

Fig. 23.3 A schema of trichophytic triangular strip using surgical scissors

Thin trichophytic triangular strips are cut 1.0–2.0 mm wide at the lower and upper edges of de-epithelialization, including one to two lines of follicular units, using surgical scissors (Figs. 23.3 and 23.4). There are individual differences in thickness of the skin, but the strips are excised as shallow as possible to protect the bulge area of the follicles and the sebaceous glands. There is no need to make the strip width uniform because faint unclear scars, which are created by adjusting the strip width with scissors at any time, look better than distinct linear scars.

23.1.4 Superficial-Layer Closure

This technique is necessary to maintain upper dermal and intraepidermal sutures through all processes to not damage follicles below the upper dermis and is performed with running sutures with a 5/0 13 mm 1/2 circle polyglycomer absorbable

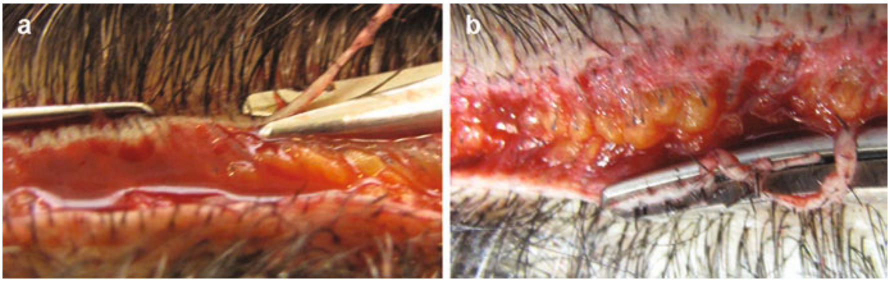

Fig. 23.4 Both-edge trichophytic technique. Triangular strips are excised as shallow as possible. Lower (**a**) and upper (**b**) trichophytic excisions

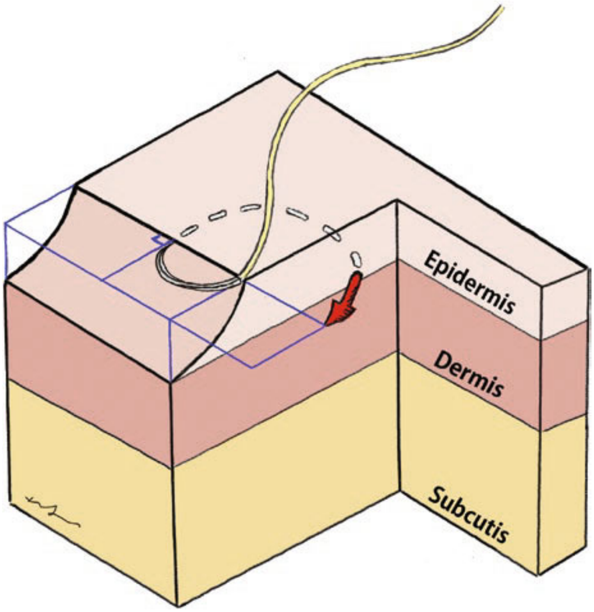

Fig. 23.5 A schema of needle insertion. The needle enters perpendicular to the wound line

suture (Polysorb™). The initial and last knots are buried at the wound ends. With shallow wavy sutures between wound ends, the needle enters perpendicular to the wound line at the boundary between the skin surface and the wound plane and approximately parallel to the skin surface and reaches a depth which is shallower than that of the upper dermis, as the suture forms a big arc and is then pulled from its boundary (Figs. 23.5, 23.6, and 23.7).

The stitches are naturally excreted outside the scalp by the regeneration of the skin in about 3 weeks, but they may be removed during that same period if inflammation develops.

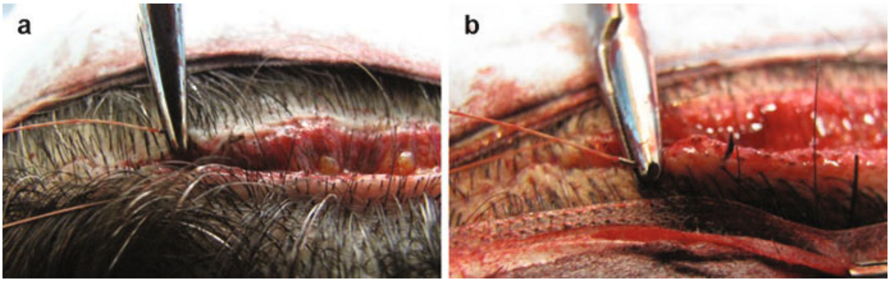

Fig. 23.6 Superficial-layer suture. Lower (**a**) and upper (**b**) sides

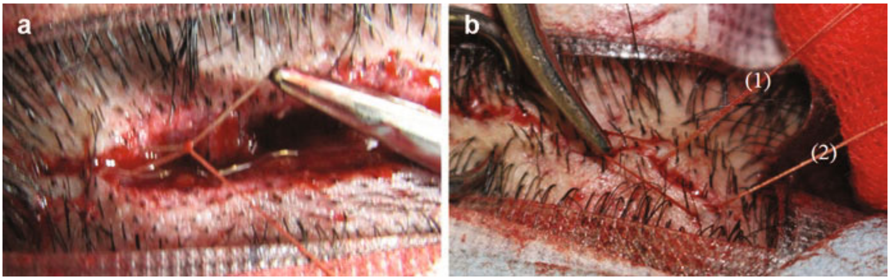

Fig. 23.7 Initial (**a**) and last (**b**) buried end sutures. The threads of (1) and (2) are knotted

23.2 Subsequent Sessions

Differences in color contrast, density, and hair angle between the scar and the surrounding skin depend on the individual and degree of donor excision, but this technique makes donor scars undetectable in most cases, even if the patient's hair at the back of the head is combed upward. Therefore, a new donor excision in a subsequent session can be harvested without including the first scar, due to the potential for widened scars by repeated excisions of previous scars. A second donor strip will be taken at a location approximately 1 cm distant from a previous trichophytic scar (Figs. 23.8 and 23.9). Donor excision including a previous donor scar is usually limited to repairing a previous linear donor scar. When performed near a previous wound in a subsequent session, the strip width is 1 cm or less because scalp elasticity is limited by scarring under the previous donor wound. An excessive excision at the same scar site may result in unanticipated visible scars, and patients are not able to have short hair at the back of the head due to one visible linear wound. On the contrary, when there are multiple invisible scars, a patient will not mind them.

It is important to keep away from previous scars because widening of scars and wound infection may occur due to impaired blood supply and tension to a wound.

In a patient who underwent strip harvesting ten times and received over 7500 grafts (Fig. 23.10), the appearance viewed from the rear is satisfactory despite his

Fig. 23.8 Donor selection in a subsequent session. (1) A scar of the previous year with mild erythema. (2) A wound immediately after the second session separated by a slightly normal skin from the previous trychophytic scar

Fig. 23.9 Donor wound 2 years after a subsequent session. (1) A subsequent donor scar. (2) A previous donor scar

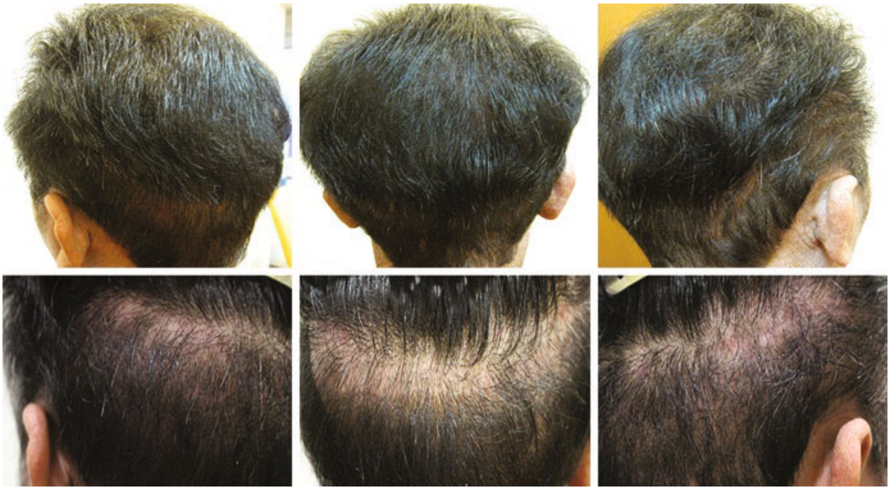

Fig. 23.10 Postoperative view after ten donor excisions for a patient with Norwood class VI

short hair and is by no means inferior to that made by several follicular unit extractions (FUEs) with the same number of grafts.

23.3 Postoperative Management

Patients are instructed to perform up and down massage around the wound and to gently peel scabs caused by folliculitis, which may occur due to new hair growth through a wound scar for 3 months after suture removal, when washing their hair. In my experience, the use of postoperative oral minoxidil is also effective for preventing excessive hair shedding and promoting early hair growth in a donor wound.

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Chapter 24
Asymmetric Dermal Suture (Deep Suture of the Two-Layer Closure)

Dae-Young Kim

24.1 Trichophytic Excision (2 mm in Width and 0.5 mm in Depth) Using Razor Blade

The effectiveness of the trichophytic closure is that it allows hair to grow through the donor scar making the scar less visible [1]. During the trichophytic excision with scissors or blade, sebum released from severed sebaceous glands is mainly responsible for causing several problems including severe inflammation, pustules, and cysts [2]. I have found that the depth of the sebaceous glands from the skin surface varies between 0.5 and 2.7 mm [3]. Therefore, when the depth of the trichophytic strip is 0.5 mm or less, all sebaceous glands are preserved intact. I created a trichophytic removal device to shorten the time required for the de-epithelialization step of the trichophytic closure and to obtain thinner trichophytic strips than those produced when scissors or blades are utilized. A 5 cc syringe is used as a blade handle. A bent half of the razor blade is inserted into the syringe lumen and securely wedged into the inner wall of the syringe (Fig. 24.1) [4]. The exposed sharp blade is then used to cut at a uniform depth less than 0.5 mm (Fig. 24.2). I believe that if the trichophytic strip excised is maintained at a depth of 0.5 mm or less, all sebaceous glands will be preserved, and problems with donor wound (inflammation, pustules, and cysts) can be dramatically reduced [2].

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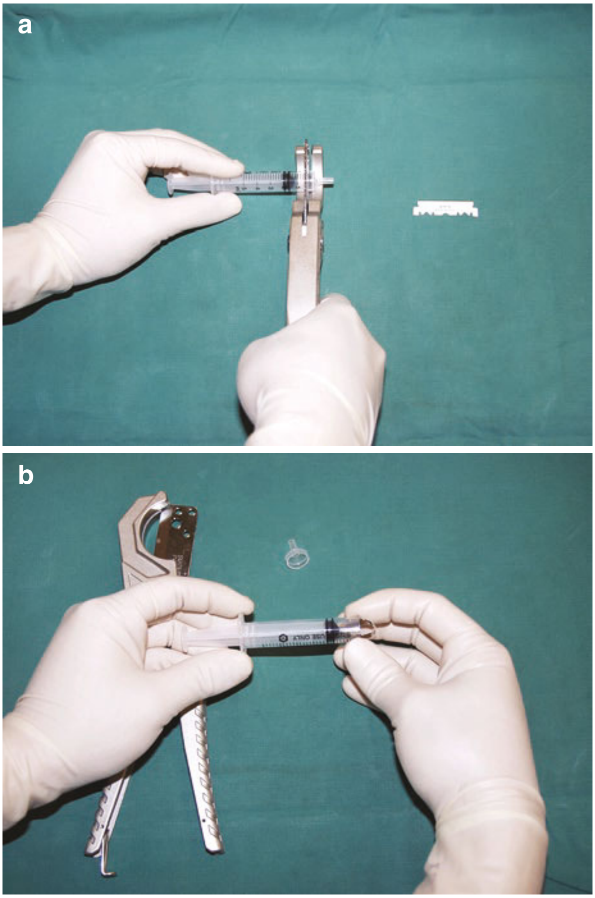

Fig. 24.1 Create a trichophytic removal device. (**a**) The handle is made by cutting off the neck of a 5 mL syringe with a PVC pipe cutter. (**b**) A bent half of the razor blade is inserted into the syringe lumen and securely wedged into the inner wall of the syringe

Fig. 24.2 Tight skin hook tractions are needed to obtain thinner trichophytic strips. A razor blade, which is a lot sharper than most scalpels, creates a thin, smooth, and clean cut

24.2 Method of Asymmetric Dermal Suture (Deep Suture of Two-Layer Closure)

My typical two-layer closure technique involves closing the dermal space using an asymmetric suture technique in which one side is distinctly higher than the other side. After the trichophytic strip (2 mm in width and less than 0.5 mm in depth) is excised, asymmetric dermal suturing is performed using a 4–0 Vicryl® suture, with the first bite being taken in subcutaneous fat layer of the upper lip and exiting approximately 2 mm below the skin surface. The needle is then reinserted at the inner border of the de-epithelialized edge of the lower lip, exiting 2 mm below the skin surface. To minimize strangulation injuries, the needle is inserted and removed vertically and parallel to hair follicles. The knot is tightened to pull both margins in the deep subcutaneous tissue, leaving the upper lip 2 mm higher than the lower lip (Fig. 24.3). The tension is fixed as the knots are tied. Sutures are placed every 2.5 cm, which is close enough to approximate both upper and lower wound margins

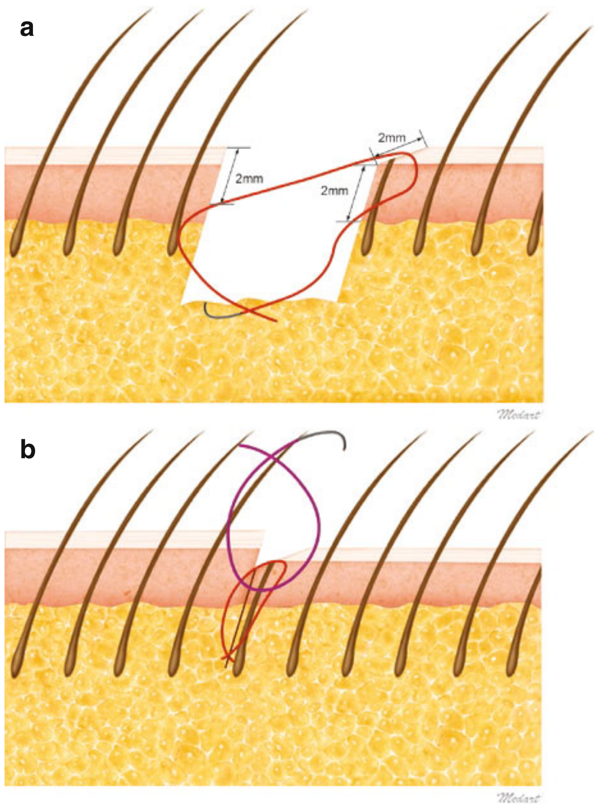

Fig. 24.3 Diagrams. (**a**) Asymmetric dermal suture (deep suture of two-layer closure). (**b**) Trichophytic closure after asymmetric dermal suturing

between sutures but far enough apart to avoid too much damage to follicles along the wound. Continuous skin suturing is performed to complete the trichophytic closure using 4–0 nylon (Fig. 24.4). Complications of buried sutures such as foreign body reaction, local infection, and long-standing inflammation can be minimized through the following three alterations to the process. Place the knots in the deep subcutaneous tissue, tie two instead of three consecutive square knots, and use Vicryl® 4–0 suture. Keep the ties small to minimize strangulation injury to the hair follicles by the dermal bites. Bearing this in mind, I try to advance the needle within 1–2 mm from the donor wound margin (Fig. 24.3). At a 1-year follow-up assessment, trichophytic closure was shown to allow the hair to grow through the donor scar and therefore make the linear donor scar less visible (Fig. 24.5a). Several small white spots along the donor scar are apparent where the knots of asymmetric dermal sutures were placed, but this is so minimal as to be considered barely evident (Fig. 24.5b).

Fig. 24.4 Trichophytic closure of wide donor wound (2.5 cm wide at the midline) after asymmetric dermal suturing; the suture thread is pulled upward, allowing the lower lip to slide underneath the upper lip

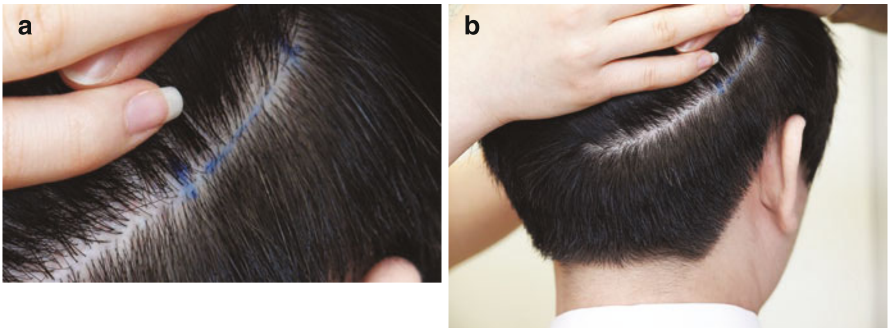

Fig. 24.5 Same photos of 1-year follow-up appearance of asymmetric dermal suturing followed by trichophytic closure of donor wound (2.3 cm wide at the midline). The line indicates virgin scalp lateral to the donor scar. (**a**) Three times enlarged view, trichophytic closure allows hair to grow through the donor scar. (**b**) 2 m distance view, demonstrating near-invisible donor scar

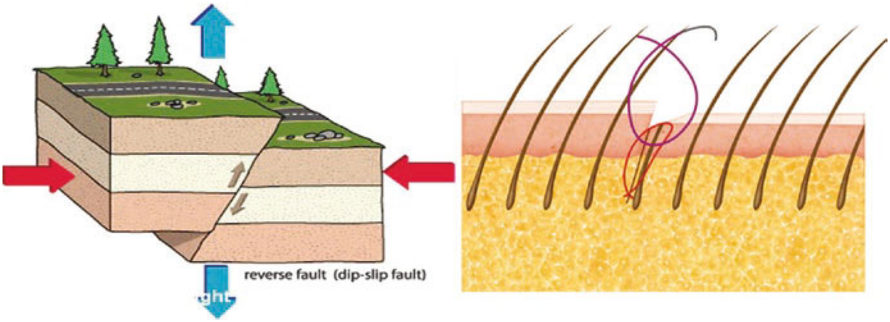

Fig. 24.6 Comparison of the fault: a planar discontinuity in a volume of rock, across which there is significant displacement along the fractures as a result of earth movement and asymmetric dermal suturing of two-layer closure

24.3 Principle of Asymmetric Dermal Suture

The asymmetric dermal suture, by transferring excessive tension from the superficial level to the deep dermal level, facilitates the tension-free skin closure and produces a faulting effect, with a 2 mm elevation of the upper lip. Thus, the 2 mm wide trichophytic excision on the lower wound edge fits perfectly with the 2 mm elevated upper lip edge (Fig. 24.6).

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Chapter 25
How to Approach Donor Harvesting in Wavy Hair

Ahmed Adel Noreldin

25.1 Introduction

A major consideration in hair restoration surgery in patients with wavy hair is the almost constant curvature of the hair follicle. The wavy hair shaft is thicker in diameter than the straight hair shaft and has an elliptical cross section in contrast to the straight hair which has a round cross section. Thus the shaft is flatter and more prone to curve (Fig. 25.1). Another contributing factor to being wavy is the more horizontal orientation of hair follicles in relation to skin surface, which differs from the rather vertical orientation of straight hair follicles. Therefore, each shaft grows in a tiny spring-like helix shape (Fig. 25.2). The overall effect is such that despite fewer hair shafts per cm2 than with straight hair, curly hair appears and feels denser and fuller than straight hair (Fig. 25.3). Wavy hair may reduce UV light exposure to hair bearing surfaces, which may explain the prevalence of wavy hair in darker skin races living at or near the equator [1].

Wavy hair is more vulnerable to physical damage including breakage than straight hair due to its dense curl and shape. Wavy hair requires particular attention to moisturizing and of all hair types suffers most from grooming issues. The frequency of hair treatments intended to straighten the curls compounds this problem. In a study of 874 South African adults, almost 60% of the women in the study had chemically treated hair, and 32% suffered from traction alopecia [2].

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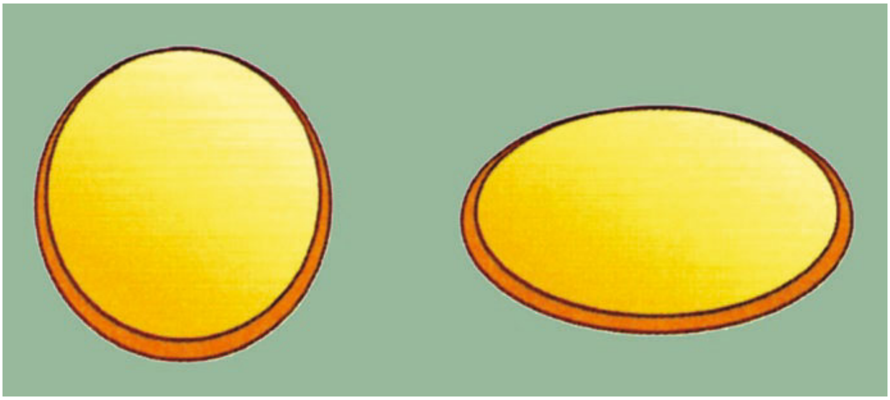

Fig. 25.1 Cross section of terminal hair. It is round in straight hair (*left*) and elliptical in wavy hair (*right*)

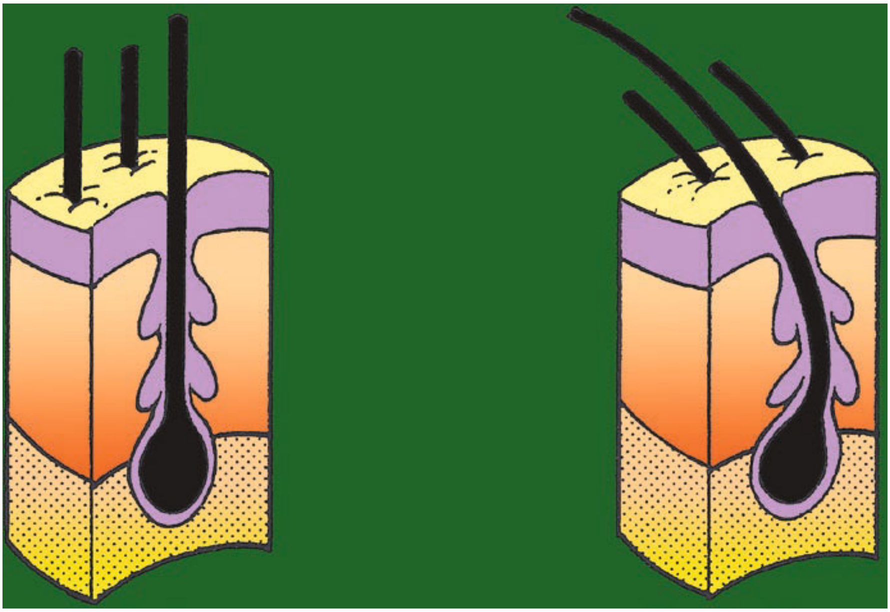

Fig. 25.2 Straight hair follicle (*left*). Wavy hair follicle (*right*)

25.2 Benefits and Hazards of Curly Follicles in Hair Transplantation

Curly hair provides better coverage than straight hair as it has more spatial volume. It tends to rise from the scalp leading to more volume and providing more fullness in contrast to straight hair which is finer and tends to lie flat against the scalp.

Fig. 25.3 Curly hair appears and feels denser and fuller than straight hair

Moreover, curly hair is thicker than straight hair; a single unit of thick hair (> 80 μm) has more coverage capacity than a double or triple unit of fine hair (<60 μm). Therefore, in evaluating the required number of grafts for a hair restoration procedure, the total number of grafts can be reduced up to 50% while achieving same coverage capacity [3].

A negative aspect of curly hair is that donor harvesting is more challenging because the curl of the hair continues beneath the skin and it is difficult to see or predict its path. Therefore hair shaft transection can occur with a greater frequency in curly hair.

25.3 Donor Harvesting in Curly Hair

As the wavy hair is curly from top to bottom, it is more prone to damage which can lead to poor growth of the transplanted hair. Since extra care is needed, curly hair can also take a longer time to be transplanted.

25.3.1 Recommendations for Strip Harvesting

Harvesting the donor area as a large ellipse, as described by Limmer [4], would theoretically obtain the highest yield [5]. Extreme care should be taken while incising the strip to avoid transection. This technique is superior to using a multibladed knife which cuts blindly through the skin causing more transection. If the surgeon chooses to use a multibladed knife, the spacer sizes should be larger (2–3 mm) to guard against transecting the follicles. The process of slivering and trimming of

Fig. 25.4 Hair follicles from a patient with wavy hair showing curls and splaying at base

Fig. 25.5 Preoperative (**a**) and 9 M postoperative (**b**) of a wavy hair candidate (a strip with 2000 units was performed in one session with good coverage)

follicular units should be performed under magnification with a good back light to respect the directions and splaying of the roots (Fig. 25.4).

An experienced surgeon with a good team is mandatory to guarantee a good yield of follicular units from the obtained ellipse. Independent of graft size, the curly nature of the follicles will give an aesthetic appearance of greater coverage (Fig. 25.5).

It should be emphasized that a thorough history has to be obtained before considering strip technique in wavy hair candidates as most of them have a darker skin complexion with a higher incidence of scar hypertrophy and keloid formation. Observation of preexisting scars can be of value; some surgeons prefer to perform a test graft before alopecia correction in high-risk individuals.

25.3.2 Curly Hair Considerations in FUE

As the follicular units of curly hair are more prone to transection when advancing a straight punch, the Fox test is advisable prior to committing to the procedure. The test, as originally described by Rassman [6], helps to determine if follicles can be removed intact to know if the candidate is suitable for FUE. With very curly hair, it may be helpful to use a slightly larger punch (1–1.2 mm) to score the skin superficially, and then a blunt punch is introduced deeper towards the base as this will be more forgiving and reduce transection. Alternatively, using a sharp punch with minimal advancement (≤2 mm) followed by delicate two-handed removal technique, will usually yield intact follicles. This technique requires an experienced and well-trained surgeon.

25.4 Practical Tips

On average I perform 20 cases of hair transplantation per month, among them the percentage of wavy hair is about 25%, thus I deal with five cases having different grades of curly hair every month. The choice between strip technique and FUE is case dependent after discussing all aspects with the candidates, but it is now evenly split with the incidence of FUE increasing regularly.

What I stress in performing FUE in curly hair is not to rush. In my centre we usually extract 650–750 FUs per hour in straight hair cases, and this figure will drop to only 500 or less in curly hair patients. Performing the Fox test for the first 50 extractions is necessary to adjust the depth and size of the punch (Fig. 25.6). I find the use of sharp serrated punches designed and manufactured by Cole instruments to be very helpful. For curly hair I usually use larger sizes, e.g. 1.0 or 1.2 mm punches in contrast to our regular 0.8 or 0.9 mm punches for straight hair. The depth of penetration is rarely more than 2 mm, and this is set in accordance with the results of the provisional Fox test. Sometimes this depth is not deep enough to set the FUs free of attachment, but it is safer lest the splayed roots should be transected. In this situation a very careful two hands technique to extract the FUs is necessary. Following these tips the transection rate is less than 5%. We have not seen problems with wound healing in the donor area, and in those cases that needed a second pro-

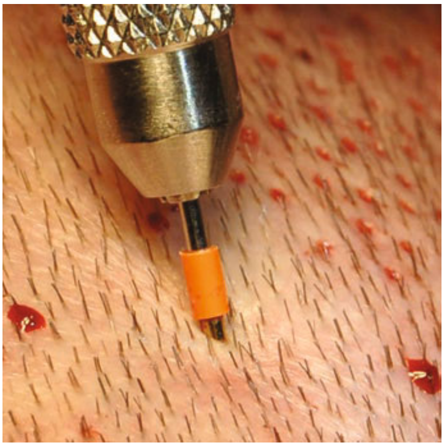

Fig. 25.6 Follicular units of curly hair are more prone to transection when advancing a straight punch

cedure, we rarely saw hypertrophic scars or other wound healing complications. Positioning the patient in a special chair designed for FUE, we can implant the extracted FUs simultaneously with extractions. This compensates for the longer extraction time and reduces the storage time of the grafts, thus providing a better outcome.

When performing the strip technique in curly hair candidates, I pay a great deal of attention to have a layered tension-free donor wound closure. This lessens wound healing complications which are more common with darker skin. If excess wound tension is noted, we inject collagenase at the wound edges and 2 units of Botox at 1.5 cm intervals about 7 mm from the wound edges. We use magnifying loops and tumescence to avoid transection during cutting the mono-block of tissue. Slivering and FU trimming are performed under magnification using a good source of back-light. In the hands of experienced assistants, the transection rate is almost zero, although the process is slower than with straight hair cases.

25.5 Pearls for Better FUE in Wavy Hair

1. During the consultation avoid promising large numbers of grafts. Remember the covering density will be reasonable due to the curly nature of the follicles.
2. Be prepared for a longer extraction time as compared to straight hair.
3. Donor hair should be shaved by electric shaver to number zero, while patient is positioned in a specially designed chair (Fig. 25.7).
4. Accurately mark the safe donor area and divide it into equal squares.
5. Tumescent local anaesthesia is given sequentially in the squares. Minimal fluid is injected, usually 2 mL per square cm.
6. I prefer to use the sharp serrated punches designed and manufactured by Cole instruments mounted to a Vortex rotatory machine designed by the same company. The serrations serve to precisely extract an intact unit without torsion.

Fig. 25.7 Patient is positioned in a specially designed chair

7. The Fox test is performed on the first 50 grafts to adjust size, direction and depth of the punch. The initial size is usually 1 mm or even 1.2 mm, and the final depth of penetration of the punch is usually around 2 mm. This larger size punch is essential to avoid cutting the splayed roots of the units in wavy hair.
8. Don't expect spontaneous pop-up of the FUs due to the limited depth used, so careful two hands technique is essential to get intact FUs. The units are stored in petri dishes on an electric cooler at a temperature of 5 °C.
9. Usually we harvest about 450–500 grafts per hour. Patients should have a rest and/or back massage while seated on the chair every hour, and this also gives the surgeon some time to relax.
10. The design of the chair used allows another team to implant grafts into the recipient area at the same time, saving time and decreasing the storage time of the grafts and thus enhancing the results.

25.6 Pearls for Better FUT in Wavy Hair

1. Accurately design the donor mono-block in the safe donor area.
2. Tumescent local anaesthesia is given, and the block is carefully and slowly harvested using # 15 blade under magnification avoiding graft transection under visual control.
3. Multilayered closure without tension is essential to avoid healing complications; collagenase and botulinum toxin injections should be available to use if tension is experienced on closure.
4. Experienced sliverers and cutters using microscopic magnification and ample backlighting are essential to produce intact FUs.

25.7 Conclusion

Donor harvesting in wavy hair is a critical issue for the success of the procedure of hair transplantation. Either of the two major techniques, strip or FUE, can be successfully performed if the surgeon is aware of the hazards existing in dealing with the curly nature of the follicles. The surgeon has to be experienced enough to use the essential tricks to have a successful outcome.

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Part VI
Donor Harvesting: Follicle Unit Extraction (FUE)

Chapter 26
FUE: Basic and Advanced Techniques

Koray Erdogan

26.1 Introduction

FUE, the hair implantation technique that removes follicular units from the skin one by one with manual or motorized systems, has experienced significant development since it was first introduced in the early 2000s. Initially, it was considered solely an acceptable procedure for limited conditions with only small graft numbers and then, just in some isolated cases [1].

Since then, FUE has progressed and has been refined to include artistry and great precision, thus providing patients with natural-looking hairlines, adequate coverage and density, and, above all, homogenization:

> As a result of FUE, the definition of hair transplantation has virtually changed, and homogenization has become the new standard for evaluating hair transplant results.—Koray Erdogan (2014)

FUE continues to be in constant evolution with great strides being made in body hair FUE and non-shaven FUE techniques. However, what remains the most amazing aspect of this evolution to date is the capability of transplanting large numbers of grafts in just a few sessions called "mega-sessions."

26.2 Homogenization

As FUE advanced and progressed, one of the major hurdles was recognized as being the ability to harvest enough follicles to create a more natural or homogeneous illusion of density. This differed greatly from the FUT technique, where a

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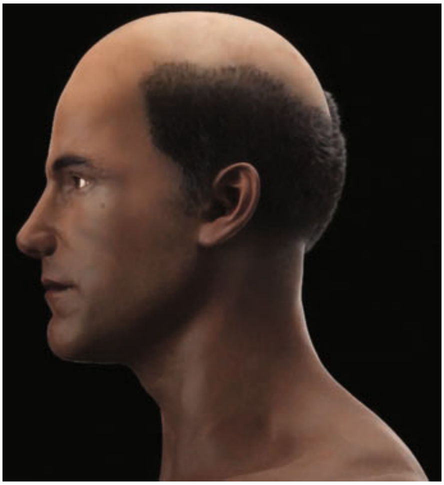

Fig. 26.1 Animated photo showing a Norwood VI patient with a 7000-graft capacity prior to surgery

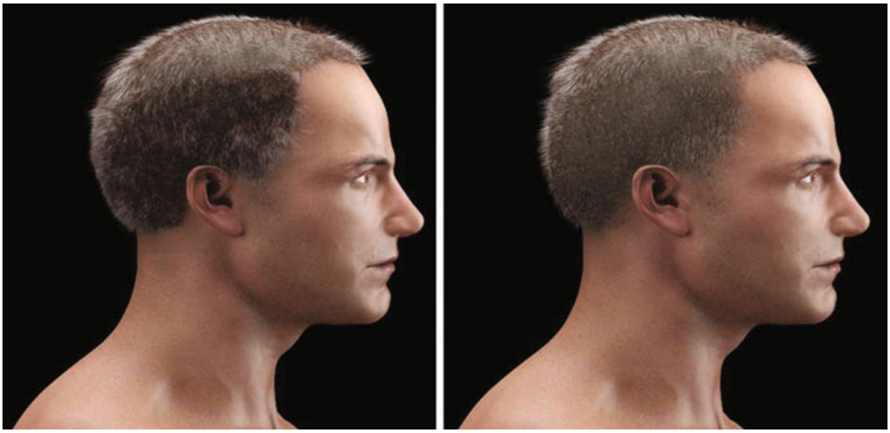

Fig. 26.2 Results comparison of FUT and FUE techniques (profile view). The animated photo shows the same Norwood VI classified patient after a 7000-graft implantation. The growth rate is the same using FUT and FUE techniques. In these animated results, on the left, the patient has undergone a FUT procedure that clearly demonstrates relatively high density remaining in the donor area after the surgery. On the right, the patient has undergone a procedure where the density has been decreased by FUE extraction

flap of scalp is removed from the donor area leaving the density of the remaining scalp areas the same and demonstrating a defined line between the areas of density (Figs. 26.1, 26.2 and 26.3).

With greater potential for more natural-looking hairlines than with FUT, FUE pioneers turned their attention to the donor area and began to devise methods of refining the procedure to achieve their objectives. As a consequence, homogenization became the norm, accomplished through new innovative tools and careful surgical planning.

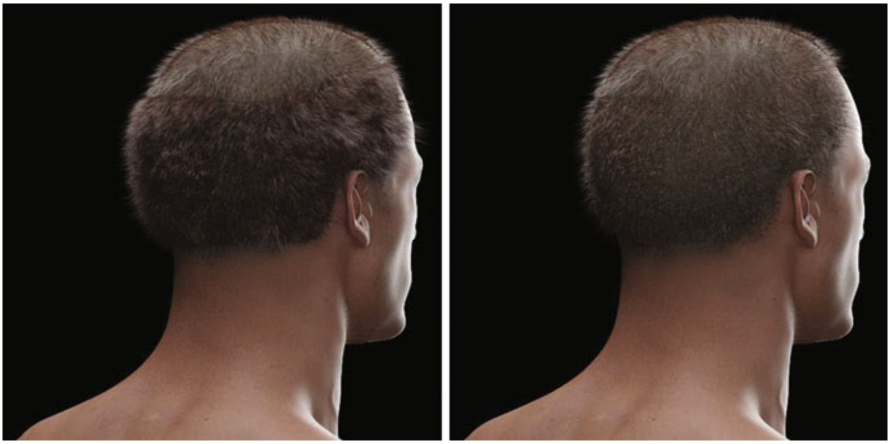

Fig. 26.3 Results comparison of FUT and FUE techniques (rear view). By decreasing the density of the donor area in the FUE procedure, the contrast in density between the donor and recipient areas is also decreased, thereby creating greater homogenization. In the FUT procedure, there is no homogenization, and the distinction between the donor and recipient areas is clearly evident. Therefore, homogenization with FUE creates a better illusion in the recipient area, especially in Norwood VI cases

More recently, FUE has advanced to become a highly refined and sophisticated technique, especially in limited donor capacity patients or Norwood V and VI patients, where hair transplantation is becoming the art of creating new illusions, and the impression of higher density is the expected outcome. This semblance can only occur when the concept of homogenization is fully implemented, all potential donor areas are utilized, and extraction takes place in precise balance, integrating all presurgical patient data such as hair/graft average and grafts per cm^2 with variations in the punch size. In this way only can the donor area be decreased in a homogenous and highly natural manner.

26.3 FUT and FUE Comparisons

Today, hair transplant surgeons can make use of both the FUE and FUT techniques to transplant large numbers of hair follicles. In both types of procedures, the donor capacity is roughly the same as is the growth rate.

Besides the ability to homogenize (an advantageous factor with FUE), there are other differences between the two procedures. The average hair per graft is 2.0 with FUT, while with FUE, more controlled graft select ability renders an average hair per graft count of 2.2.

Additionally, many patients report higher levels of pain and discomfort with FUT due to swelling on the area where the strip tissue was removed. The use of the FUT strip extraction method typically results in a very narrow linear scar in the back of the head.

Table 26.1 Comparing FUT with FUE

	FUT	FUE
Donor capacity	3000–10,000 grafts	4000–10,000 grafts
Average hair per graft	~2 hair/graft	~2.2 hair/graft
Regrowth rate	Same	Same (in good hands)
Pain heading	Good	Less pain-faster healing

With no stitches required and no linear scar left to heal, FUE procedures have a faster healing time and less post-procedure discomfort compared to the traditional FUT procedure. Also, since FUE procedures involve removing hairs individually from the scalp, there is no linear scarring. However, there will be tiny 1 mm in diameter or less puncture marks that tend to heal by themselves after scabbing over in the days following the procedure [2]. These tiny wounds typically heal within 3 to 7 days. See Table 26.1.

26.4 Basic FUE

The overall premise of FUE is that grafts must be kept relatively small in size and in large numbers. In order to accomplish this feat, specific instruments had to be developed to assist with extraction and implantation. Increasing the number of grafts per surgery required skill and eventually, even speed. With these developments emerged other issues such as how to minimize scarring, diminish damage and trauma to the follicles, preserve the donor area, and maintain the viability of the graft outside the body. These were just some of the trepidations that were addresses as the technique advanced.

26.4.1 FUE Instrumentation: Manual Punch

During an FUE procedure using the manual punch, individual follicular unit grafts are manually harvested one at a time using a small cylindrical tool with a hollow sharp end and a handle [3]. The punches, ranging in size from 6 to 1.2 mm, penetrate the skin around each follicular unit thereby detaching them from the soft tissue that anchors them. Penetration is most effective when performed perpendicular to the skin's surface, while depth and extraction should be performed at a right angle to the skin to avoid unnecessary scarring (Fig. 26.4).

Removal of hair follicles in FUE depends on two forces. One is the axial force or the inward pressure on the skin. The second is the tangential force created by rotation or oscillation. Both forces vary with the degree of sharpness or dullness of the punch and the skin type of the patient [3] (Fig. 26.5).

Sharp punches, more appropriate for thick-skinned patients, generally reduce unintentional follicle transection or amputation of the follicles, often resulting in damage to the follicle and impaired follicular survival [3]. On the other hand, dull or blunt punches can accomplish the same by enveloping hidden follicular units

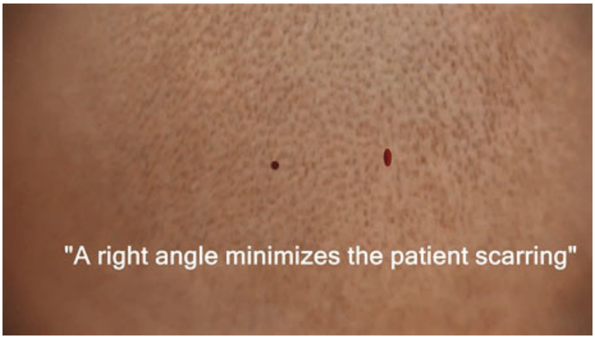

Fig. 26.4 Scarring using a manual punch at right angle

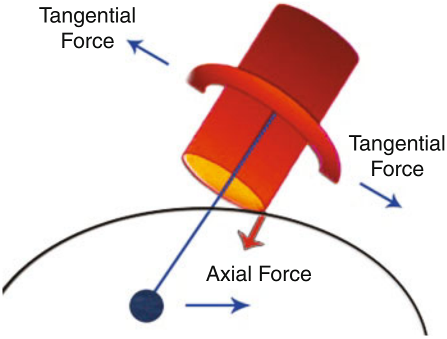

Fig. 26.5 Tangential and axial forces

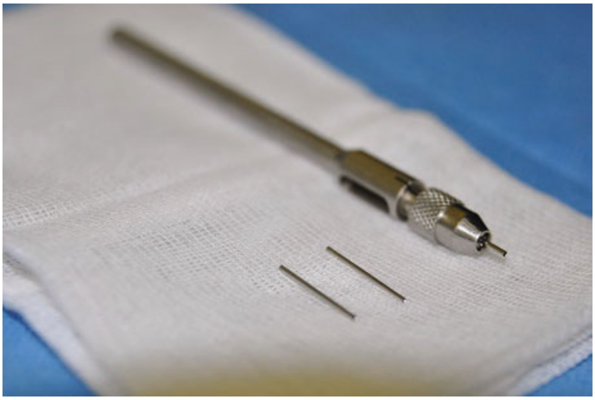

Fig. 26.6 The manual punch

while separating them from the surrounding soft tissues. This process is typically referred to as "blunt dissection" (Fig. 26.6).

In addition to the sharpness or dullness of the punch, the cutting surface can be either smooth or serrated (Fig. 26.7).

The outside diameter punch, also called the inside bevel punch, is a smooth punch where the cutting edge is located on the external surface of the punch wall [4]. This punch is ideal to avoid splay, the divergence of follicles from one another. On the other hand, serrated punches offer many points of contact with the skin,

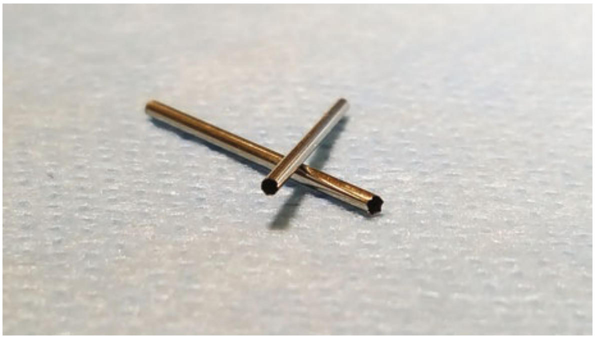

Fig. 26.7 The serrated punch

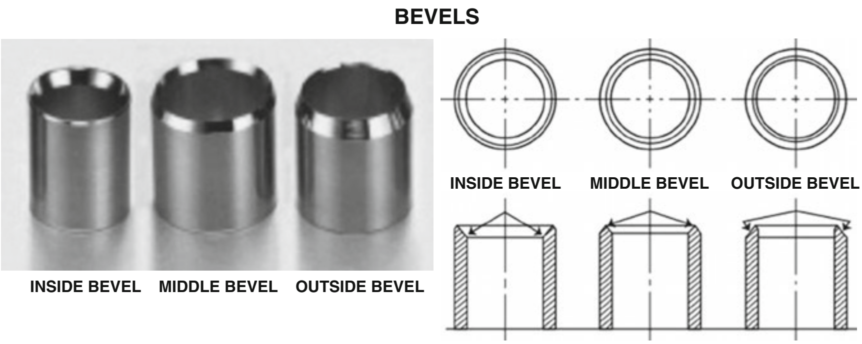

Fig. 26.8 The inside bevel punch

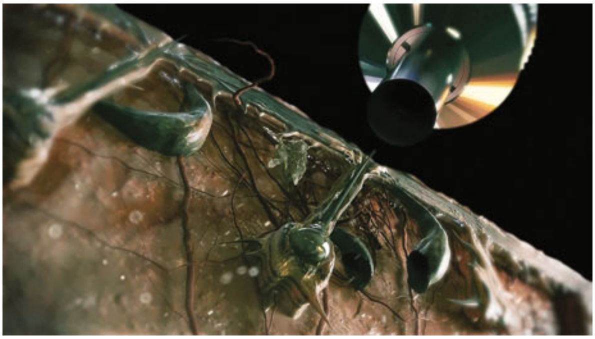

Fig. 26.9 FUE extraction using a manual punch

therefore reducing (1) the cutting surface in contact with the skin at multiple angles and (2) friction (Fig. 26.8).

The manual punch is used by rotating the punch back and forth between the thumb and forefinger while at the same time applying pressure in order to score the skin tissue to a desired depth of between 3.5 and 4 mm. Once the desired depth is reached, the graft is gently extracted using forceps. This requires expertise to avoid damage to the follicle (Fig. 26.9).

Fig. 26.10 The motorized punch

26.4.2 FUE Instrumentation: Motorized Punch

Motorized FUE devices harvest follicular units via a sharp or blunt-tipped punch, as does the manual punch. However, with the motorized version, the hollow punch is attached to a small motor rather than a manual handle. The device has a rotation of between 100 and 15,000 revolutions per minute and is operated via a button or a foot pedal. Depending on the motor, the punch is either spun (rotated) continuously in one direction, or it oscillates (alternates) back and forth in opposite directions. When placed around a follicular unit, the rapid spinning motion of the motorized punch allows for fast scalp puncture and graft separation without manual force from the operating hair transplant surgeon.

While early versions of the motorized punch resulted in decreased yield due to the strain put on the follicular units through rapid rotation, tension, torsion, heat, and friction, improvements somewhat resolved these issues by decreasing speed, minimizing the size of the arc pattern made by oscillation, and switching from rotating heads to oscillating heads. The most recent of these devices allows surgeons to remove a large number of grafts per hour with low transection rates and high yields, but does not allow the tactile feedback to the surgeon, and this can result in follicular damage [5] (Fig. 26.10).

26.4.3 FUE Instrumentation: Robotics

The robotic device uses a two-step process where a sharp V-shaped punch first pierces the skin followed by an unsharpened rotating punch that penetrates deeper into the tissue to liberate the graft. The robotic device is an automated system that evaluates follicular unit density, hair angle, and proper depths of sharp and unsharpened punch insertion, based on the physician's input data. In this way, the device has the capability to suggest which units should be targeted and it can then be aligned

Fig. 26.11 The robotic device

in the proper direction for dissection. The grafts are then harvested using a tension device and removed with forceps [6].

The robotic device typically requires much less expertise, artistry, and understanding of homogenization on the part of the surgeon. Its usage is also limited to a patient's suitability (straight, dark hair). Many patients require an extended donor area, and robotic devices are capable of extractions solely from the backs and sides of the head. Typically larger punches used to extract follicles can also damage nearby follicles, and graft survival rate is lower than with an experienced surgeon (Fig. 26.11).

26.4.4 Graft Placing Instruments

Generally, the placing of grafts during FUE procedures is performed using two different methods. In the first method, pre-made incisions are made with a tiny blade or needle throughout the recipient area, and then the grafts are gently placed into the incisions with either forceps or a placing instrument. See Figs. 26.9 and 26.10.

Diversely, in the second method, an implanter pen device is used that both incises and then plants with the creation of one implantation site at a time with only one step (Figs. 26.12 and 26.13).

The implanter is a pen-like device with a hollow needle attached to a tube/plunger apparatus. During graft placement using this device, several extracted follicular units are loaded into the implanter. The implanter is loaded by grasping the upper portion of the graft (epithelial region/infundibulum) with forceps and gently placing them into the

Fig. 26.12 Forceps used for placing with pre-made incisions

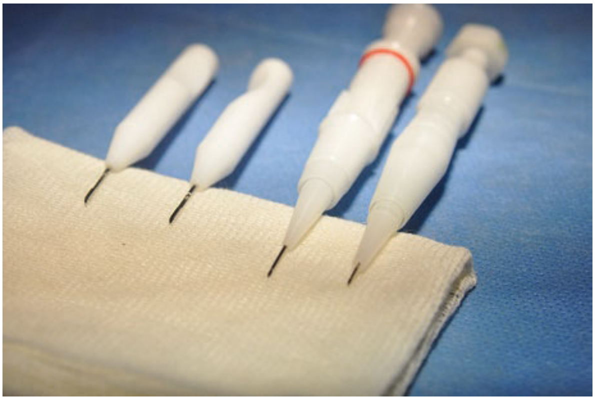

Fig. 26.13 Placing device used with pre-made incisions (*left*), an implanter used without pre-made incisions (*right*)

Fig. 26.14 Incising and placing grafts using an implanter

hollow needle. The surgeon then inserts the implanter into the scalp using the appropriate angle and implants the graft by pressing down on the plunger [7] (Fig. 26.14).

26.4.5 Specific FUE Terminology

Anchor System—This defines the structure that impedes the extraction of the follicular group from the surrounding tissues. The follicular adherence includes the sebaceous gland and the insertion of the arrector pili muscle, the attachment of the

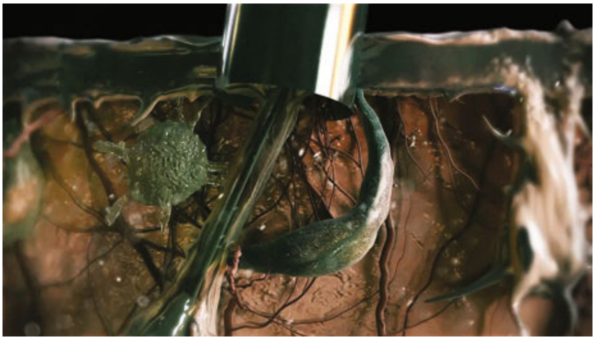

Fig. 26.15 Anchor system showing the sebaceous gland

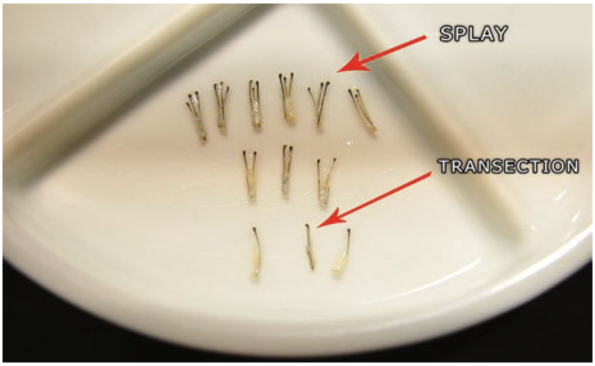

Fig. 26.16 Splay and transection

dermis, and the connection between the connective tissue sheath and the surrounding adipose tissue [4] (Fig. 26.15).

Splay—This describes divergence of follicles from one another, typically occurring at the lower one-third of the follicular unit. The degree of splay is widely varied from no splay to substantial splay. Splay may involve one follicle within a group or all follicles within a group [4] (Fig. 26.16).

Transection—This is a term used to report any microscopically visible breakage of a follicle anywhere along its entire length. A graft can be completely transected when all the follicles are cut transversally or a partial transected graft when one or more follicles are cut leaving one or more intact follicles. Transection rates should not exceed 3% [4] (Fig. 26.17).

Splitting—This is the action of separating with the punch in vivo (or in situ) a portion of the follicles from a group (follicular family or follicular unit). The extracted graft will contain fewer follicles than are in the group. Splitting can be produced deliberately or unintentionally [4] (Fig. 26.18).

Beard Hair Transplant—Donor follicles are harvested from the beard area on the face and neck of a patient. Beard hair transplants have a higher yield than other sources of body hair and a much faster rate of growth than other sources of body hair [4].

Body Hair Transplant—Donor Follicles are harvested from any region of the body except the traditional scalp donor areas. Body hair includes all hair inferior to and inclusive of the neck and beard. Body hair has an unpredictable and variable yield [4].

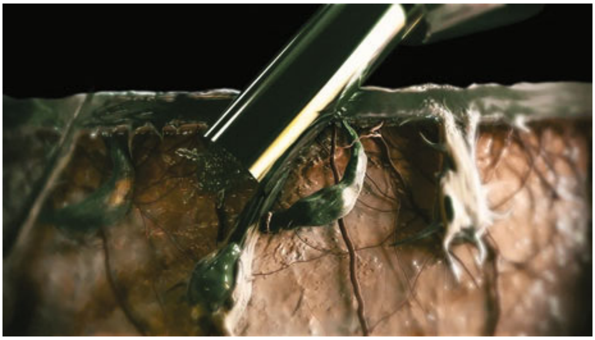

Fig. 26.17 Transection

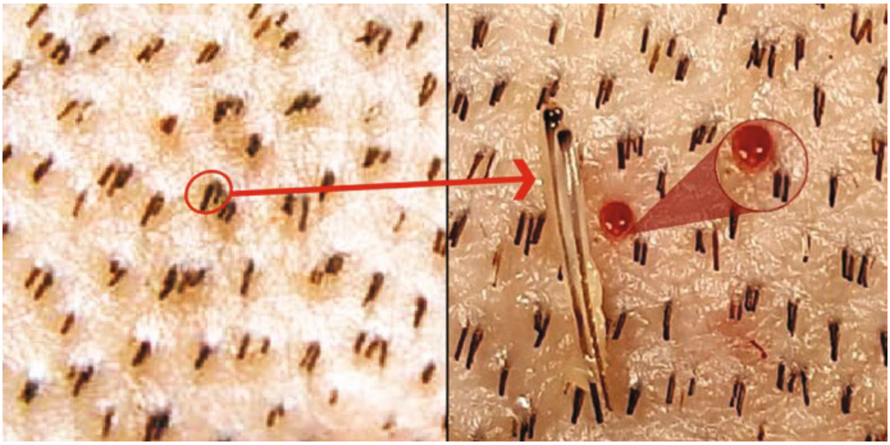

Fig. 26.18 Splitting

26.5 Advanced FUE

The objective of advanced FUE is to create artistic homogenization through detailed surgical planning that includes the splitting of multiple follicular units and the minimization of scarring. With advanced FUE, the aim is the illusion of density, and this requires a series of detailed calculations that allow for sequential adjustment during the procedure.

26.5.1 Evaluating the Quality of the Donor Area

In advanced FUE, the evaluation of the donor area is the key to successful harvesting and overall outcome of the procedure. It requires exact calculations that address the density or number of follicular units per cm^2 (Caucasians usually have 70 follicular units per cm^2), number of hairs per follicular unit (more hair means better coverage), and multiple follicular units (maximizing the yield of the donor area). Other equally important considerations that need to be addressed are the characteristics of the hair including thickness (between 49 microns thin and 61 microns thick), the texture of the hair (straight, wavy, or curly), and the hair color (black/brown vs. blond or white).

26.5.2 Donor Capacity

A hair transplant relies greatly on the capacity of the donor area to supply enough hair to cover the surface area of hair loss. In some cases, the area has been depleted of grafts either due to excessive scarring from previous operations or as a result of the donor hair quality not being adequate. This can be either caused through miniaturization or simply the existence of low density with possible signs of DUPA. Both are necessary considerations in evaluating the feasibility of FUE surgery [8].

The recommendations of FUT expert Dr. Walter Unger defining the presumed donor margins or “safe zones” have been used as extraction guidelines for decades. These guidelines suggest that when the scalp is examined under a high luminosity microscope, areas that are unaffected by alopecia are clearly identifiable and that these are considered “safe zones.”

However, in actuality, there can be no fixed directive that defines a patient’s permanent “safe zone,” as it is impossible to predict the donor graft behavior in all patients and especially into the future. This is especially true in the case of younger patients whose density in the so-called “safe donor” area becomes arbitrarily less dense with age. The only element that we do know is that areas unaffected by alopecia in youth lose density while aging at a slower rate than other areas of the scalp.

Remarkably and with increased innovation, some FUE surgeons have expanded previously established harvesting boundaries to incorporate the inferior temporal, periauricular, and suboccipital and occipital zones. These areas are of course impossible to harvest using the FUT technique but are of a great advantage to FUE surgeons who wish to use single fine follicles to create a more natural-looking hairline and to fill temple peaks.

26.5.3 Density

Density, or the number of follicular units per cm^2, is one of the major factors in obtaining positive FUE results. Experienced and skilled hair transplant surgeons can achieve natural-looking results through the determination of sufficient density based on the illusion of the transplanted area being of the same density as the donor area (Fig. 26.19).

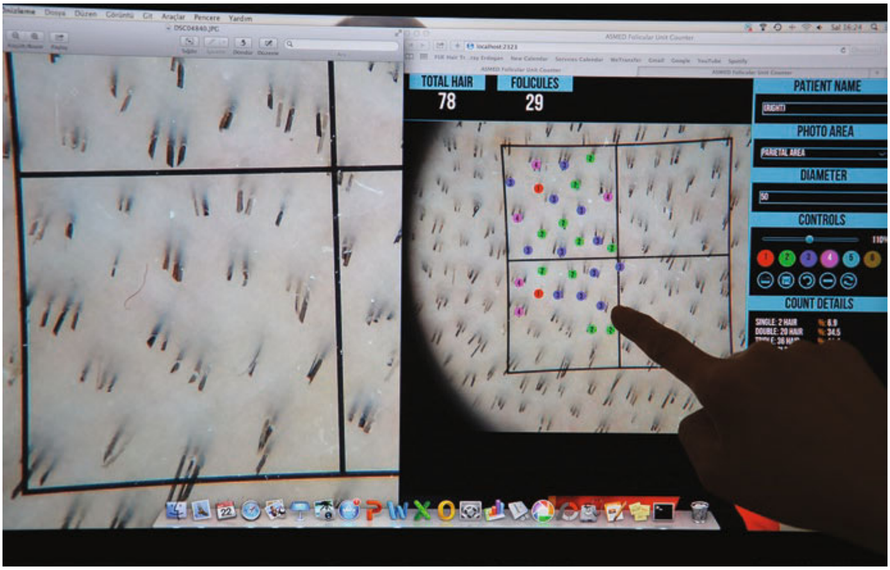

Fig. 26.19 Computerized analysis of density

26.5.4 Calculated Density

Essentially, in FUE, there are three densities: the hair density or the number of hairs per square centimeter, the follicular density (number of follicular groups per square centimeter), and the number of hairs per follicular group. The latter is a calculated value. The calculated density determines the percentage of follicular groups containing a specific number of hairs. Therefore, once the calculated density is determined, a fairly accurate prediction can be made of the proportion of follicular groups of any particular size; the number of three hair follicles, two hair follicles, and natural one hair follicles. Using the graft counter computerized application during surgery, the surgeon and his/her team can control graft quality and keep track of number hairs per graft [9] (Figs. 26.20, 26.21, and 26.22).

26.5.5 Hair per Graft Average

In the donor zone, there are typically one to four hair units, and the final coverage received is directly related to the number of hairs transplanted. Essentially, the higher the number of units, the better the result. At the front hairline, only single hairs are needed to create a natural look, while behind the frontline, units of two hairs and then three hairs are utilized. In the crown area, many units of three hairs

Fig. 26.20 Graft counter application keeps track of data during surgery

Fig. 26.21 Graft quality control using the sequential method and the graft counter during a surgical procedure

are required to guarantee coverage in an area where the hair is distributed in a centrifugal pattern emanating from a central cowlick. Therefore, depending on the area to be covered, the needs vary with an objective of averaging between 2.0 and 2.5 hairs per follicular unit. This factor is of equal or greater importance than the density of the donor zone [10].

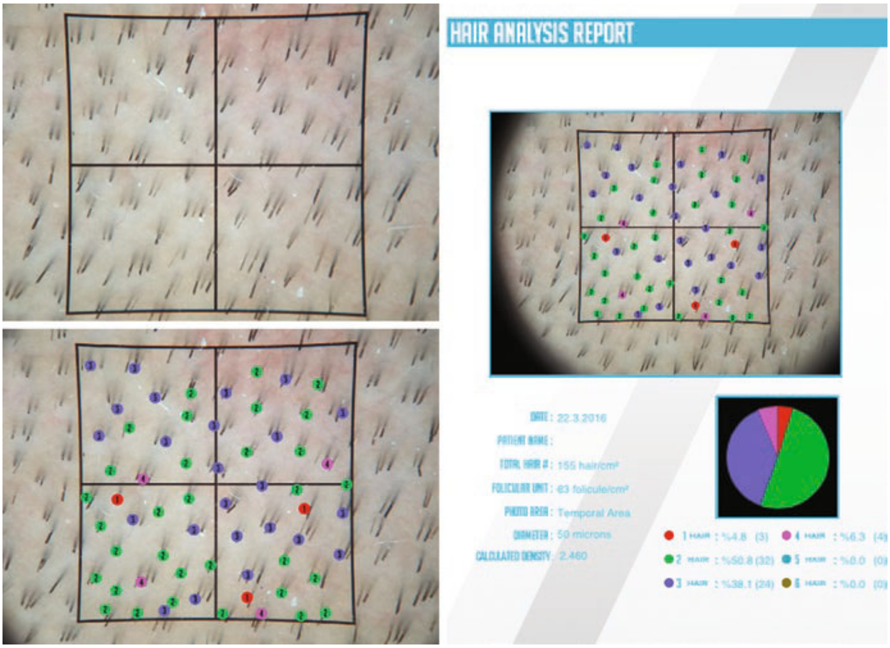

Fig. 26.22 Computerized output of calculated density

26.5.6 Coverage Value

A new calculation was recently introduced called "coverage value" whereby the hair density or number of follicles per square centimeter is multiplied by the calculated density (hair per follicle) taking into consideration the caliber of the hair in millimeters to determine the number of grafts necessary in order to obtain optimum density and homogenization.

26.5.7 Penetration Angle

The proper understanding of the angle of the hair below the surface of the skin is of the upmost importance for extraction. In almost all instances, the angle of the emergent hair is more acute than the angle of follicle in the dermis. The incision must obviously anticipate this and be oriented in the direction of the follicle rather than the visible hair. This takes skill and precision.

Initially, the skin should be penetrated perpendicular to the skin. Once penetration has taken place, the angle of the punch should be adjusted to an acute position in order to minimize wound size and scarring and to follow the angle of the follicle (Figs. 26.23 and 26.24).

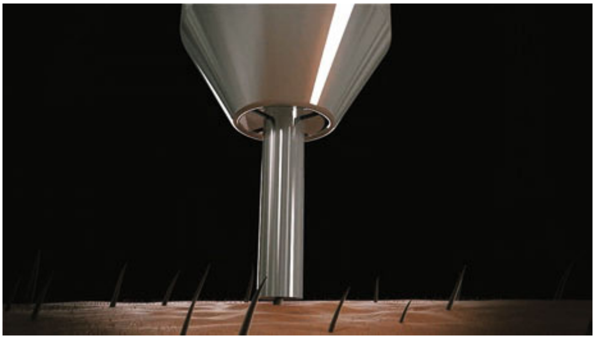

Fig. 26.23 Initial penetration with the punch perpendicular to the skin

Fig. 26.24 The punch is adjusted to an acute angle after initial penetration

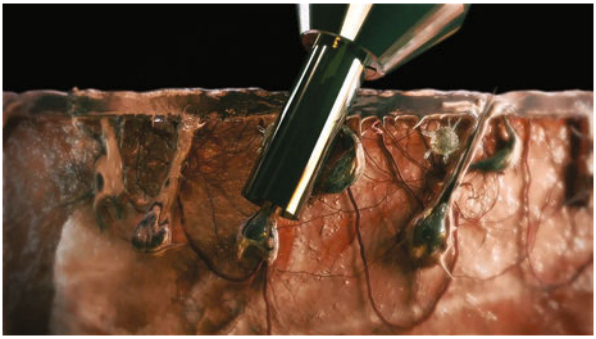

Fig. 26.25 The angle of the punch avoids transection and minimizes scarring

The hand should be perfectly stable while performing the short twisting motion of the punch. Most surgeons agree that a back-and-forth motion causes unnecessary transection and is incompatible with successful FUE, as is a 360 degrees rotation of the punch (Figs. 26.25 and 26.26).

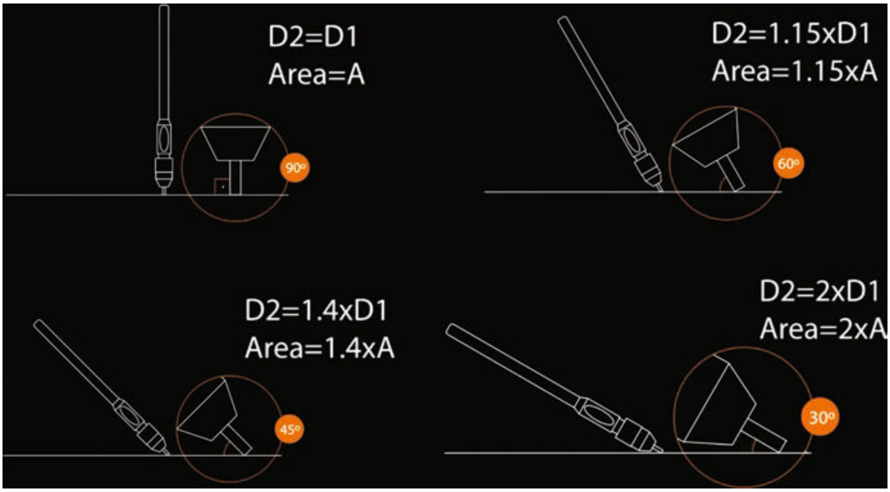

Fig. 26.26 Acute punch angles

26.6 Conclusion

In conclusion, FUE has come a long way in the last 15 years. Its popularity as an alternative to FUT has provoked steady technical development, added precision, and constant innovation. At the same time, it has challenged FUE surgeons to implement artistry in the creation of more natural-looking results through homogenization. Where will FUE go from here? The possibilities are endless as more and more research is being done and tested by various organizations specializing in hair restoration and especially FUE worldwide.

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Chapter 27
Follicular Unit Extraction in East Asians

Jae Hyun Park

27.1 Introduction

Follicular unit extraction (FUE) is a technique that involves graft harvesting of individual follicular units using a punch with a 0.8–1.2-mm diameter. This technique was first developed in the 1990s by Woods, an Australian doctor, and it became widely known in 2002 when Rassman and Bernstein published their version of FUE (the "FOX Procedure™") [1]. Given the increase in popularity and demand, FUE now accounts for about 50% of all hair transplant procedures according to the 2014 International Society of Hair Restoration Surgery census [2].

FUE offers several advantages, such as minimal invasiveness, lack of a linear scar, minimal postoperative pain, and rapid healing. However, FUE necessitates shaving of the donor region, has a long learning curve, and is associated with other disadvantages [3]. Recently established techniques designed to reduce the need for shaving, such as non-shaven FUE, are receiving worldwide attention.

27.2 Application of Follicular Anatomy to FUE Technique

27.2.1 Follicular Unit

An understanding of follicular units is necessary to comprehend the FUE procedure. The follicular unit is a histologic term first suggested by Headington in 1984 [4].

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Fig. 27.1 Follicular unit

A follicular unit comprises one to four terminal hairs, a sebaceous gland, an arrector pili muscle, surrounding neural and vascular tissue, and surrounding extra tissue (Fig.27.1).

However, a single insertion of a punch does not always mean that one follicular unit will be extracted for transplantation. Therefore, other terms such as the follicular isolation technique or follicular separation extraction have been considered more suitable for describing the technique. However, the term FUE has been in use worldwide for a long period of time, and this technique is thus generally still called FUE [5].

27.2.2 Hair Characteristics

In Caucasians, the average hair diameter is 50–60 μm. Hairs thicker than 70 μm are considered very thick. In Asians, however, the average hair thickness is >70 μm. In general, thin hairs require a more delicate and careful extraction technique than do thick hairs to avoid capping, which refers to extraction of only the epidermis, leaving the actual follicular unit behind. However, thicker hairs should be handled with caution because they usually have deeper and thicker hair follicles, increasing the transection rate.

The hair thickness is usually directly proportional to the thickness of the hair follicles; thus, the thicker the hair, the larger the punch should be. East Asians have thick hairs measuring 80–90 μm, and the most commonly utilized punch size in such patients is 1.0 mm. Punches measuring 0.80, 0.90, 1.00, and 1.10 mm are commonly used depending on the individual case and surgeon's preference.

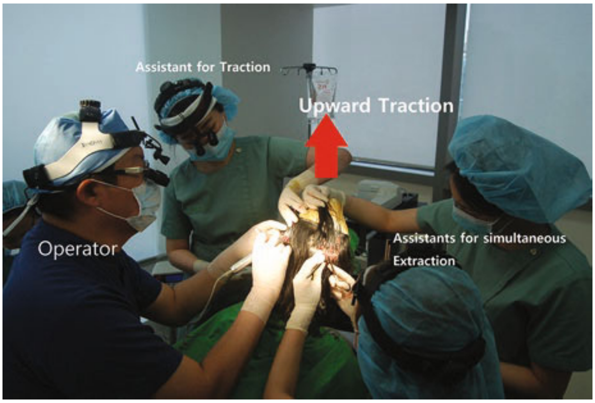

Fig. 27.2 Upward traction by assistants

27.2.3 Skin Properties

The nature of the skin also influences the surgery results. Rubbery skin that is tough and stiff in nature will result in increased axial, tangential, and friction forces upon punch insertion. It is helpful to raise the rotation speed of the punch when faced with this problem.

27.2.4 Punch Insertion Angle and Direction

Deeper insertion of the punch at a more acute angle will induce greater soft tissue damage. Injection of tumescent solution or slight upward traction of the occipital scalp may help to bring the hair follicles into a more obtuse angle [6] (Fig. 27.2).

27.2.5 Follicular Adhesion

Follicular adhesion is the most important component in the process of extracting hair follicles. Graft extraction after punch insertion can be more easily performed when the anchoring system of the hair units is well understood. The most important structure that is attached to and supports the hair follicle is the sebaceous gland, followed by the arrector pili muscle [7] (Fig. 27.3).

Therefore, punch insertion that is deep enough to reach the lower part of the sebaceous gland will enable easy extraction of follicular units. Additionally, East Asians are known to have a higher incidence of idiopathic occipital fibrosis, which may lead to a deeper punching depth [8].

Deeper insertion of the punch will increase the transection rate. The understanding that the lower portion of the hair follicle lacks structures that play decisive roles

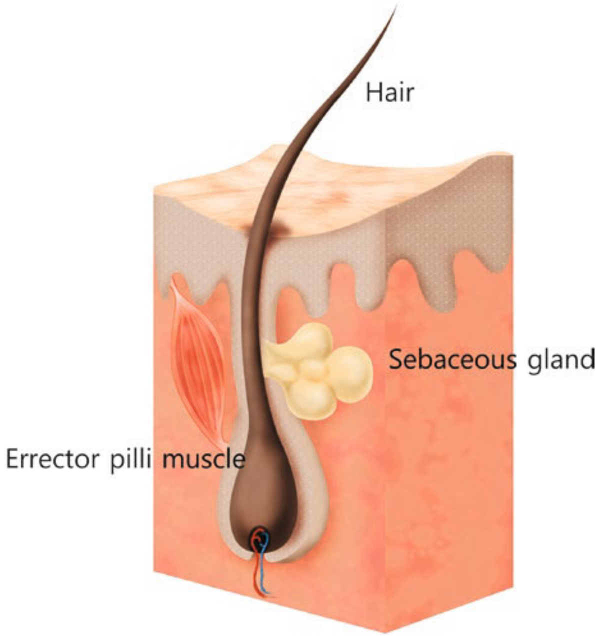

Fig. 27.3 Sebaceous gland and arrector pili muscle play important roles in follicular adhesion

in enabling successful engraftment has led to a generalized opinion that deep punch insertion reaching the lower part of the arrector pili muscle is unnecessary. However, an adequate punch insertion depth that yields successful extraction of hair follicles depends on the surgeon's skills and preferred methods.

27.3 Shaving the Donor Area

FUE usually requires shaving in the donor region. The ranges of shaving in the donor zone are as follows: total shave, partial shave, micro-strip shave, and non-shave [9–11] (Fig. 27.4).

27.3.1 Total Shaving

One of the merits of FUE is the extraction of large numbers of hair follicles in a random fashion, dispersed in a large donor area. Therefore, if allowed by the patient, it is best to proceed with total shaving.

Fig. 27.4 Various types of donor shaving. (**a**) Total shaving. (**b**) Partial shaving. (**c**) Micro-strip shaving. (**d** and **e**) Non-shaving

27.3.2 Partial Shaving

A certain portion of the donor area is shaved in a box form, which is covered by the unshaven hair above. Notably, however, the decreased hair density resulting from extraction may be focused in a certain portion on the occipital donor area.

27.3.3 Micro-strip Shaving

This technique involves shaving one to three rows of hairs in the form of several horizontal lines. Extraction of a small number of hair follicles is not problematic. Extraction of more than 400–600 grafts, however, may lead to several linear scars, resembling donor scars from strip surgery, and is thus infrequently used nowadays.

27.3.4 Non-shaven FUE

This technique does not involve any type of shaving. It can be classified into two different patterns depending on methods implemented.

27.3.4.1 Pre-trimming (Two-Step Method)

Hair follicles about to be extracted are selectively cut. This is later followed by punch insertion. This technique is easily approachable for a novice, but it may prolong the operation time.

27.3.4.2 Direct Non-Shaven FUE (One-Step Method)

The hair and graft are cut simultaneously using a rotating punch. Although this method takes less time to perform, the hair length of the extracted grafts is shorter than when applying the pre-trimming method.

27.4 Patient Position

Harvesting using the FUE procedure involves two patient positions: prone and sitting. The position most familiar to the surgeon can be chosen depending on his or her preference and surgical techniques.

27.4.1 Prone Position

The patient's head remains fixed and stabilized. However, a long period of lying face downward may be difficult for the patient. Furthermore, his or her shoulders impede a convenient approach to harvesting from the temporal areas.

27.4.2 Sitting Position

Perfect centering, or bull's-eye centering, in the punch-upon-punch insertion technique can be more easily performed in the sitting position. Use of a support apparatus for the forehead provides more comfort during long operation hours than in the prone position. Such a position also aids the surgeon in obtaining a better understanding of the insertion angle and securing a clear surgical field.

27.5 Process of Punch Insertion and Graft Extraction

27.5.1 Targeting

Multi-follicular units composed of more than two or three hairs must be targeted to achieve a greater calculated density. To achieve a higher calculated density with a low transection rate, the surgeon should avoid cutting splayed follicles or inserting the punch simultaneously into two follicles located very close to each other.

27.5.2 Punch Insertion

In Caucasians, who generally have hair follicles with thin hair and shallower depths, a limited depth punch may be adequate for efficient extraction. When treating East Asians, however, punch insertion should reach a deeper level using a punch with a larger diameter.

27.5.2.1 Punch

Punches of various calibers are needed according to the hair thickness. When a sharp punch is used, it should be changed without delay when the edge has become dull. A blunted edge increases the axial force and leads to graft distortion, which in turn may increase the transection rate [7] (Fig. 27.5).

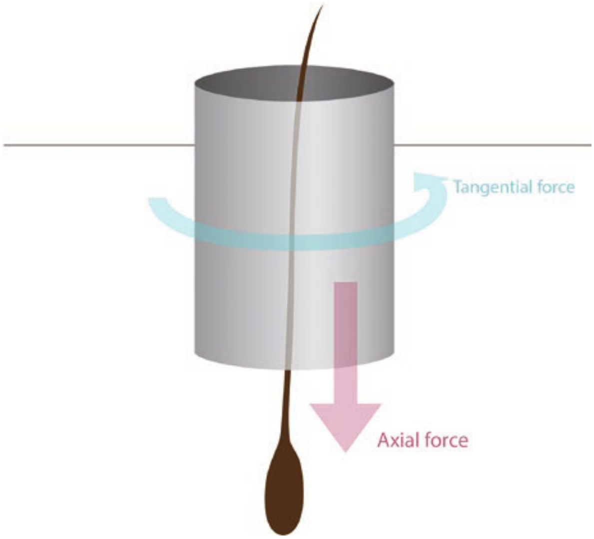

Fig. 27.5 Axial force and tangential force

27.5.2.2 Angle

It is important to understand the hair exit angle above the scalp. Loupes of at least 5.0× should be utilized. The hair exit angle generally becomes more acute in the temporal area or when going downward into the occipital region. In particular, the angle rapidly changes to a more acute degree just below the occipital protuberance; thus, care must be used. The hair exit angle is not always identical; every punch insertion should be approached slightly differently from the previous one.

Raising hairs up into a more obtuse angle helps to create wounds with a smaller surface area while simultaneously reducing follicular damage. Injection of tumescent or upward traction of the scalp is applied to allow for the punch to be directed at a more obtuse angle.

27.5.2.3 Punch Depth

The basic target depth is directly below the level of the sebaceous gland.

Deeper punch insertion than the ideal punching depth will increase the risk of follicular damage. However, punch insertion that is too shallow will result in capping or plucking and the resultant inability to successfully extract the graft.

The punch depth differs according to the surgeon's skills, experience, and preferences and the type of punch. I personally prefer a slightly greater depth than the minimal punching depth, within the range that does not increase the risk of follicular damage. I call this depth the "safe punching depth." Extraction is more convenient, and more abundant perifollicular tissue remains. The safe punching depth varies according to the patient, dissection location, and surgeon (Fig. 27.6).

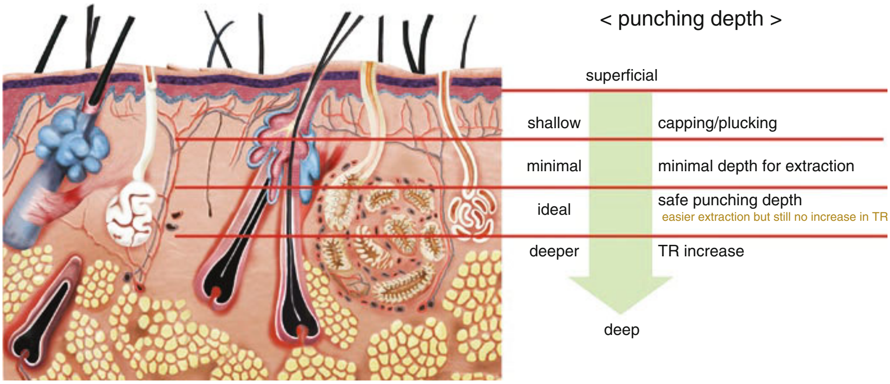

Fig. 27.6 Ideal punching depth: safe punching depth

The punch depth for proper extraction differs by the dissection location and graft. Therefore, a change in the location of dissection should be followed by test extraction of a few grafts at a time to assess possible follicular damage, the location and direction of damage, and ease of extraction.

27.5.3 Centering

FUE is fundamentally a blind procedure; that is, the surgeon cannot see through the skin to detect the hair follicle located below the skin and is only guided by the direction of hair above the skin surface. Therefore, perfect centering of the device over the follicular unit is imperative.

However, a surgeon with advanced skills may find that positioning the device slightly off-center over the hair follicle provides a lower transection rate in rare cases. For example, in patients with rubbery skin, the skin slightly shifts in the direction of the punch rotation. Such cases require purposeful alignment of the punch slightly off-center, application of traction of the donor region to tighten it, an increase in the rotational speed of the punch, or setting of the device in oscillation mode. The surgeon's technical knowledge and experience will provide solutions to various scenarios.

27.5.4 Tumescence

Use of tumescence depends on the surgeon and the method used. Tumescent infiltration diminishes bleeding and makes consistent punching possible because of the tense scalp tissue. It also increases the hair exit angle.

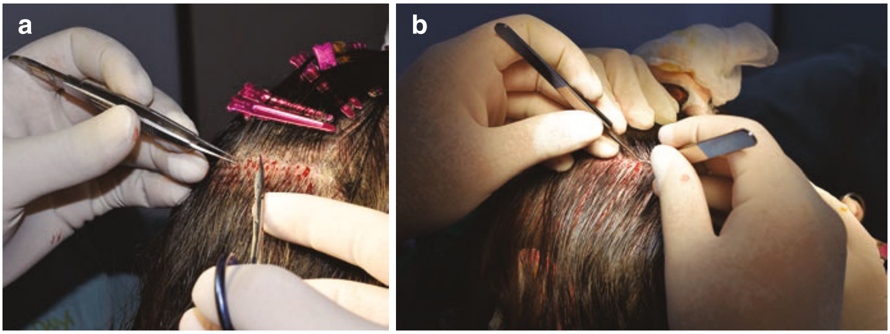

Fig. 27.7 Extraction with ATOE forceps versus jeweler's forceps. (**a**) Extraction with ATOE forceps. (**b**) Extraction with two jeweler's forceps

27.5.5 Rotating Speed, Rotational Direction

The rotating speed of the punch is critical. A low rotation speed increases the axial and tangential forces, leading to a higher transection rate due to graft distortion or shifting of the scalp tissue upon punch insertion. Of course, the skin type determines the possibility of this phenomenon, which usually occurs in thicker or hyperelastic skin. In contrast, these obstacles are less likely to be encountered in a firm scalp with low elasticity. In general, unidirectional punches are used at a high RPM and oscillating punches at a low RPM. This also depends on the surgeon's preference.

27.5.6 Graft Extraction

There are two main ways of gathering hair follicles. One involves the use of a regular forceps, and the other involves the use of an aide to extraction (ATOE) forceps specially developed for extraction in FUE. Utilization of a regular forceps by the practitioner has many variations. The most commonly used methods are two-step and three-step techniques (Fig. 27.7).

27.5.6.1 Extraction Using a Jeweler's Forceps

One or two forceps are used according to the practitioner's personal preference. Pulling grafts out with one forceps requires deep punch insertion to a depth of more than 5–6 mm for complete separation of the hair follicle from adjacent tissue. This method makes extraction easy to perform but increases follicle damage during the process of dissection. In a two-forceps method, the epidermis of the graft is lightly lifted for exposure down to the level of the sebaceous gland. With a second forceps held in the other hand, the graft is grasped at the level of the sebaceous gland or immediately below it and pulled out.

27.5.6.2 Extraction Using ATOE Forceps

The ATOE forceps is a device designed for extraction of large numbers of grafts with speed and ease.

27.6 Special Considerations when Performing FUE in East Asians

Performing FUE in East Asians poses the following difficulties and particular procedural aspects.

27.6.1 Facial Shape and Hairline Design

East Asians often have a broad, flat face with a prominent zygoma; this is often referred to as a brachycephalic-type face (Fig. 27.8). The hairline design in East Asians greatly differs from that in Caucasians. Although some patient variation exists, a flat and low hairline is commonly preferred to an oval design. The flat design generally demands a larger number of grafts than required for the oval design.

27.6.2 Hair Characteristics

Asians have thicker, deeper hair follicles than Caucasians, and their hair is black. Of all Asians, East Asians have the lightest skin color, creating the highest scalp–hair color contrast. Moreover, their hair density is very low. While the average hair density in Caucasians is about 190–200 hairs/cm^2, East Asians with androgenetic alopecia have a hair density of approximately 120–130 hairs/cm^2, accounting for only 60–70% of Caucasians' hair density.

The recipient's hair density must be as high as that of Caucasians to prevent the see-through phenomenon due to a high scalp–hair color contrast. That is, the available number of donor hairs is smaller when there is little difference in the amount of hairs to cover the recipient area.

For East Asian patients, larger punches are used in FUE because the hair follicles are thicker and deeper.

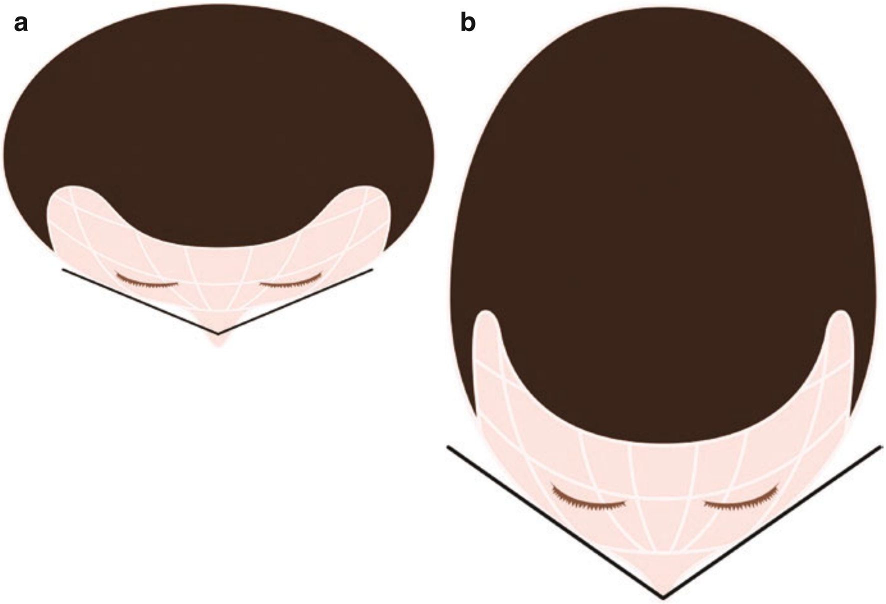

Fig. 27.8 Brachycephalic face in East Asians versus dolichocephalic face in Caucasians. (**a**) Brachycephalic facial skeleton in East Asians. (**b**) Dolichocephalic facial skeleton in Caucasians

27.6.3 Nature of Scalp

Idiopathic occipital fibrosis occurs more often in Asians than Caucasians [8]. In East Asians, the scalp from the occipital donor area is much tighter with stronger attachment of the subcutaneous tissue and hair follicles; in other words, a greater extent of fibrosis is present. This leads to the hair follicles being stripped of any surrounding extra tissue, which can result in a low survival rate, ultimately giving rise to donor depletion.

Although the skin of East Asians is the lightest among all Asians, East Asians still have darker skin than Caucasians; thus, the white dots are more noticeable.

Additionally, the lower laxity provides a smaller amount hair that can be gained from follicular unit strip surgery.

27.6.4 Female Hairline Correction Surgery

Female hairline correction surgery to create a slimmer and more feminine facial appearance is gaining popularity among East Asians [12]. Side hairline correction is often required in East Asians because of their brachycephalic facial skeleton [13]

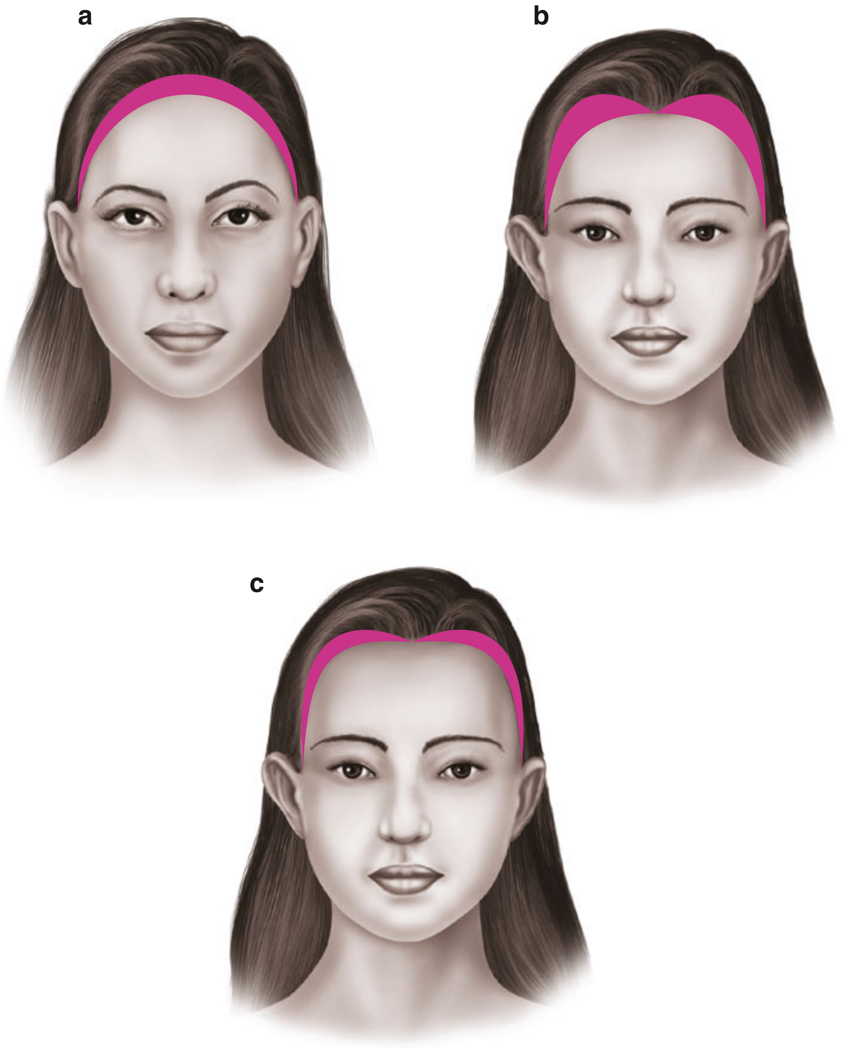

Fig. 27.9 Different preference of female hairline correction surgery between Caucasians and East Asians. (**a**) Frontal hairline lowering is common in Caucasians. (**b** and **c**) East Asians prefer frontotemporal recess area and side hairline correction

(Fig. 27.9). Side hairline correction requires much more one-hair follicular units and possibly thin one-hair units as much as possible. Therefore, in vitro splitting to create one-hair follicular units is sometimes inevitable when performing female hairline correction surgery in East Asians using the FUE technique.

27.6.5 Conclusion

In summary, harvesting with FUE is more difficult in East Asians, and when larger numbers of hairs are required for transplantation, such patients tend to have a lower amount of available donor hairs. Therefore, when performing hair transplantation in East Asians, the surgeon should carefully consider the surgical indications, carry out intensive management with medical treatment, and work with a practiced and skillful surgical team.

27.7 Non-shaven FUE

FUE has many advantages over follicular unit strip surgery, but it is also associated with a number of weaknesses. Its chief problem is the need to shave the donor zone. In non-shaven FUE, with the donor area left intact, the target hair is dissected through long hairs, extracted, and transplanted. There are two main ways of carrying out this procedure [9–11].

27.7.1 Pre-trimming Method

The donor area is divided into several zones that are marked with a marking pen. A certain number of hairs are then selectively cut from each area and subsequently cut with the punch one by one. Strictly speaking, it is not a "non-shaven" technique, but actually involves highly selective trimming of the donor area followed by punch insertion into the pre-trimmed graft.

The advantages of this method include a shorter learning curve compared with that required for the direct method and a longer hair length in the extracted grafts. The main disadvantage is the prolonged operation time.

27.7.2 Direct Method

The donor zone is prepared without any hair trimming. Graft dissection and hair cutting are performed simultaneously using a rotating punch.

The advantages of this method include a short surgery time and the ability to personally select the hair follicles to be cut by the surgeon. The disadvantages include a shorter hair length in the extracted grafts (caution should be used for transplantation of eyebrows, eyelashes, and pubic hair) and the higher learning curve due to difficulty in assessing the hair exit angle.

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Chapter 28
FUE in South Asians

Kapil Dua, Aman Dua, and Monica Chahar

28.1 FUE in South Asians

There are a variety of presentations of baldness and hair characteristics in different parts of Asia such as East Asia, South Asia or the Indian subcontinent and West Asia. The points mentioned below should be taken into consideration when performing FUE in South Asians.

28.2 Anatomical Characteristics of the Skull and Hair

28.2.1 Anatomical Shape of the Skull and Hairline Design

People of the Indian subcontinent have a relatively round (brachycephalic) shaped skull with a wider transverse section as compared to the oblong (dolichocephalic) shape of the Caucasian skull. They generally also have wider and more curved frontotemporal angles when compared to their Western counterparts. Therefore, a relatively flat and low-set hairline is preferred in South Asians. However, the round shape is less pronounced when compared to that of the East Asian population [1] (Figs. 28.1 and 28.2).

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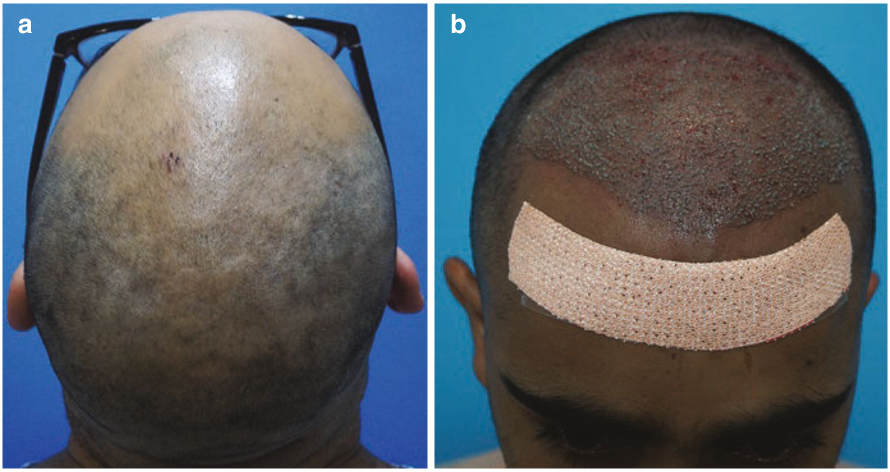

Fig. 28.1 South Asian patient—round-shaped skull (brachycephalic) of an Indian patient

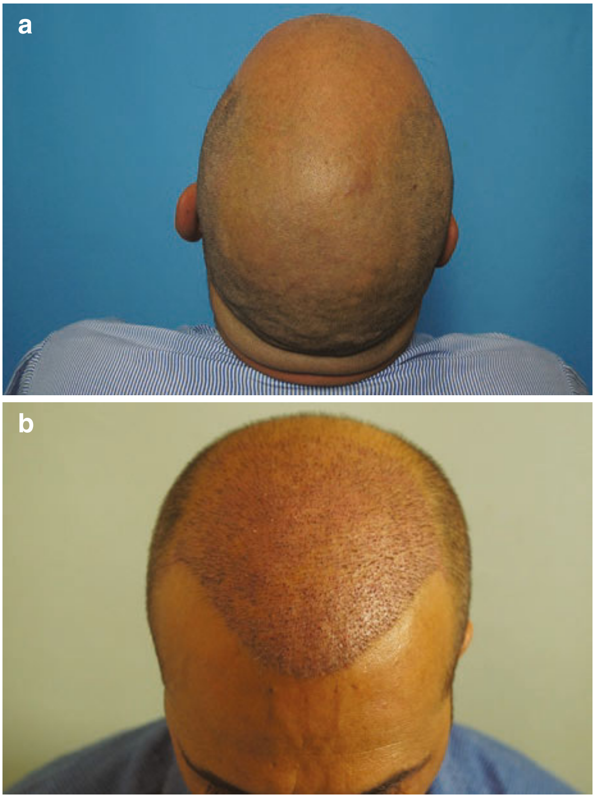

Fig. 28.2 Caucasian patient—oblong-shaped skull (dolichocephalic) of a Caucasian patient

Fig. 28.3 Hair and scalp characteristics of an Indian patient

28.2.2 Hair Colour and Texture

People from the Indian subcontinent have straight dark hair against their dark- to light-brown-coloured scalp (Fitzpatrick III–VI). This gives moderate to good coverage that is much better than that observed in the East Asians [2] (Fig. 28.3).

28.2.3 Scalp Laxity

South Asians have a relatively tight skin over the scalp. This low scalp laxity increases the risk of wide scars postoperatively with the strip method. Therefore, FUE is preferable for patients who are not good candidates for FUT.

28.2.4 Hair Characteristics and Density

Routine hair analyses performed by the authors on their patients over the past 9 years have found that the average calibre of the Indian scalp hair is 65–70 μm with an average of 1.9 hairs per follicular unit and an average follicular density of 65–80 FU/cm^2. This is comparable with findings of previous studies [3]. Therefore, due to the limited hair density of the donor area in South Asians, in advanced cases of baldness, the hairline should be kept relatively high, with a round to ovoid contour, more like Caucasians, rather than the usual flat East Asian style (Figs. 28.4 and 28.5).

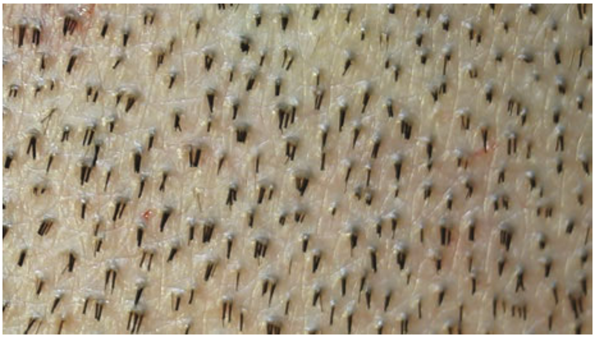

Fig. 28.4 TrichoScan of Indian patient. White-coloured ring, single hair grafts; *red-coloured ring*, two hair grafts; *yellow-coloured ring*, three hair grafts. The maximum number seen is of two hair grafts

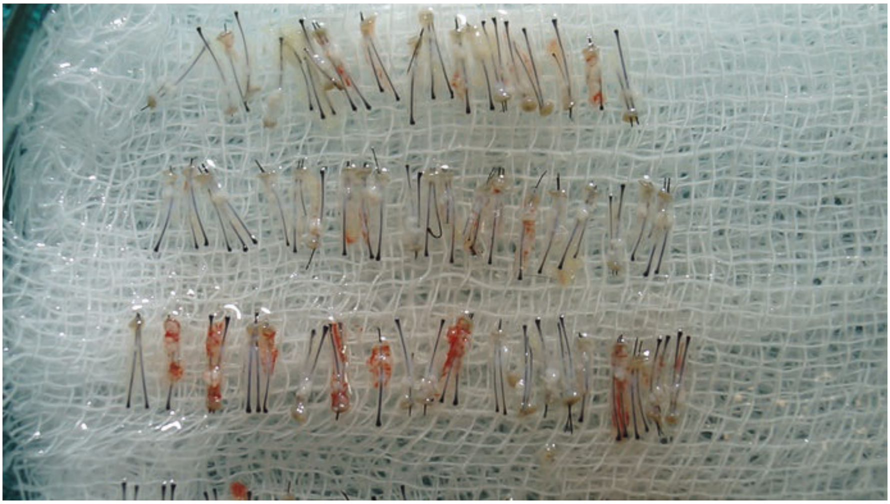

Fig. 28.5 Primarily two hair grafts in South Asian patients

28.3 The Technique of FUE Hair Transplant in South Asians by Powered FUE Technique

The authors started performing FUE in the 2007 using the manual two-step technique devised by Jim Harris. However, it was a tiresome and tedious process, and the SAFE System, a powered FUE device also devised by Harris, was adopted in late 2009. The authors used the dull 0.9 mm diameter and 4.0 mm shaft length diameter punches until 2014 when they started using customized punches developed by them with variable cutting surfaces, diameter and length of the shaft. These and other devices and techniques are now used by different surgeons around the world.

Fig. 28.6 Full trim of the donor area of Indian patient

Fig. 28.7 Patient in prone position and surgeon in sitting position

28.3.1 Preparation of the Donor Area

The authors prefer to trim donor hair at their clinic on the day of surgery. The typical case is of 2000 grafts for which full trimming of the donor area is preferred (Fig. 28.6). For smaller cases of 1000 grafts, multiple-layered trimming is performed, while for cases of only 500 grafts, only a partial trim is necessary. In very rare cases, no trimming of donor hair is required.

28.3.2 Position of the Patient

The patient is placed in the prone position. The surgeon will generally sit but may stand depending upon the alignment of the grafts and the ease of their extraction (Fig. 28.7).

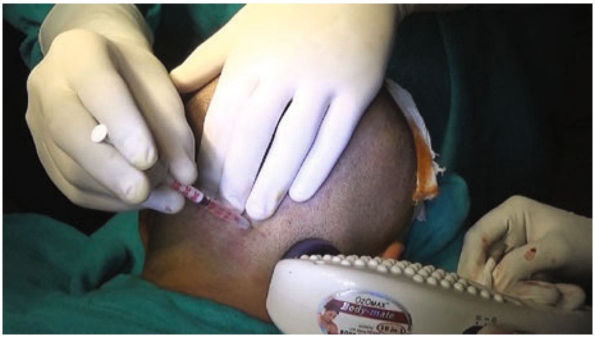

Fig. 28.8 Demonstration of occipital block (LHS): the middle finger is placed on the occipital protuberance. And the anaesthesia is given around 2 cm lateral and inferior to the protuberance

Fig. 28.9 Demonstration of occipital block (RHS)

28.3.3 Local Anaesthesia

The authors are very particular about this step and spend around 30 min administering local anaesthesia to the donor and recipient areas to make the procedure virtually pain-free for the patient. A topical anaesthetic cream is applied preoperatively to the sites of local anaesthesia injections and is kept for 45 min. The authors use a vibrating device to decrease the pain sensation on the basis of the gate theory which states that stimulation by non-noxious input (touch, pressure, vibration) is able to suppress pain sensation. The authors perform an occipital block (1 mL of 2% lidocaine with 1:100,000 adrenaline given each side of midline) to anaesthetize the donor area. Then they perform a field block at the base of the donor zone using lidocaine 1% with 1:100,000 adrenaline. In the remainder of the donor area, plain lidocaine 1% is injected in a serial manner (Figs. 28.8 and 28.9).

28.3.4 Selection of the Punch

Important aspects of the punch include the type of cutting surface, the diameter of the punch and the length of the shaft of the punch. The authors extract five test grafts from the middle of the donor area to calculate the average length of the grafts (from the epithelium to the inferior surface of the hair bulb) to see the health of the grafts (whether

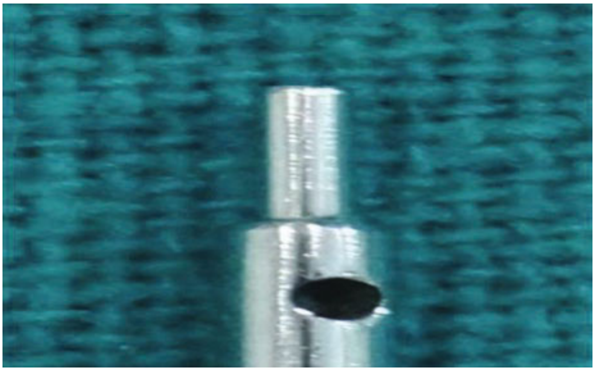

Fig. 28.10 Blunt punch

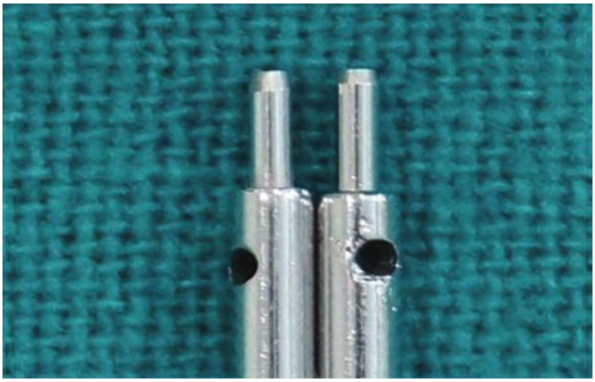

Fig. 28.11 Sharp punch

the follicles are strong or weak and whether they are loosely or firmly attached) and to judge the laxity of the scalp, so as to select the right type of punch for each patient. The authors prefer to use a blunt punch as the cutting surface. The amount of force required to advance a blunt punch (Fig. 28.10) into the skin is more when compared to the sharp punch (Fig. 28.11), but complete transection of the grafts is very low (less than 2%). In case more force is required, then the speed of the motor is increased to facilitate the advancement. Only very rarely when the skin is very firm, which is sometimes the case in South Indian patients (Fitzpatrick types IV–VI), that the authors use a semi-sharp punch developed by them. They also prefer punch sizes (0.8 or 0.9 mm inner diameter) (Fig. 28.12) for Asians because of relatively fewer hairs per follicular unit (1.9) as compared to 0.9–1.0 mm size punches used in Caucasians. The smaller punch has the additional benefit of reducing the wound size. Since the average hairs per follicular unit is less than 2, 0.8 mm punches can be used, but the authors prefer the 0.9 mm punch as it not only facilitates an increase in the number of hair per grafts but also removes more perifollicular tissue which may improve FUE graft survival.

The average length of the hair follicle in Indians is 5–5.5 mm [3]. In the unusual cases where the length is greater than 6 mm, the authors select a punch whose shaft length is 1 mm less than the average length of the grafts. Thus if the average graft length is 5.5 mm, then the authors will use a punch of 4.5 mm length, while if the length is greater than 6 mm, a 5 mm punch will be used (Figs. 28.13 and 28.14).

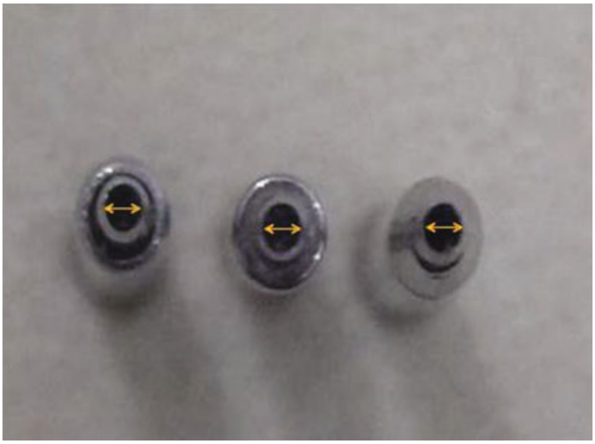

Fig. 28.12 Punches with different diameters

Fig. 28.13 Graft length 6 mm

28.3.5 Speed of the Motor

The authors set the motor at the minimum possible speed (usually between 1000 and 2000 rpm for the dull punch and between 500 and 700 rpm for the semi-sharp punch) necessary to penetrate the epithelium with maximum possible control. However, if the punch is difficult to advance, then the speed is increased as needed.

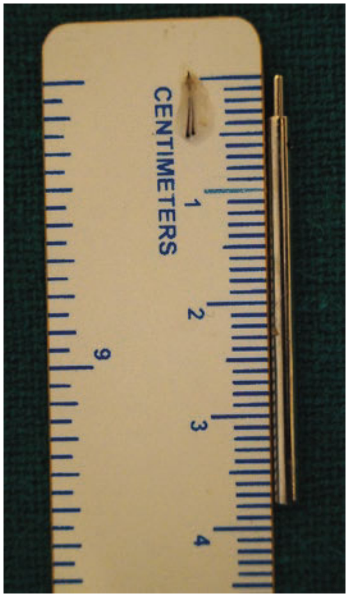

Fig. 28.14 Shaft length of the punch 1 mm less than graft length

28.3.6 Infiltration

The authors then infiltrate around 1 mL of normal saline per 1–2 cm^2 of the donor area in a serial manner. This small amount is used so as not to alter the exit angle making alignment difficult.

28.3.7 Traction-Counter-traction

The authors then hold the handpiece in their dominant hand while positioned on the left side of the patient and apply traction towards the head with their nondominant hand. The assistant standing on the other side applies counter-traction towards the foot. This helps to stabilize the skin and decreases the exit angle of the hair which facilitates the entry of the punch into the skin (Fig. 28.15).

28.3.8 Alignment

Alignment refers to the placement of the shaft of the punch parallel to the targeted hair emerging from the scalp. The direction and exit angle of the hair change every few centimetres, so the alignment must change accordingly [4]. However, the straight dark hairs of South Asians are relatively easier to visualize when compared to Caucasians making alignment comparatively easier (Fig. 28.16).

28.6 Conclusion

Hair transplantation in Asians, particularly in South Asians, can be complex. Careful attention to the elements discussed can give cosmetically pleasing results. Also, Asians generally have a smaller donor area and less hair density, so relatively fewer numbers of follicular units can be extracted per sitting. The goal should be to keep full and partial transection at the minimum (0–5%).

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Fig. 28.15 Demonstration of traction and counter-traction

Fig. 28.16 Punch is aligned parallel to the exit angle of the graft

28.3.9 Engagement

Engagement is when the tip of the punch touches the epithelium around the targeted hairs. It is one of the most important steps in the entire surgery, and the authors make sure that the targeted hair is either in the centre of the circular impression of the punch or in the superior aspect. If the hair is in the inferior aspect, then the graft will be transected while advancing the punch (Figs. 28.17 and 28.18).

28.3.10 Advancement

When using a sharp punch, a general dictum is to stay as superficial as possible in order to loosen the pilosebaceous unit but not cause transection. However while working with the dull punch, one has the liberty of penetrating deeper due to a lower chance of transection. In fact, the authors have found that introducing the punch deeply down to 4 or 4.5 mm not only frees the pilosebaceous unit efficiently but also makes it easier to remove the graft with minimum force (Fig. 28.19).

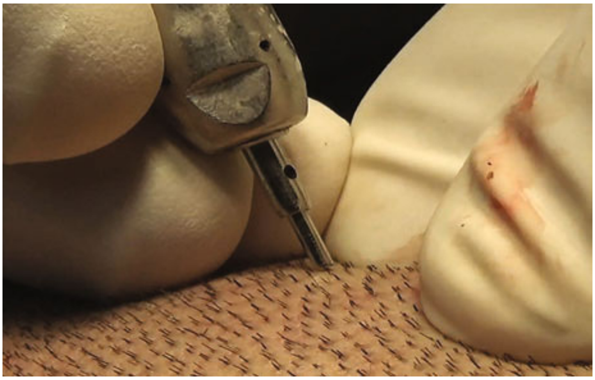

Fig. 28.17 Engagement: the point when the cutting surface comes in contact with the epithelium

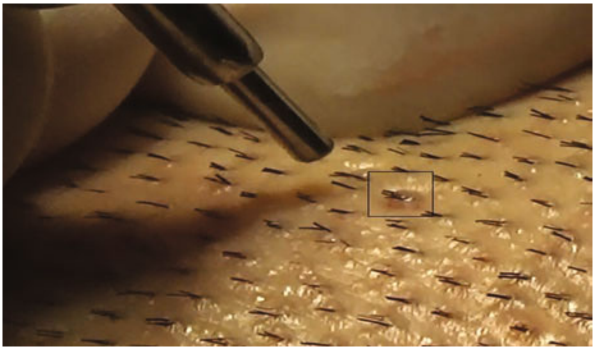

Fig. 28.18 The targeted hair is in the centre of the impression by engagement of the punch on the scalp

28.3.11 Simultaneous Removal of Grafts

The assistant removes the grafts in a downward direction using the dominant hand with wrist movement only. The assistant holds the grafts just underneath the epithelium so as not to damage the hair root (Fig. 28.20).

28.4 Out of Body Time of Grafts

In order to reduce time out of the body, the authors make slits before beginning extraction so the grafts can be placed into the recipient area immediately after the extraction is complete. In difficult cases, the authors also break up their surgery (2000 grafts) into two sessions (of 1000 grafts each) to decrease the out of body time for grafts to less than 1 h.

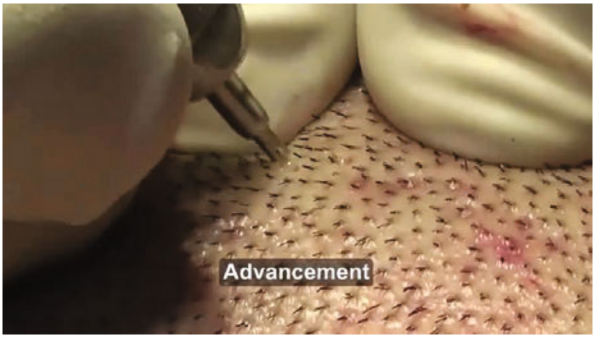

Fig. 28.19 Advancement: when the punch is pushed through the epithelium

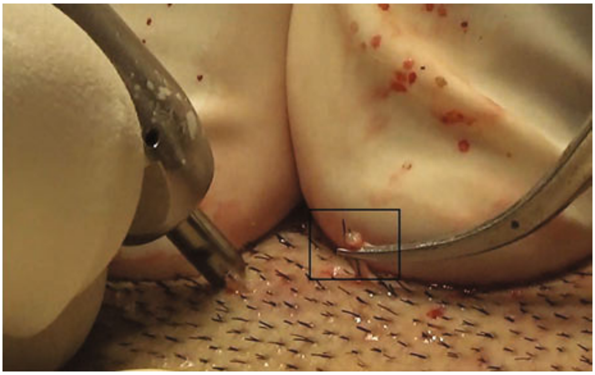

Fig. 28.20 The graft being removed simultaneously

28.5 Difference in Posttransplantation Complications After FUE

Asians are genetically more susceptible to abnormal donor area scarring, keloids and hypertrophic scars. The hypopigmented scars are much more prominent on the darker scalp when compared to the Caucasians [5]. Due to the relatively low density in the scalp donor area of Asians, there is also a higher risk of overharvesting, resulting in skip areas. Therefore, caution must be exercised by the surgeon and extraction of alternate grafts must be performed in a zigzag fashion to prevent donor area thinning. This technique also helps to prevent coalescence of hypopigmented spots that may appear after the wound heals [5]. The incidence of folliculitis is also relatively higher in South Asians. Therefore, if a graft is buried, the surgeon should remove it using gentle pressure along the edges of the site [5].

Chapter 29
FUE Experiences in West Asians

Koray Erdogan

29.1 Introduction

West Asian FUE surgical candidates typically present some challenges to the FUE surgeon due to genetic characteristics that affect the nature of the follicle and the skin in this ethnic group. Though most hair loss patterns in these individuals follow the classifications of the Norwood scale, others do not. Curled multi-haired fragile follicles with large bulbs often presenting with splay require a high level of expertise and delicacy both with extraction and implantation. Low calculated density and low coverage value present a challenge to the FUE surgeon who strives to create natural hairlines with adequate homogenization.

29.2 Definition of West Asia

Before beginning to discuss the application of FUE procedures on West Asian patients, the geographic definition of the West Asian area must be clarified. Though there has been some discussion as to the area defined as Western Asia (the westernmost subregion of Asia), the expression significantly overlaps the term Middle East with the exclusion of Egypt, which is considered part of Africa. For the purposes of this chapter and according to the United Nations Statistics Division [1], patients of West Asian origin will be referred to as those whose roots are found in Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey, the United Arab Emirates, and Yemen (Fig. 29.1).

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Fig. 29.1 Map of West Asian countries

29.3 West Asian Hair Loss Psychology

In dealing with West Asian patients, it is important to understand that both presently and historically hair loss, for this population, has had implications that often lead to self-doubt, difficulties in socializing, and embarrassment, all related to the ethno-cultural definition of masculinity and virility. This refers not only to alopecia of the head but also of the beard and moustache. Because of this sensitivity, it is almost a given that patients from this ethnic group tend to be more stressed about their surgeries.

29.4 Typical Hair Loss Patterns in West Asian Men and Women

The Norwood scale has been the accepted standard classification chart for male pattern baldness for decades and can be applied to patients from throughout the world. However, it fails to identify or classify specific patterns according to ethnicity. Although Ludwig's pattern is most often implemented for the classification of hair loss in women, this pattern also targets a vast majority of men whose baldness is presented in the mid-frontal scalp. The crossover pattern is not uncommon in men of West Asian origins [2] (Fig. 29.2).

Fig. 29.2 Typical hair loss patterns in West Asians

Fig. 29.3 West Asian patient showing typical balding pattern

Additionally, an unnamed pattern commonly exists among West Asian men that is crescent shaped and progresses around a small tuft of hair (Fig. 29.3).

29.5 Typical Hair Structure and Characteristics in West Asians

In gathering statistics from among patients of West Asian origin, it is noted that the graft caliber is higher than in Europeans or North Americans of European ethnic origin, while the exact opposite is true when it comes to graft length. Hair strands tend to be coarse and flat bearing an elliptical shape (Figs. 29.4 and 29.5).

Lower calculated density is also commonplace among members of the West Asian group averaging 2.6 hair/mm compared to a 2.821 average in North Americans and Australians thus rendering less hair from the donor area. Europeans tend to have calculated densities similar to West Asians (Fig. 29.6).

At the same time, the grouping of hair follicles in the follicular unit is typically higher in these patients than in other ethnic groups. For instance, there are typically 3–4 hairs per follicle, a phenomenon that requires hair splitting during FUE surgery into one- and two-hair grafts (Figs. 29.7 and 29.8).

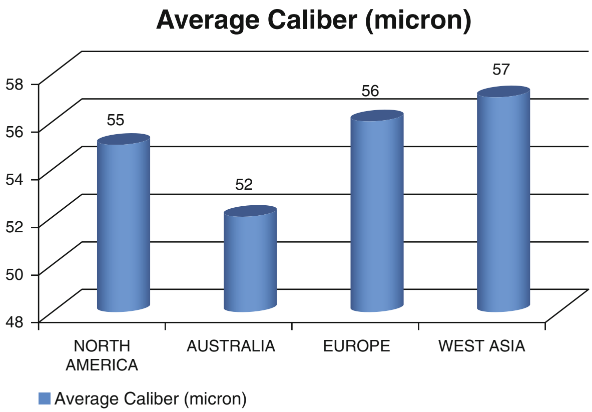


Fig. 29.4 Average caliber of West Asian patients in comparison with North American, Australian, and Asian patients

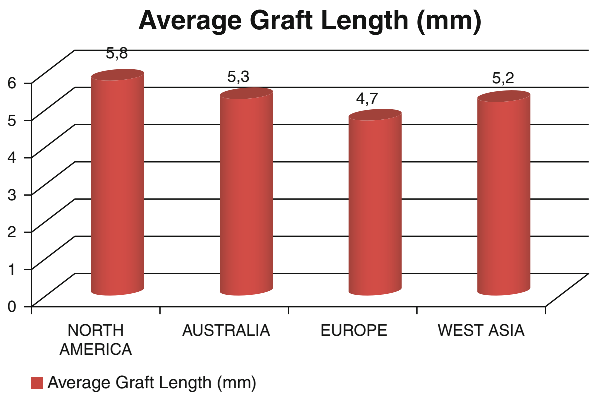


Fig. 29.5 Average graft length of West Asian patients in comparison with North American, Australian, and Asian patients

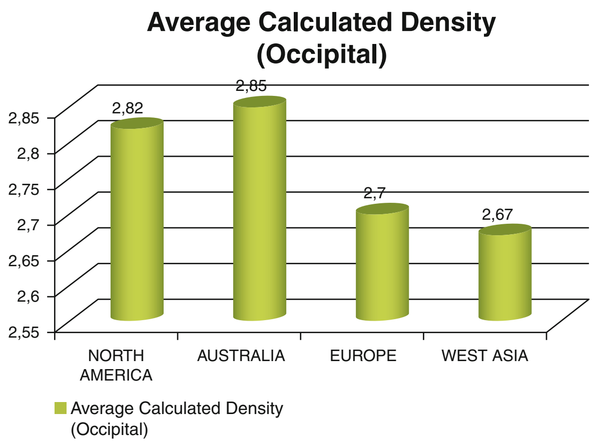


Fig. 29.6 Average calculated density in West Asian patients

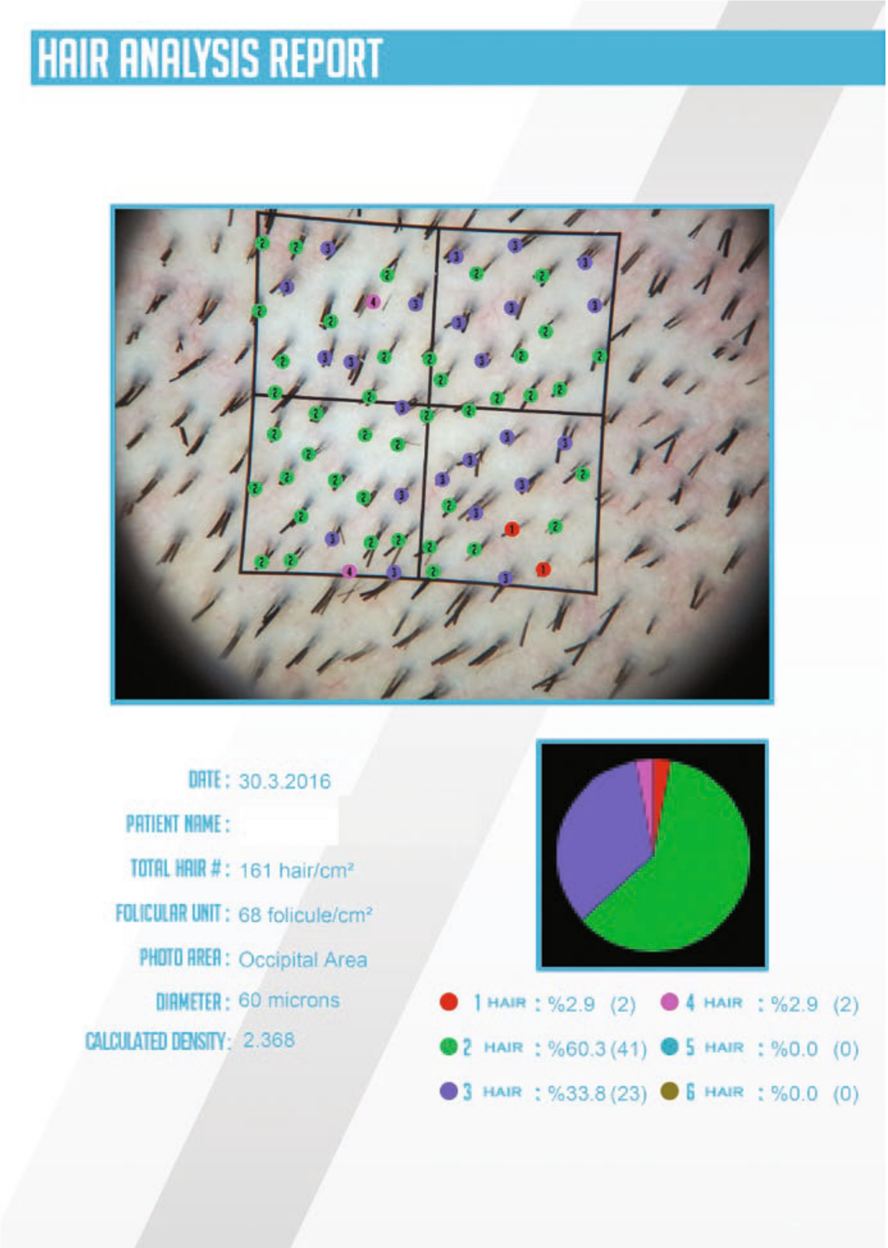


Fig. 29.7 Hair per follicle distribution in a West Asian patient

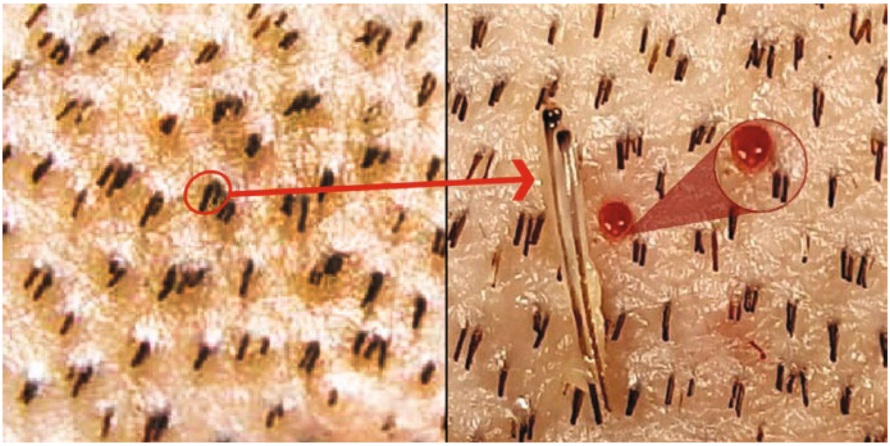
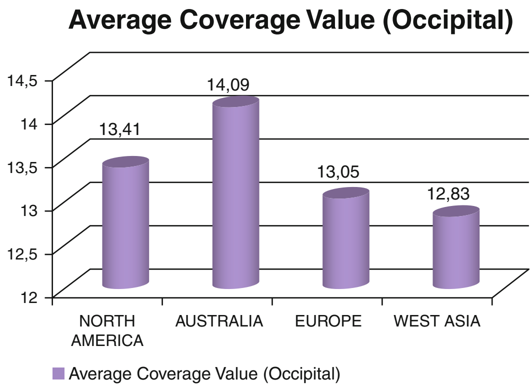


Fig. 29.8 Splitting

Fig. 29.9 Lower average coverage value in West Asian patients



The greater number of hairs that exist in a follicular unit coupled with lower density results in a disproportionate number of follicular units per square mm. Low density would normally mean that in a case of extreme baldness, there may not be adequate coverage to warrant surgery; however, with patients of this ethnic group, the coverage value overrides the density factor (Figs. 29.9 and 29.10).

In addition to the abovementioned characteristics, the hair shafts of this ethnic group tend to curl in the fatty dermis Fig. 29.11.

29.6 Potential FUE Complications with West Asian Patients

Harvesting, or extraction, takes extreme skill and precision with any FUE procedure but particularly so with West Asian patients where several factors inhibit successful harvesting. One is that the follicles normally bend and twist under the skin in three

Fig. 29.10 A West Asian patient with a low coverage value

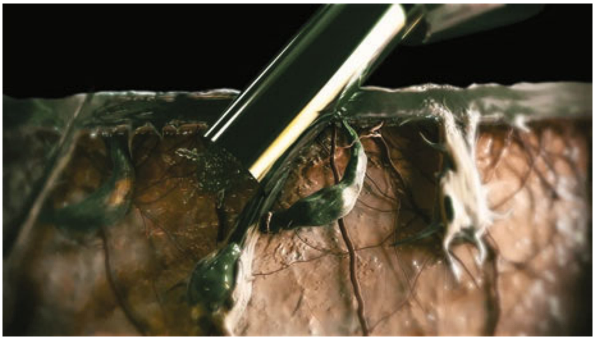


Fig. 29.11 Transection

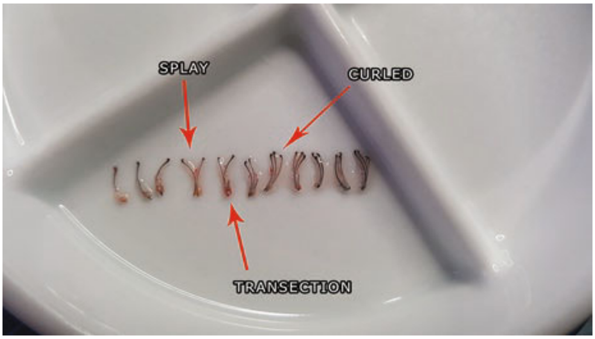


Fig. 29.12 Curled, transected, and splayed follicles

dimensions and that they descend to varying depths below the skin's surface varying by several millimeters [3]. In West Asian patients, the bend and curl is more pronounced making it extremely difficult to avoid transection during extraction.

When the follicular unit is severed from its fibrous attachment, the natural curl of these follicles typically dominates the follicle's shape even outside the body (Fig. 29.12).

Like patients of African origin, the follicular units characteristically demonstrate a wide splay even in their natural state embedded deep within the dermis. This splay becomes wider and even more pronounced when the follicle has been removed from

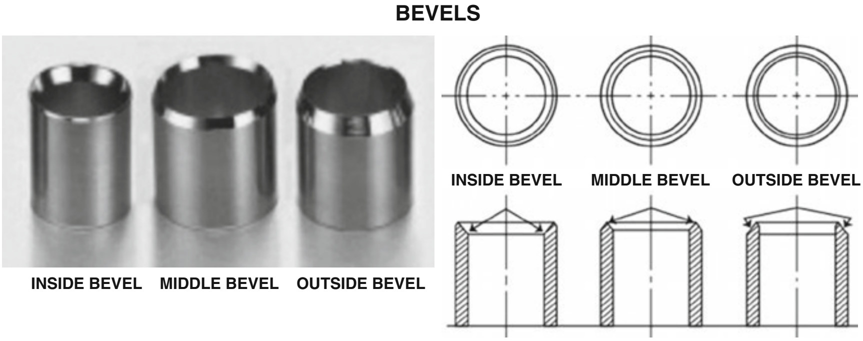


Fig. 29.13 Inside bevel punch

Fig. 29.14 Implantation using a placer and forceps

the body. It is for this reason that the inside bevel punch is highly recommended to decrease transection under these conditions (Fig. 29.13).

As a result, implantation becomes extremely difficult and requires an expert technician and the proper instruments. In general, the grafts cannot be inserted directly into the incision of the recipient site as with North American and European ethnicities using manual forceps but must be gently and carefully coerced into the incision preferably using a placer. This is also due to the extreme fragility of the follicle in these patients (Fig. 29.14).

It is also not uncommon that incisions in the recipient area may have to be slightly larger to accommodate larger bulbs and the follicle's given shape outside of the body. Homogeneity can be accomplished by packing less densely.

Characteristic inflexible scalps and thick skin not only create difficulty during extraction but also during the incision and implantation phases. For this reason, among other hair, scalp, and skin disorders, it is not unusual to witness excessive bleeding and, sometimes, eventual scarring. Keloids and hypertrophic scars that occur at the donor site may require intralesional and topical steroids.

29.7 Theories About Hair Loss in West Asian Patients

There have been numerous theories related to the high incidence of alopecia in West Asian patients and its possible and probable causes in this particular ethnic group. Though the majority of theories blame genetic mutation resulting from consanguinity due to long-standing ethno-religious beliefs, there is some evidence that other elements and conditions may also influence the onset of alopecia in patients from this ethnogeographical area. These include, but are not limited, to autoimmune disease, hormonal imbalance, stress, desalinated water use [4], the absence of adequate vitamin D levels due to mutations of the vitamin D receptor gene [5], head shape, grooming practices, and even tooth decay [6].

In order to evaluate these theories and assess their potential impact and effect on the feasibility and eventual outcome of FUE surgery, it is wise to evaluate the potential cause of the alopecia.

29.8 Conclusion

In conclusion, FUE surgeons must have a clear understanding of the typical characteristics of the West Asian ethnic group prior to planning and performing FUE surgery. Some cases of alopecia stemming from genetic mutation are clearly inoperable, while others could be considered feasible. In considering the success rate among victims of genetic mutation, surgeons must question the outcome over a period of time and the overall effect of the mutation long term.

Even if the high incidence of genetic mutation were not considered to be the primary cause of alopecia in this ethnic group, it would still not be enough to simply evaluate the patient's balding patterns, density, caliber, and donor and recipient areas alone when considering FUE. Surgeons must also consider the psychological factors pertaining to hair loss as well as the patient's realistic and sometimes unrealistic expectations of surgical outcomes.

Additionally, the FUE surgeon treating West Asian patients must be aware of and open to the possibility that nontraditional causes of alopecia, such as excessive use of desalinated water, tooth decay, and grooming practices, if not remedied, may have a negative impact overall effect on the outcome of the FUE surgery.

29.8.1 *Some Insights When Performing FUE Surgery on West Asian Patients*

- The punch size should not be less than 0.08 mm.
- The punch length should not be less than 4 mm.
- Punch sizes may require variation during surgery.
- Inside bevel punches are a must when dealing with splay which is prevalent in this ethnic group. Dealing with splay without the inside bevel punch poses a high probability for transection.
- Initial penetration with the punch should be executed perpendicular to the skin and then subsequently angled to avoid transection.
- The punch should be rotated for initial penetration using tangential force through the epidermis, as this ethnic group is mostly thick skinned, and then subsequently pushed and very slightly and delicately rotated through the dermis using axial force. This generally reduces unintentional follicle transection or amputation and the resulting impaired follicular survival.

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Chapter 30
NeoGraft™: My Experience in Asians

In Joon Lee

30.1 The NeoGraft™ Technique

The NeoGraft™ is a surgical device with a handheld wand that extracts follicular units from the donor area and implants them in the recipient area via an air pressure/suction-based system (Fig. 30.1). The NeoGraft™ device relies on manual control provided by a human operator in order to select and extract follicular unit grafts. Thus the NeoGraft™ device is dependent on the skill level of the physician just with a manual or motorized punch. The NeoGraft™ technique can be classified as a one-step extraction procedure in accordance of classification below:

30.1.1 One-Step Procedure

This procedure involves punching and extraction simultaneously. Usually suction is applied with the punch, and the graft is extracted at same time as punching (e.g., NeoGraft™).

30.1.2 Two-Step Procedure

In the first step, a sharp punch is placed over the follicular unit, aligned according to the direction of the hair shaft, and inserted while rotating to an appropriate depth. In the second step, fine-toothed forceps are used to apply gentle traction to the top of

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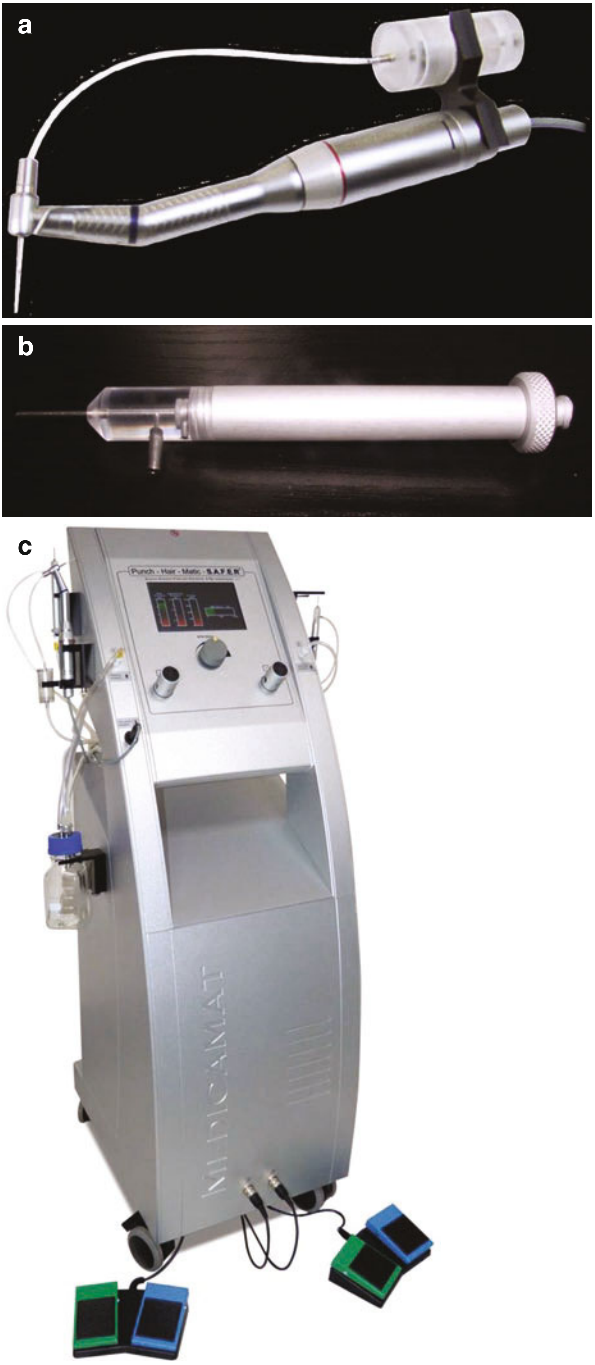

Fig. 30.1 (**a**) Graft removal: contra-angle removal handpiece, receiver flask, rotary punch. (**b**) Reimplantation of graft: reimplantation handpiece. (**c**) Figure of NeoGraft™

follicular unit until the unit is pulled loose from deeper dermal and subcutaneous connections (e.g., manual/motorized punch).

30.1.3 *Three-Step Procedure*

This step is based upon Harris' concept of first using a sharp punch to score the epidermis and then using a dull punch to bluntly dissect the follicular unit with a twisting movement from the surrounding epidermis and dermis. Lastly, the graft is grasped with forceps and extracted (e.g., ARTAS).

30.2 How the Technique Works?

The NeoGraft™ device is used to first separate the graft from the surrounding donor tissue with a rotating sharp punch that is connected to a suction unit. Once the upper part of the graft is dissected by the punch, the suction pulls the graft out, separating it from the remaining tissue (Fig. 30.2). The graft is sucked through a tube into a small holding chamber. This process has the advantage of not requiring a technician

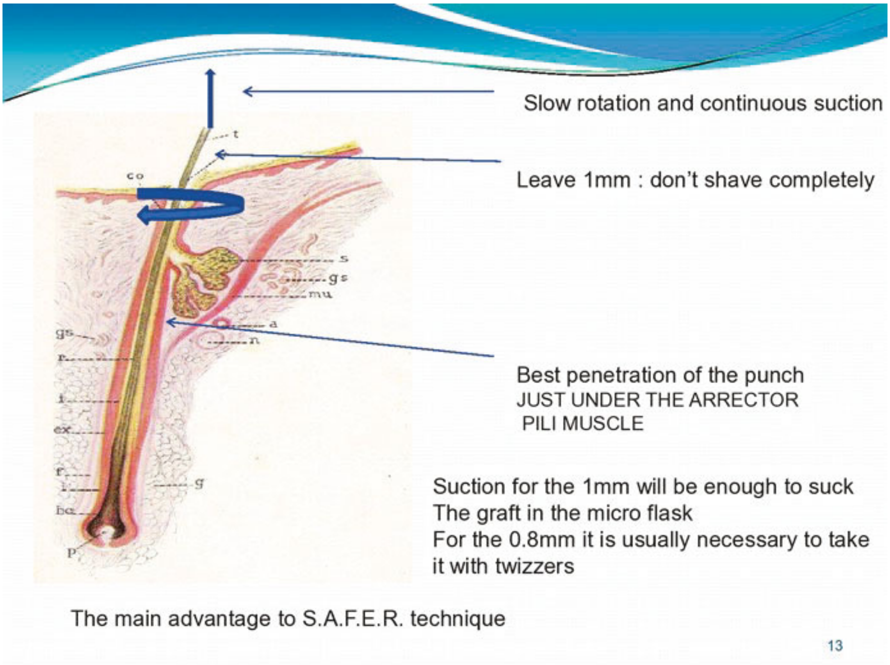

Fig. 30.2 Drawing of the mechanism of punch and suction

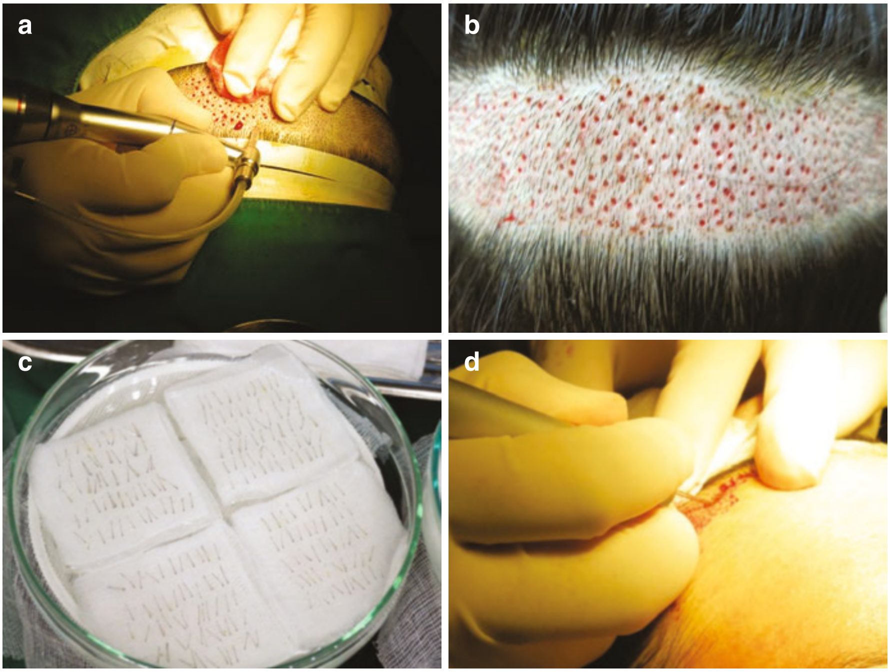

Fig. 30.3 Photograph of NeoGraft™ in action. (**a**) Extraction of grafts. (**b**) Result of extraction. (**c**) Extracted grafts. (**d**) Insertion of graft using implanter

to manually remove the graft from the scalp, but it can expose the graft to dry air, requiring the regular addition of a preserving solution to the holding chamber.

Once approximately 50 grafts are extracted, the collection chamber is opened, and the harvested grafts are placed into a Petri dish that contains a preserving solution. Recipient slits are created in the scalp using traditional instruments, and slits can be created before the extraction phase to shorten the out-of-body time of the extracted follicles.

In the placement phase of a hair transplant using NeoGraft™, a small number of extracted grafts are removed from the holding solution, and a second arm of the NeoGraft™ device is used to draw up the grafts one at a time via suction into the needle-tipped device. They are then individually inserted into the recipient sites using the pneumatic implanter, or they can be inserted with other implanting devices such as forceps or hand-powered implanter (Fig. 30.3).

30.3 Comparison Between ARTAS and NeoGraft™ Technologies

I have listed some of the technological characteristics of NeoGraft™ and ARTAS and made a comparison table (Table 30.1). I hope this will help to make the comparison of both technologic merits easier.

Table 30.1 The comparison table of NeoGraft™ and ARTAS technology

	NeoGraft™	ARTAS robot
Punch system	Pneumatic dermal punch drill susceptible to operator variability	Robotic precision two-step dermal punch drill (sharp punch first and dull punch second)
Hair mapping	Human eye scanning for selection of hair to be harvested	3D digital analysis of hair follicle for selection of hair to be harvested
Dissection technique	One-step sharp punch dissection	Three-step sharp and blunt punch dissection
Insertion technique	Slit and pneumatic implanter	Slit and forceps insertion

30.4 My Experience with NeoGraft™

In follicular unit extraction (FUE) performed with the NeoGraft™ device, the physician removes the follicular units one by one from the donor area until there are enough for a transplant session. This technique requires different skills on the part of the physician when compared to strip harvesting and has the benefit for the patient of no linear donor site scarring, although small polka dot scars may appear at sites of follicular unit extraction [1]. This can be a problem for East Asian patients because of high color contrast between the scalp and hair.

In my office, I usually use a 1 mm punch to accommodate the thick Asian hairs and only use 0.8 mm punch in patients with very fine hairs. I start the procedure by extracting about 5–10 follicles scattered about the area of scalp that I plan to extract. I measure the average hair follicle length to determine the proper depth of the punch. I insert a silicone tube over the shaft of punch to control the depth during the extraction (Fig. 30.4). The usual depth of the punch is between 3 and 4 mm.

Transection can occur with every FUE harvesting technique, including NeoGraft™. The problem of transection is related both to patient factors and physician factors. A punch aligned with hair visible above the skin may make an inadvertent cut into invisible follicles if they take an unforeseen direction under the skin. In addition, physicians who lack skill and/or experience will cause transections more often [2]. My experience of transection with the NeoGraft™ device in my office is as follows:

1. Transection rate (TR) in 30 cases performed in my office from January to June in 2014

$$\begin{aligned} \mathrm{TR} &= \frac{\text{number of partial and complete follicular unit transected}}{\text{number of follicular unit extracted}} \times 100 \\ &= \frac{58{,}907}{640{,}297} = 0.092 \times 100 = 9.2\% \end{aligned}$$

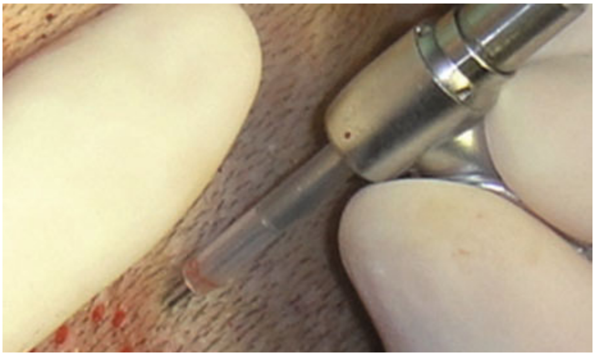

Fig. 30.4 The silicone tube over the shaft of punch to control the depth of the punch going in the scalp

2. Total transection rate (TTR) in 30 cases performed in my office from January to June in 2014

$$\begin{aligned}\text{TTR} &= \frac{\text{number of complete transected follicular unit}}{\text{number of follicular unit extracted}} \times 100 \\ &= \frac{18{,}374}{640{,}297} = 0.029 \times 100 = 2.9\%\end{aligned}$$

The increasing popularity of FUE being performed on East Asian patients may be due to the higher rate of visible scarring that occurs in the donor area when using the strip technique. The NeoGraft™ device will cause the same problems and complications that are seen with other FUE techniques; however, three problems seem to be more prominent in East Asians than in other ethnicities. First is the higher rate of hypo/hyper-pigmented dot-like changes in the donor area with FUE, which may result in empty spots, mottling, and snail tracts. Second, with lower density of hairs in the donor area, the chance of invading non-safe donor area can be high for East Asians. Third, the length of individual follicles tends to vary more in East Asian people [3], so careful control of the punch depth is needed. The ideal depth of punch has to be deeper for a long follicle and, if not controlled well, the transection rate of the follicular unit may suffer as a result. However, there is one advantage in performing FUE on East Asians, namely, low frequency of curly hair [4], as it is easier to perform FUE on straight hair.

30.5 The Advantages and Disadvantages of NeoGraft™ Technique and the Conclusion

The advantages of NeoGraft™ are, in my opinion, as follows:

1. Shorter operation time compared to other FUE techniques
2. Better survival rate because of less handling trauma to the follicles compared to other techniques

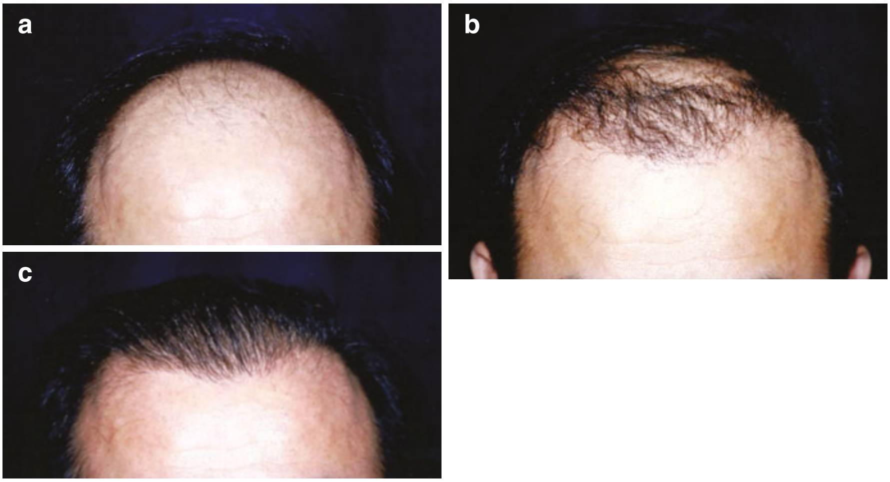

Fig. 30.5 Photograph before and after NeoGraft™ transplantation. (**a**) Before transplantation. (**b**) After 6 months of transplantation. (**c**) After 1 year of transplantation

3. Lesser number of personnel involved compared to other FUE techniques

The disadvantages of NeoGraft™ are, in my opinion, as follows:

1. There is a longer learning curve to the novice to FUE technique.
2. Compared to strip technique, it takes longer operation time for the same number of follicles transplanted.
3. Compared to strip technique, more careful handling of the follicle is required.

The NeoGraft™ device is a semiautomatic device that lessens the burden of follicular extraction. Although most of the steps require careful human concentration, it can help minimize handling trauma and the out-of-body time of extracted follicles. It enables us to shorten the time of the entire operation and achieve a better survival rate. The results are on par with any other techniques utilized for hair transplantation if not better (Fig. 30.5). The device also does not require many personnel. In fact, small scale of hair transplantation can be done with just two personnel. However, for the novice hair transplant surgeon, there is a longer learning curve, and many procedures are required to achieve excellent results.

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Chapter 31
Robotic Follicular Unit Extraction

Chang-Hun Huh

31.1 Introduction

Hair loss treatment has been one of the biggest medical challenges throughout the ages, and those treatments can be found in many ancient documents. The Ebers Papyrus, a medical textbook of ancient Egypt from BC 1550, offers many folk remedies for treating hair loss which are not used anymore. The ancient Greek physician Hippocrates, the father of medicine, also try to treat his male pattern baldness. Many unsuccessful attempts have been tried in history, but only hair restoration surgery has proved its efficacy until minoxidil and finasteride were introduced.

Hair restoration surgery can be categorized in various ways, including graft bundles, harvesting method, and grafting method. Two kinds of harvesting methods are currently used, "follicular unit strip surgery (FUSS)" and "follicular unit extraction (FUE)." Until recently, FUSS was the conventional harvesting method and was more widely used than FUE, as it is an easy and fast method for harvesting grafts. However, it leaves a linear scar on the donor area. While this scar is unnoticeable in most of the cases, occasionally the scar is wide enough not to be concealed; thus some patients regret this type of surgery. Some patients also experience persistent pain in the donor area due to occipital nerve damage during FUSS. These issues may explain an increasing preference for FUE over FUSS. However, FUE is a highly technique-dependent surgery with a steep learning curve, and surgeons must spend long hours mastering the techniques needed to perform FUE successfully. Furthermore, even experienced surgeons are vulnerable to effects of a tedious labor

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Fig. 31.1 ARTAS® system. The first and only robot system for follicular unit extraction

intensive operation. The transection rate (TR) of hair follicles, which is a measure of successful FUE harvesting, might increase during surgery as time goes by.

Robots are electromechanical machines guided by a computer program or electronic circuitry and have replaced humans in performing repetitive and dangerous tasks which humans prefer not to do or are unable to do. Because of the explosive growth of technology, robots have been adapted for use in surgery. Robotic systems are assisting surgeons with difficult, repetitive, and precise surgical movements, reducing manual variability, and have improved outcomes over the past decade. Their reproducible accuracy and precision has also enabled less invasive techniques that allow more patients to be treated and to have better experiences.

The gap between demand and supply, the increasing need for FUE harvesting in hair restoration, and the difficulties of learning it, all drove the development of a robot for FUE harvesting. The first and currently only FUE harvesting robot is the ARTAS® system (Restoration Robotics, Mountain View, CA, USA) (Fig. 31.1). It was cleared by US FDA in 2011 and operates successfully in many countries. The system was developed to reduce TR, shorten the operation time, and minimize human errors.

31.2 Image Analyzing System

In order to achieve the best results with the ARTAS device, it is important that the surgeon understand how the robot works. The ARTAS robotic system is an interactive, computer-assisted punch harvesting system for the FUE that utilizes image-guided artificial intelligence to enhance the quality of follicular units (FUs).

The robot quantifies the digital images captured by specialized cameras 50 times per second. It differentiates hairs from the skin in the images and analyzes each hair follicle's image. Using the color differences between scalp skin and hairs, the system can identify hairs. It regards a black or dark-colored rod as a hair and white or pale background as the skin. Then the robot calculates where the bulb of the hairs should be and determines the vector of the hair. Every hair shaft is assigned a vector, and each vector has an angle, direction, length, and thickness. After analyzing the vectors, groupings of vectors are made. These clusters of vectors indicate a follicular unit, which has more than one hair shaft emerging from one opening. The decision for which graft will be harvested next is made automatically and rapidly, and the speed of this process is fast enough that the robot can easily adapt to the minute movements of patient.

Blood can be an obstacle for recognition of hairs, but red light is used to illuminate the operation field during the procedure in order to attenuate the red color of blood and facilitate the recognition of hairs from the backgrounds. Since the robot can recognize hairs only by color differences, gray hair is not easy to recognize. Thus those who have gray hair must use black hair dye before the operation, usually early in the morning or the night before the procedure. There are reports of successful operations on patients with blonde or red hairs, but if the hair color is too pale, it will be helpful to dye the hair before the operation.

An important step for image analysis is cutting the hairs down to 1 mm in length, and a motorized clipper is used right before the operation to trim hairs. If the hairs left are too long, groupings of hairs will not be correct because the vectors of hairs will overlap. On the contrary, if the hairs are too short, the robot cannot calculate the directions and angles of hairs because hair is displayed as a dot rather than a vector, thus TR might increase. Thus, the operating staff must understand the importance of clipping of hairs correctly as the starting point of the robotic operation.

31.3 Skin Tensioner

The skin tensioner is a unique part of the robot operation. It ensures that the skin maintains sufficient tension during the operation and allows the robot to track the follicular units, follow patient movement, and guide precise control of incision depth. The needles on the inner plane of skin tensioner allow secure attachment to the scalp, while fiducial markings on the outer plane of the tensioner are used as reference points to track the relative position of dissection punch during the procedure (Fig. 31.2).

The tensioner is made of a deformable plastic, and after being applied to the scalp, the flexures at the corners pull the skin toward the sides of the tensioner to convert the convex scalp surface to a flat plane. In addition, it helps the punched units to elevate above the skin surface, facilitating easier extraction. It allows permits better visualization of operative field due to a compression effect on the blood vessels. Elastic tubing attached to the tensioner reduces excessive head motion and holds the tensioner against the patient's scalp.

Fig. 31.2 Skin tensioner. The marking on the outer plane is working as a reference points

Fig. 31.3 Upper long hairs can conceal the clipped area for robot FUE

The inner area of the currently used skin tensioner is 4.3 × 3.8 cm when it is relaxed and 3.5 × 3 cm when it compressed. These areas are used for the harvesting FUs and each one is called "grid." However, due to gaps between the angle of incidence and the thickness of tensioner's edges, the robot cannot extract hairs from the whole area inside of skin tensioner. Along the sides and especially at the bottom of the grid, un-operable zones exist with areas depending on the hair directions and angles. Generally, the effective area for harvesting with a single tensioner grid is roughly 3 × 2.5 cm. The number of harvested FUs per grid ranges from 80 to 140 in typical patients with average hair density. If the surgeon decreases the spacing distance between harvested follicles, the harvesting FU number will increase. For those who required 1000–1200 FUs, ten grids are required in general, meaning that at least 15 × 5 cm of the donor scalp must be clipped to 1 mm length for harvesting. This is the most distressing aspect for the patient undergoing the robotic procedure and should be explained before the surgery. If the patient's donor hair is long enough, upper long hairs can conceal the lower clipped area (Fig. 31.3). Temporary use of wig can be helpful for socially active patients. Because the growth rate of hairs is approximately 1 cm/month, this temporary problem will resolve after several weeks.

Of course, the safe zone area of patient is an important factor when deciding the maximum numbers of grids. The total operation time should be taken into consideration, as well. Unlike manual FUE, the robot cannot perform harvesting and grafting at the same time. Thus, the surgeon must take into consideration the duration that follicles are outside of the body, an important factor determining graft survival. Tissue preservation solutions and chilled storage surfaces can be used to protect grafts during storage.

31.4 Harvesting System

After the skin tensioner is attached to the scalp, the robot arm moves to the left lower corner, ready to begin harvesting. The surgeon can decide which FU is to be harvested, one by one; but in most cases after a few test harvests, the decision is made by the robot using its unique randomized algorithm. Basically, the robot determines which FU to harvest or skip, the angle and direction to approach the FUs, and the depth of puncture and coring of the FUs. The surgeon can control minor adjustments to dissection depths and angles and make the decision to skip an FU during the process. The harvesting speed is quite fast and the process is dynamic. The total time for harvesting varies with training proficiency, clipping of hairs in the grids, and the degree of homogeneity of the vectors of hair follicles. In general, 1–1.5 h is required for harvesting 1000–1200 FUs. During the extraction, three colors of dots can be seen: a light blue circle is a dissected FU, a purple circle is the next target, and a green circle is the currently targeted FU. The surgeon must closely observe the entire operation directly or through the monitor view and precisely control the robot.

The ARTAS® system uses a needle-in-needle design, the so-called dual punch system, to split the roles of puncture and dissection (Fig. 31.4). This method originated from Dr. Jim Harris' two-step "blunt/sharp" harvesting method to facilitate lowering TR during the FUE procedure. Dual punches are composed of an inner sharp needle and outer blunt punch, and the dissection process is made in three steps. First, the sharp inner needle punctures the scalp around the selected FU and holds its position in the center: Second, the dull dissection punch rotates outside of the sharp needle to core the FU deeply without damage. Finally, light suction is applied on the final step to elevate the dissected graft. Currently, the inner needle is a sharp bi-beveled needle with an inner diameter of 1 mm, but smaller needles

Fig. 31.4 The needle-in-needle system. Inner needle is sharp and bi-beveled, outer dull punch dissect the hair follicle

measuring 0.8 mm diameter or needles with multiple bevels have been successfully tried in experiments and may eventually be available.

The harvesting process can be divided into two parts: dissecting the FUs and extracting the dissected FUs. The extraction of dissected FUs is still done manually, but the process is easier than with manual FUE. In manual FUE, extradition of FUs is performed with the positive pressure of pushing force. However, the dissected FUs produced by the ARTAS® robot are raised slightly above the surface of the scalp due to the light suction during dissection and the tension made by skin tensioner. Staff can easily collect dissected FUs with one tiny forceps during the operation, or the Atoe (Aids to extract) forceps can be used to reduce damage to the FUs. Extraction of grafts can be performed during the dissection of a grid or after the dissection. After grafts are collected, they are examined and trimmed under the microscope as in other hair restoration surgery methods.

The donor area dressing and grafting process is the same as with other surgical techniques. Surgeon using hair implanters recognizes the difficulty of loading FUE grafts into implanters due to the shortly clipped hairs.

31.5 Characteristics of Robot-Harvested FUs

When ARTAS was firstly introduced, it was not known if the robot could efficiently extract both single hair and multiple hair grafts or if it was suitable for Asian patients who have thick hair caliber and deeply located dermal papillae. However, the author's published data [1] analyzing robotically harvested FUs demonstrated that the robot can harvest multiple hairs efficiently. Among the harvested FUs, 44.1% contained two hairs and 31.9% contained three hairs. As the number of hairs in a follicle increased, TR also increased, however the overall TR was 4.9%, which is quite a bit lower than published US data at 6.6% [2]. We conclude that the robot system can be successfully used in Asians.

In addition to the consistently low TR and high speed, another advantage of the robot is the harvested FU size (Fig. 31.5). Graft size may affect graft survival, and compared to the "skinny" grafts from manual FUE, robotically harvested grafts are "chubby" with more abundant surrounding tissue. This chubbiness is cause by negative suction power during the harvesting and might be helpful for the graft survival.

31.6 Future Development of the Robot

Many FUE surgeons use punches with the smaller possible diameter to minimize donor wounds, so the 1 mm inner diameter of the robotic punch has been a weak point when compared to manual FUE. However, as previously mentioned, new punches with smaller diameters are under development.

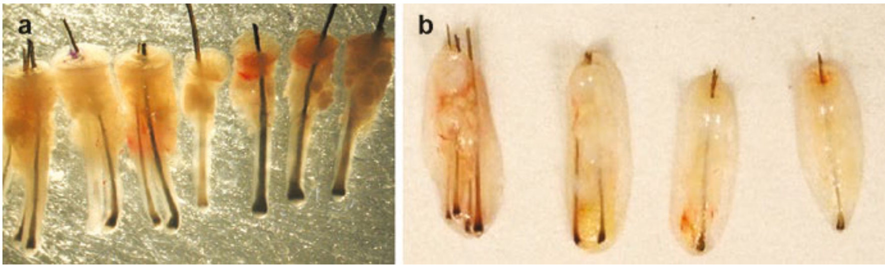

Fig. 31.5 (**a**) Manually extracted follicles. (**b**) Robotically extracted follicles

Currently, the robot is also approved for slit making. The surgeon first designs a recipient plan using a 3D simulating system, and the robot then make slits according to the surgeon's plan. The final step will be robotic implanting of FUs, currently under development. The author believes that robotics will lead the future of hair restoration surgery and that the robot will perform all steps of the hair restoration procedure.

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Chapter 32
Hidden Transection by Follicular Unit Extraction (FUE)

Dae-Young Kim

32.1 Hidden Transection

FUE (follicular unit extraction) hair transplantation has been commonly used among hair transplant surgeons over the last 10 years [1]. A low transection rate during FUE graft harvesting is the key to successful FUE hair restoration surgery [2].

The FTR (follicle transection rate) as presented by the FUE research committee of the ISHRS (International Society of Hair Restoration Surgery) in 2014 is defined as the number of transected follicles divided by the total number of extracted follicles, both intact and transected [3].

FTR equals

$$\frac{\text{Total number of transected follicles}\left(\text{partially} + \text{completely}\right) \times 100}{\text{Total number of extracted follicles}}$$

However, when determining the formula for this calculation, the ISHRS FUE research committee did not consider damages that may arise in the donor site through the process of using the FUE punch.

My investigation of damages to tissue surrounding the extracted follicular units after FUE harvesting confirmed that not only were extracted follicles sometimes transected, but often so too were follicles surrounding the donor site wound.

The size of the study boxes on the donor strip was $1 \times 1\ \text{cm}^2$, with the horizontal width divided at intervals of 0.25 cm marked by three vertical lines, A, B, and C. Eight FUE punches were made, four along each line A and C. The slivered cross sections along lines A and C were then analyzed (Fig. 32.1).

Two to four study boxes were drawn on the donor strip of each of 20 follicular unit strip surgery (FUSS) patients (Fig. 32.2). FUE was performed within the study

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Fig. 32.1 Design of study box. The circles indicate the punch sites

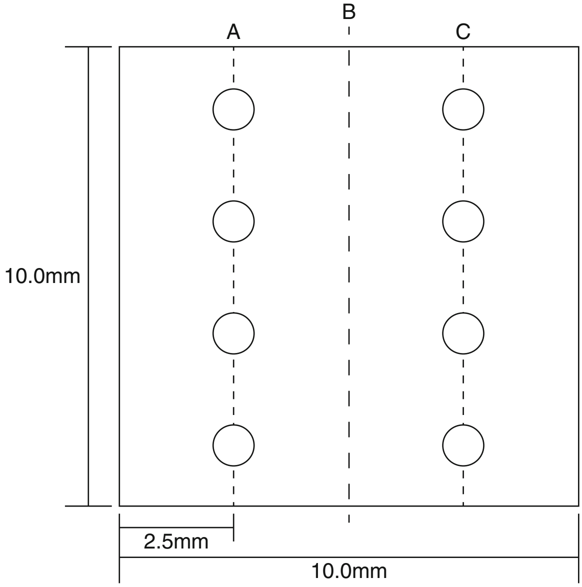

Fig. 32.2 Four FUE study boxes on the excised FUT donor strip. Each study box is isolated by slivering

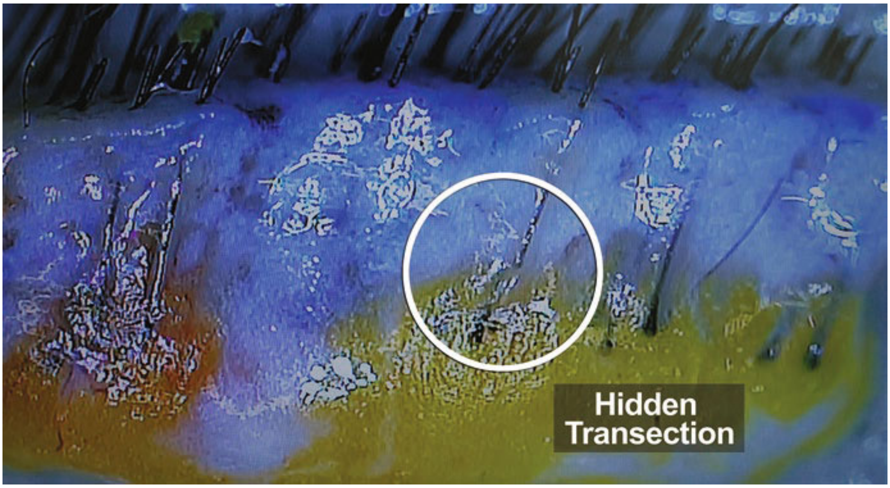

Fig. 32.3 Hidden transection: the transected site is hidden under the scalp surface, keeping the shaft alignment

boxes before strip excision. A motorized FUE device (Folligraft®, Lead M, Seoul, Korea) with a 1 mm sharp cannula punch was used. After the FUE procedure was done, the donor strip was harvested, and the tissues of each study box were separated from the donor strip. The two cross sections along the punch lines A and C, as well as the eight follicles obtained from each study box, were then observed and analyzed using a 20-power digital video microscope.

I examined the transections around the punched holes in the donor site and observed partial and total transections of the extracted follicles obtained by the FUE punch. I found various transections in the donor strip through the analysis of the cross sections of the study boxes. For example, one partial transection had the transected lower part of the hair follicle left in the sliver, and its upper part was found in the extracted follicle. Among the various transections, some were hidden under the scalp surface, keeping the shaft alignment (Fig. 32.3). I named this occurrence "hidden transection." Transection from a slivering injury caused by a technician must be differentiated from the phenomenon of hidden transection. I could recognize a slivering injury due to its great distance from the punch sites. To differentiate slivering injury by technicians from hidden transection, the whole process of slivering was videotaped and reviewed. By my design, harvesting was performed by an FUE expert for ten patients and by an FUE beginner for the remaining ten. While the two surgeons harvested FUE grafts with similar levels of transection rate, there was a significant difference in the hidden transection rate: 2% for the expert and 8% for the beginner. Eighty-eight percent of the hidden transections caused by punches were noted along the upper side of the punched hole. The depth of hidden transections ranged from 1.7 to 4.0 mm, and the average depth was 2.9 mm. Based on the results of our study, I have proposed the concept of hidden transection by FUE punch of hair follicles surrounding the punched hole in the donor site. For a truly

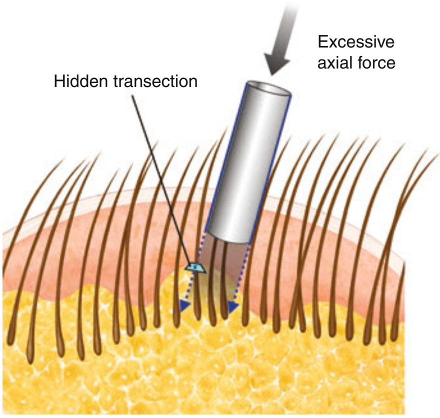

Fig. 32.4 Excessive pressure on the skin during punch insertion is the first possible cause of hidden transection

accurate definition of transection rate, we must account for hidden transection. I further investigated the causes of hidden transection so as to ultimately reduce these transections. The first possible cause of hidden transection is excessive pressure on the skin during punch insertion [4] (Fig. 32.4). The second proposed cause is that hidden transection can result from extraction performed with an extremely deep insertion of a punch. This often occurs among Asians with long hair follicles [3]. Lastly, a high splay of a hair follicle itself can lead to a high hidden transection [5]. Overall, the main finding of this study is that the correct way to calculate the real-transection rate in FUE harvesting is to consider both the extracted follicular transection and the rate of hidden transection.

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Chapter 33
Non-shaven Follicular Unit Extraction in East Asians: Pros and Cons

Young Geun Ryu

33.1 Introduction

The demand for follicular unit extraction (FUE) is rapidly increasing, despite having the disadvantage of the requirement to shave completely. As an alternative, the demand for non-shaven FUE is also increasing, even though its cost is relatively high compared to total shaven FUE.

First developed by Cole in 2004 [1], non-shaven FUE allows patients to return to daily activities shortly after the surgical procedure, with perfect camouflage. As the name implies, every other follicular unit with 2–3 hairs is individually selected from the safe donor area, trimmed into 2–3-mm lengths using scissors, and extracted using a motorized punch, without using a clipper. The author's goal is to describe the pros and cons of this surgical procedure in East Asians based on experiences with non-shaven FUE method.

33.2 Methods

33.2.1 Cutting Methods

With the exception of donor preparation, this does not differ from conventional FUE procedures. First, the patient is prepared for cutting at the hospital about 1 h before the surgery. The hair has to be at least 4 cm long, the minimum length to be gathered by a hairpin or to be held by the surgeon's hand, in order to perform non-shaven FUE (Fig. 33.1). However, excessively long hair can be difficult to handle, and

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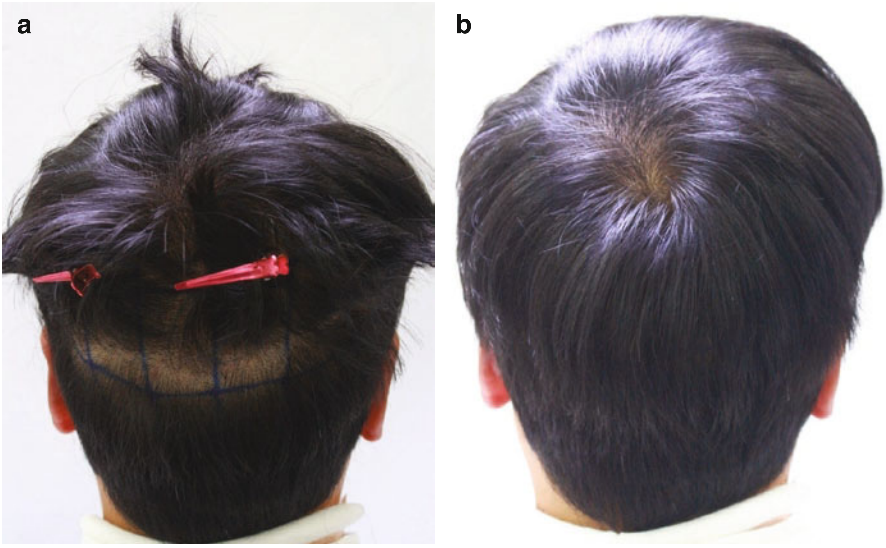

Fig. 33.1 Non-shaven cut: before (**a**) and after (**b**) cutting 2500 follicular unit hairs for a 1600 unit transplant

female patients with long hair are recommended to undergo partial shaven FUE method (Fig. 33.2).

The safe donor area, as defined by Cole [2], is accurately marked prior to cutting. The scissors used for cutting should have blunt tips (Fig. 33.3), and cutting is usually done by 2–3 assistants (Fig. 33.3). Cutting takes about 30 min for every 1500 follicular unit (FU) hairs, and usually one follicular unit with 2–3 hairs is cut at a time. It is optimal to cut every other hair (Fig. 33.3). However, if the surgery is a large session over 2000 FUs, then 1.5–2 times the usual amount of hair is cut, and it is better to cut as much hair as possible without exposing the occipital region. The assistants are instructed to constantly check the visibility of the scalp by using a comb during the cutting process and to select thick hairs in good condition and cut them in 2–3-mm lengths. If the hair is trimmed to less than 2–3 mm, it will be hard to find the follicular units during the procedure, and they could easily be missed.

The amount of hair cut from the follicular units is restricted by the donor density in each patient. However, patient complaints about donor depletion are rare if cutting is done by leaving at least 30–35 follicular units/cm^2. For example, if a 1500 follicular unit surgery is planned and the patient's donor density is 70 follicular units/cm^2, the maximum number of follicular units that can be cut is 40/cm^2. Moreover, this allows the surgeon to select the follicular units at the time of punching, which prevents extraction of two nearby units and allows selection of units in good condition.

An important tip for preoperative preparation is to moisten and smooth the donor hair as much as possible, since brittle hair is hard to handle and prolongs punching or extraction time.

Fig. 33.2 Partial shaven cut: advantages include convenience and low cost, but donor area is limited

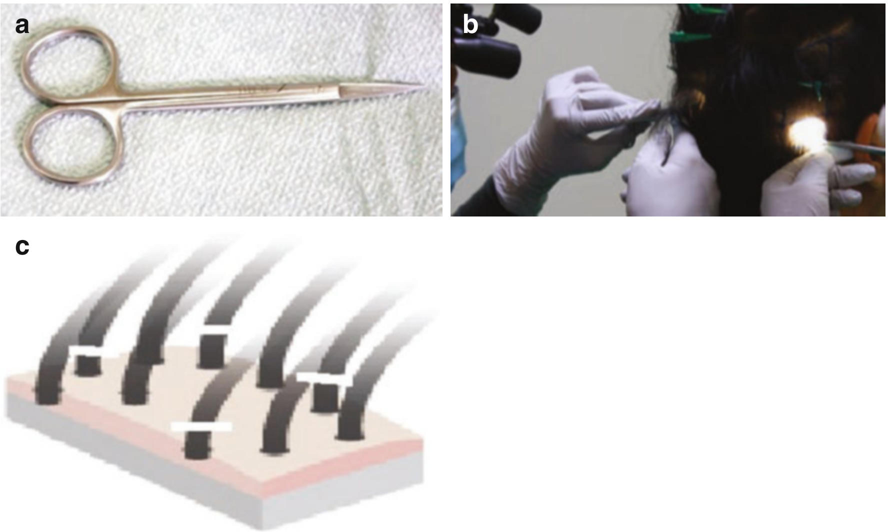

Fig. 33.3. (**a**) Blunt tip scissors (**b**) pre-hair cutting: 2–3 assistants, 3000 FUs cut/hour (**c**). Cut every other hair (2 FU or 3 FU)

33.2.2 Punch Methods

The punch process and mechanisms are similar to those used in total shaven procedures. The major difference is the decreased visibility due to existing hair.

The following are points to consider when performing non-shaven FUE using a motorized punch:

- Use hairpin traction to increase visibility.
- Insert a tumescent agent as evenly and firmly as possible.
- Decrease the RPMs of the punch to the lowest rate possible.
- Check for punch blade blunting and change when needed.

The author primarily recommends hairpin traction. In cases of total shaven FUE, the scalp is retracted by using a scalp tensioner or the left finger or thumb. However, in non-shaven FUE the scalp cannot be fixed focally, as retracting the scalp by grasping hair will cause uneven traction and lower punch accuracy. Fixing the scalp via hairpins will create even traction, increase visibility, and cause less strain on the surgeon (Fig. 33.4).

Although firm traction is created using hairpins, the author allots a significant amount of time to the insertion of tumescence (Fig. 33.4). The tumescence controls the tangential force [3, 4] in non-shaven FUE, which has low visibility, and serves to straighten follicles and decrease the possibility of bleeding caused by blood vessel injuries. The author uses a tumescence composed of diluted lidocaine and injects it as firmly and as evenly as possible. The tumescence is injected into a small area of approximately 2 × 3.5 cm immediately before harvesting this area, since preinjection of tumescence into a larger area may require reinjection.

It is best to keep the RPM as low as possible, and approximately 1500 RPM is used for punching. High RPMs can pull nearby hair into the instruments, causing avulsion. In addition, thermal injury can be produced when the RPM is high and when surgery is prolonged (Table 33.1).

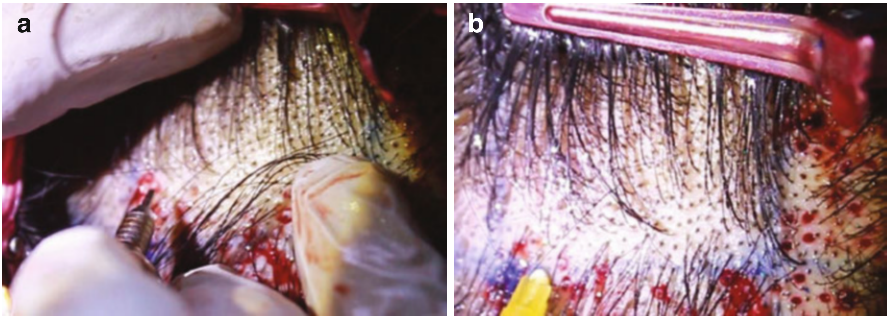

Fig. 33.4. (**a**) Hairpin scalp retraction: uniform scalp traction is possible and increases visibility for punching. (**b**) Tumescent injection: addition of tumescent further improves scalp traction. With proficiency, punch stability can be better than with total shaven FUE

Table 33.1 Setting: total shaven versus non-shaven

	Total shaven	Non-shaven
RPM	1500–2500	<1500
Punch	1.0 mm, serrated	1.0 mm, serrated
Punch replacement	1000–1500 punches	700–800 punches
Punch depth	3.8–4.1 mm	3.8–4.1 mm

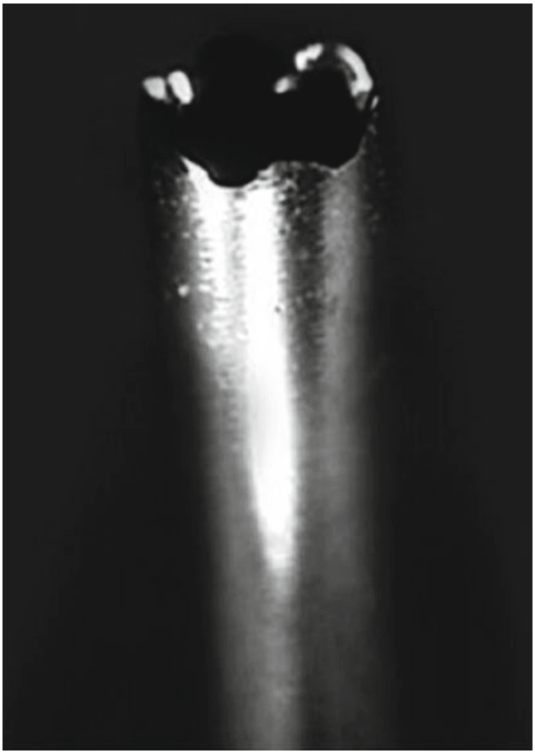

Fig. 33.5 Serrated punch blade: photo courtesy by John P Cole MD

The author prefers to use a serrated punch (Fig. 33.5) for the procedure. The scalp is very smooth and the punch does not become blunt even after 1500 extractions in total shaven FUE. However, in non-shaven FUE, the nearby hairs can be caught and transections can dull the punch. Therefore, the blades are changed after 600–700 punches (Table 33.1). Asians have thicker hair than Caucasians [5]. Therefore, blunting of punches should be watched for during procedures on Asians. The difference between non-shaven FUE in Asians and Caucasians is the length of the follicular unit, which averages 1 mm longer in Asians [6]. Moreover, tethering around the hair follicle is more common than in Caucasians (Fig. 33.6), which makes regular extraction difficult using a 3-mm-depth punch, and can cause loss of follicular units from damage. The author recommends using a 4-mm-depth punch

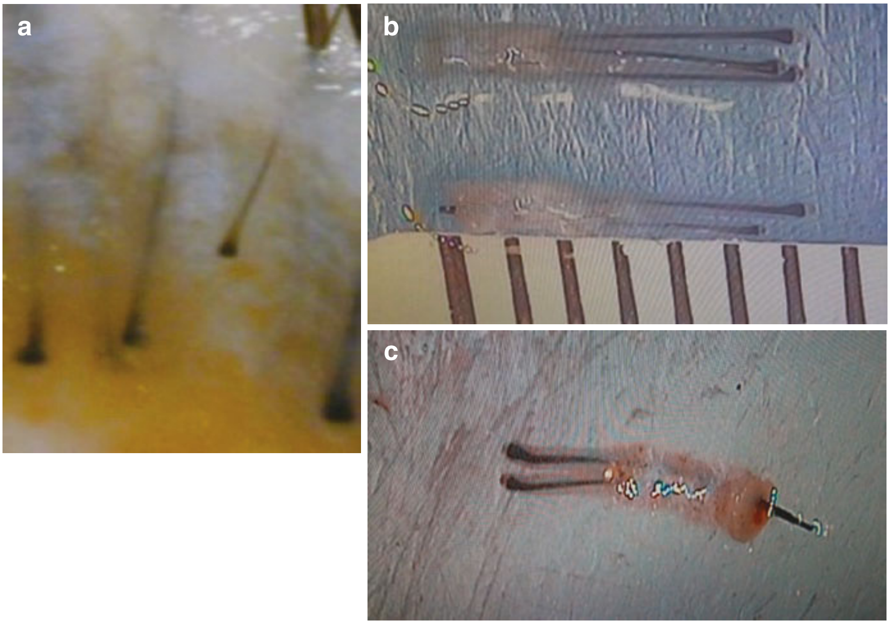

Fig. 33.6 East Asian hair and scalp variation. (**a**) severe tethering, (**b**) variable length, (**c**) variable curvature

for non-shaven FUE on East Asians. Use of a 4-mm punch causes a relative increase in the transection rate, but the number of damaged follicular units is less than when a shallow punch is used. Moreover, the successful survival rate is higher when using a 4-mm punch since the extracted follicular units are healthier. Deep punching during non-shaven FUE is more challenging and has a long learning curve.

33.2.3 Extraction Methods

The extraction process after punching is a difficult procedure and requires caution, as nearby hairs and bleeding can obscure the visual field (Fig. 33.7). The procedure takes longer than with total shaven FUE, and the tissue out-of-body time must be considered, as prolongation of the surgery can also cause loss of follicular units. For successful extraction, it is important to have a good visual field. Therefore, hairpins should be used to improve visual field, and although it may take longer, the procedure should be performed slowly using ATOE forceps and Forester forceps (Fig. 33.7) after complete removal of blood clots. The follicular units are readily desiccated and should be transferred to chilled storage after every 10–15 extractions. If an assistant performs this procedure, more time should be allocated. Capping [7], the extraction of epidermis without a follicle, should be prevented with deep punching.

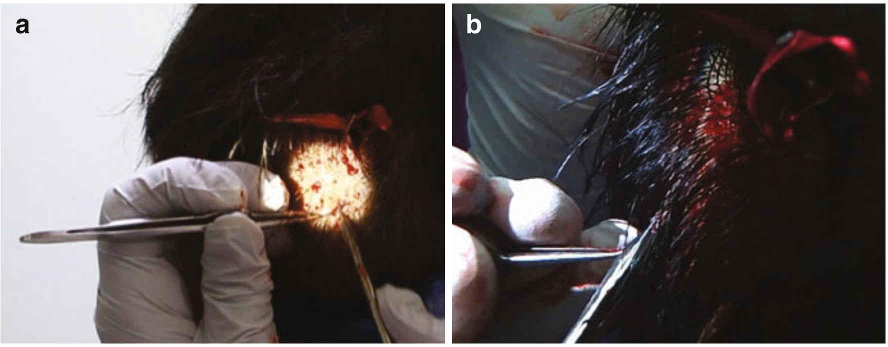

Fig. 33.7 (**a**) ATOE forceps and Forester forceps. (**b**) Non-shaven FUE extraction can cause distracted hairs and bleeding

Table 33.2 Comparison between non-shaven FUE and total shaven FUE

	Non-shaven FUE	Total shaven FUE
Mean age	38.5 (8.8)	34.0 (8.7)
Mean operation time (min.) per 1500 FUs	360.3 (47.0)	316.3 (56.8)
Mean transaction rate (%)	5.6 (2.2)	5.1 (2.2)
Mean calculate density	2.3 (0.2)	2.3 (0.1)
Mean VAS score	7.9 (1.3)	4.9 (2.1)
Number of observations	50	50

Note: The values in parenthesis are standard deviation. VAS score 0, not at all satisfied; 10, very satisfied

33.3 Advantages of Non-shaven FUE

As previously mentioned, the advantages of non-shaven FUE are the perfect camouflage and patient satisfaction (Table 33.2). Although it is more difficult than other procedures, the number of patients who request non-shaven FUE is increasing despite its high cost. If a surgeon becomes proficient after many cases, the operative time is no more than 15%–20% longer than for total shaven FUE, and the extent of surgery is no greater than that of the total shaven method. Based on the author's experience, and assuming that a maximum of 3000 follicular units can be extracted daily from an East Asian patient's occipital region, non-shaven FUE can be performed if the case is deemed possible by the total shaven method. No cases presented difficulty in covering the occipital region after surgery (Table 33.2).

Donor depletion and visibility are frequently observed with excessive extraction but can be prevented in non-shaven FUE by preoperative cutting. Non-shaven FUE allows selection and extraction of follicular units that are in relatively better condition than in total shaven FUE, in which hair thickness is hard to predict by looking at 2-mm-long strands.

33.4 Disadvantages of Non-shaven FUE

The decrease in surgical visibility due to existing hair is a significant disadvantage of non-shaven FUE. This disadvantage can present as a disturbance in punching and in extraction. As previously noted, it is important to apply firm traction and tumescence injections to increase visibility. To obtain better visibility, good posture, at least 5× magnifying power, and high-quality LED illumination (Fig. 33.8) are required. Despite the concern that the transection rate would be increased in non-shaven FUE, it is actually no different from that in total shaven FUE (Table 33.2) after a few cases. With experience, punching becomes less stressful, and stabilized punches rarely affect the outcome of surgery. A variable that affects surgical outcomes is the prolongation of extraction. The author directly extracts 20–30% of FUs after punching in each area and examines the extracted follicular units in order to determine individual and regional patterns. The rest of the procedure is performed by the assistant; assuming the assistant is skilled, the procedure duration averages 1.5–2 times more than that required for total shaven FUE. The prolongation causes tissue out-of-body time to be extended, and therefore, the negative effects on survival rate should be considered. The author always uses a chilling device to prevent the stressed follicular units from desiccating and uses an extracellular matrix holding solution, such as HypoThermosol® FRS, depending on the condition of the follicular units. Since punching and extraction in this procedure are relatively more difficult techniques, disadvantages must be overcome by performing many cases and by monitoring the surgical team's attention to quality control.

Fig. 33.8 8× loupe magnification with LED light

33.5 Results

The results of the comparison between non-shaven FUE group (Group A) and total shaven FUE group (Group B) are in Table 33.2. The numbers of observations for each group is 50 and 50, respectively. The average operating times per 1500 FUs for each group are 360.3 min (Group A) and 316.3 min (Group B), while the mean values of visual analogue scale (VAS) for each group, which measure the degree of satisfaction for returning to usual life after surgery, are 7.9 (Group A) and 4.9 (Group B), respectively. The result shows that while non-shaven FUE takes 15–20% longer time to perform, it also significantly increased the patient satisfaction. However, the mean values of calculated density (CD) and transection rate (TR), which measure the quality of the surgery directly and indirectly, are close to each other.

33.6 Conclusion

Non-shaven FUE is stressful even for a hair transplant specialist due to its high degree of difficulty. However, non-shaven FUE can be safely performed in many cases and addresses the need for patients to go back to work as soon as possible. As non-shaven FUE is relatively more difficult in East Asian patients, and the disadvantages of the surgery can affect the outcome, extra attention should be paid to development of a system to minimize tissue out-of-body time and to control the operation team's quality. The author believes that non-shaven FUE has a promising future in hair transplantation (Table 33.3).

Table 33.3 Pearls of non-shaven FUE Pearls of non-shaven FUE

• At least 4-cm-long hair length is recommended for non-shaven FUE
• Cut every other follicular unit with 2–3 hairs individually, trimmed into 2–3-mm lengths using round tip scissors
• Use hairpin traction to increase visibility
• Insert a tumescent agent as evenly and firmly as possible
• Decrease the RPMs of the punch to the lowest rate possible
• Check for punch blade blunting and change when needed
• Punch as deep as possible at least 70% depth of follicle length
• Minimize an out-of- body time

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Chapter 34
Gigasession with FUT: Refining the Technique for Optimal Results

Jerry Wong and Thomas C. Nakatsui

34.1 Introduction

Over the years, follicular unit hair transplantation has evolved in many respects. The most recent significant modification concerns extraction technique, and in many offices follicular units are now being extracted routinely via follicular unit extraction (FUE). Despite this new trend in extraction technique, the strip technique still retains some distinct advantages, the foremost one being the large number of follicular units that can be harvested in a single session and, consequently, the ability to achieve more spectacular results in a single session (Figs. 34.1 and 34.2).

Follicular unit transplant single-session yields have increased to what have been referred to as megasessions and gigasessions [1]. At this time, there is no universally agreed upon definition of a gigasession but for the purposes of this discussion, a gigasession will be defined as any transplant session involving 5000 or more grafts. To our knowledge, FUE single-session yields have never even been close to 5000 grafts.

A gigasession is not for the faint of heart. It requires the right patient with the right hair and scalp characteristics, and it requires an experienced and talented team that is willing to work hard. If any one of these characteristics is not present, a gigasession is not going to be successful.

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34.2 Patient Selection

The first and most important step is patient selection. This type of session requires a patient with above average to excellent hair density and above average scalp laxity. There are several devices available to assess hair density although with experience it becomes easier to assess this on physical examination.

Fig. 34.1 (**a**) 6000 grafts in a single session, frontal view. (**b**) Top view

Fig. 34.1 (continued)

There are also some devices available to measure scalp laxity, but the "Wong wiggle test" is a practical and simple method to ascertain how much laxity is present (Fig. 34.3). After the width of the donor site has been marked out and the patient lying prone, the mobility of the donor site is assessed by placing the thumb and index finger of the right hand on the superior and inferior edge of the donor area, respectively. The index finger of the left hand is used to mark the center of the donor site. The thumb then pushes up the superior border of the donor site to see if it will readily reach the line indicated by the index finger of the left hand. This process is repeated for the inferior border and if the edges readily reach the center line, this indicates that the donor site can be safely removed. However, it is prudent to recheck the laxity after one side of the donor area has been removed as laxity sometimes decreases after the initial section(s) have been removed.

Asian hair is usually less dense than Caucasian hair, and in order to obtain sufficient grafts for a gigasession, it is usually necessary for the patient to perform scalp stretching exercises. This is accomplished by having the patient stretch the donor area 10–20 times daily for 5–10 min at a time. The occipital and parietal scalp in the donor area is stretched by firmly pushing the scalp up and down using the palms of the hands. Using this simple method for 4–8 weeks, the donor yield can often be increased by 500–1500 follicular unit grafts [2].

Despite these exercises, it is not always possible to obtain enough grafts to do a gigasession. For patients of Chinese or Japanese descent, it is almost impossible; conversely, for patients of Indian descent, it is often relatively easy. Koreans are somewhere in between so it is difficult to generalize with so many different Asian ethnicities.

Fig. 34.2 (**a**) 4298 grafts in a single session, frontal view. (**b**) Top view

34.3 Procedure

After marking out the donor area and trimming the overlying hair, anesthesia of the donor site is accomplished by infiltration of 1% Xylocaine with 1:200,000 epinephrine, followed by infusion of a tumescent solution containing 1:400,000 epinephrine. The donor site is then removed in two to four sections by first scoring the incision lines and then carefully dissecting down to the fat and just below the follicles. The section is then removed paying close attention to preservation of the underlying vessels. The section is then closed using absorbable dermal sutures and surface staples, and the process is repeated for all sections.

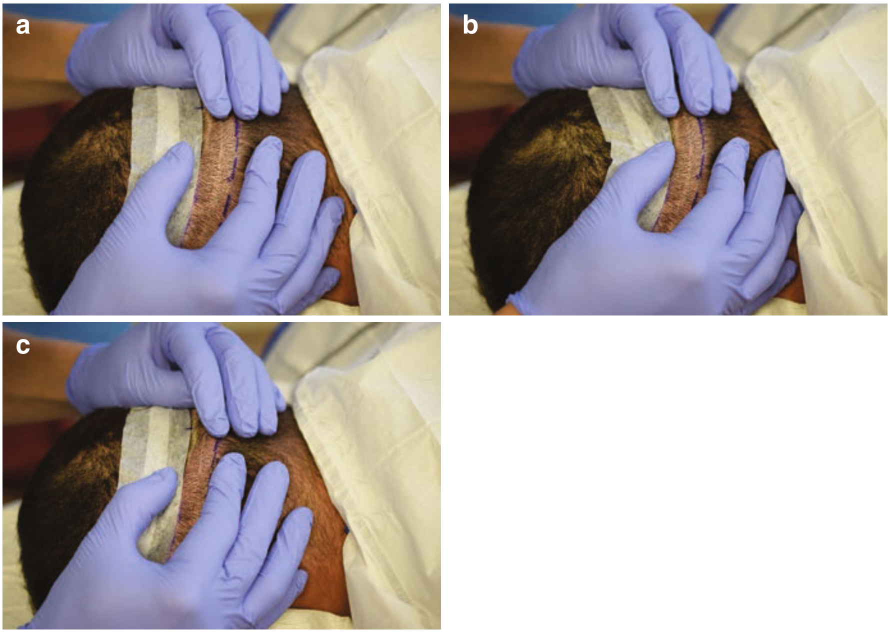

Fig. 34.3 (**a**) Laxity is assessed by first placing the index finger of the left hand over the center of the donor strip with the patient lying prone, in this case from a patient with a preexisting donor site scar. (**b**) The superior border of the donor strip is pushed toward the left index finger to see if the scalp will readily stretch to this position. (**c**) The inferior border of the donor strip is then pulled toward the left index finger

In the past, we often incised deeply with the first stroke without paying as much attention to preservation of the vasculature. By making a shallow initial incision and carefully dissecting down, we are now able to preserve more hair follicles and protect more blood vessels. Preserving the larger underlying blood vessels at this stage is of great importance as this may improve graft survival in the vertex. Maintaining the patency of these vessels is sometimes difficult, particularly in patients with very little subcutaneous fat or very superficial vessels, but every effort should be made to avoid transecting, cauterizing, or tying off these important vessels.

After the first section has been removed and while the subsequent sections are being removed, the donor hair is slivered into one follicular unit wide transverse slivers that are then broken down into individual follicular units by the rest of the transplant team. This aspect has not changed much since the inception of follicular unit transplants. The grafts continue to be created using microscopes and magnifiers to produce teardrop-shaped grafts with more tissue at the bottom of the graft than at the top. This layer of tissue surrounds the hair follicle and protects the follicle from desiccation and trauma. Interestingly, this is the opposite scenario that we see with many FUE grafts where there is very little tissue left at the base of the follicle.

The recipient area is then shaved down to 2 or 3 mm to allow efficient and accurate placement and angulation of the recipient sites and to allow quicker insertion of the grafts. Although smaller sessions can be performed without shaving down the recipient area, gigasessions require the recipient site to be shaved down in order to get these grafts in as efficiently as possible.

Anesthesia of the recipient site is performed in different ways. One author (JW) prefers to perform a ring block using 1% lidocaine and 1:200,000 epinephrine slowly administered with a dental injector and a 33 gauge needle. The other author (TN) prefers to anesthetize the frontal scalp by doing supraorbital and supratrochlear nerve blocks [3]. The sites are anesthetized initially with bacteriostatic normal saline as it contains 0.9% benzyl alcohol, which provides a mild amount of anesthesia with very minimal discomfort. This is followed by the infiltration of bupivacaine 0.25% and 1:200,000 epinephrine into the same sites to provide longer-lasting anesthesia. The use of bacteriostatic normal saline attenuates the sting of the bupivicaine injection, making it more tolerable.

Once the recipient site areas have been completely anesthetized, the target area is tumesced with normal saline containing 1:300,000–1:400,000 epinephrine. In general, we try to use the lowest concentration of epinephrine that is effective at reducing bleeding. Although we do not have any concrete data, lower concentrations may lead to increased graft survival. Creating tumescence in the subcutaneous space is very important to decrease bleeding while the slits are being created, and to prevent transection of the underlying vessels as excessive transection may lead to decreased graft survival and even cutaneous necrosis.

Another modification we have been trying is the use of lower concentrations of epinephrine in the tumescent fluid to see if this will lead to any benefits in graft survival. At this point, it is too soon to declare if there is any true benefit.

The authors create the recipient sites using the lateral slit technique using custom cut blades [4, 5]. The size of the blades varies from case to case, depending on multiple factors such as the coarseness of the hair, the tightness of the hair bundles, the elasticity of the skin, the fragility of the hair bulb, and the curl of the hair. For example, if the hair is coarse and the hairs in each follicular unit are splayed out, this will require a larger slit size than very fine hair that is tightly bundled. There are also some grafts where the bulb is extremely fragile. In this case, the slit size may need to be enlarged slightly to minimize insertion trauma and/or compensate for slightly chubbier grafts. In general, our slit sizes range from 0.65 mm to 1.2 mm, depending on the aforementioned factors and number of follicles per graft.

Graft insertion techniques have largely remained unchanged for the last 10 years or more. We have trialed various insertion devices, but in our hands, the insertion forceps is still the best way to insert grafts.

34.4 Final Thoughts

A final modification is the inclusion of a small follicular unit extraction (FUE) session after one or two sessions of strip transplantation. For a patient with Norwood 6 hair loss, one to two strip sessions are performed first to move the required

6000–8000 grafts, then FUE is done to improve the scar if needed and for any refinement work. This hybrid approach gives the patients the best of both worlds and leaves the donor in great shape.

This is our current approach to gigasession follicular unit hair transplants. Proper patient selection with respect to scalp mobility and hair density is probably the most important decision to be made prior to embarking on a gigasession. However, if the patient has the appropriate hair and scalp characteristics, gigasessions can be done safely and can achieve outstanding results.

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Chapter 35
Gigasessions with Combination of FUT and FUE in Asians

Akaki Tsilosani

Follicular unit transplantation is the leading method of hair restoration surgery, and current techniques allow harvesting and implanting large numbers of FUs in a single session. For patients with advanced degrees of baldness (Norwood classes IV–VII), patients may require very large numbers of follicular units (3500–10,000), and there are a number of potential benefits to the patient of transplanting these very large numbers during a single session:

1. Faster results—the optimal cosmetic result of the hair transplant surgery is seen earlier, because it occurs 1 year after the first session, instead of 1 year after the last session.
2. Less inconvenience—patient undergoes the inconveniences related to surgery only once.
3. Lower cost—patient saves money, since in general the cost for one gigasession will be less than the cost of two smaller sessions.
4. Better donor scar—in general, the first scar is the best, even if the donor strip is wide.
5. Improved growth—in general, grafts from the first session grow better than after subsequent sessions [1], possibly due to less recipient area scarring or other potential reasons.

However, many hair transplant surgeons believe that performing gigasessions may cause a variety of problems:

1. Dense packing problems—placement of large numbers of grafts close to each other may compromise the vascularity of the recipient area and lead to a decrease in graft survival.

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2. Long surgery time concerns—long duration of gigasession (8–12 h) increases out-of-body time and the risk of grafts dehydration. In addition, the patient and the staff get tired and that may affect the quality of work.
3. Poor donor area issues—wide strip excisions in patients with low donor density or poor scalp laxity may cause an unacceptable scar.

Regarding dense packing concerns, usually gigasessions are performed in cases of advanced baldness, with Norwood classes IV, V, VI, and VII, when the recipient area exceeds 100 cm^2 and when transplanting less than 3500 FUs would result in average density of less than 50 FU/cm^2. Recent studies have shown that when small (less than 1 mm) and sharp instruments are used for recipient site creation, blood supply is not altered and graft survival is not decreased even when the density of implantation is greater than 70 FUs/cm2 [2, 3]. This suggests that planting densities of 35–50 FUs per 1 cm^2 can be considered safe as well.

While long surgery times are a valid concern, gigasessions of up to 5000 grafts should only be performed at clinics with a large team of professionals capable of completing these cases within a 6-h time frame. Mostly important is to efficiently organize the teamwork. Gigasessions begin with tumescent anesthesia, which decreases bleeding and persists for a long time, and are completed in 30 min with one surgeon and one nurse. Next the same two-person team harvests a large donor strip, which takes less than 1 h including trichophytic closure of the wound. The same team next prepares recipient sites, which takes no longer than 1.5 h. Thus, from the first steps of local anesthesia through the creation of the last recipient site, only 3 h are needed.

During this time, a second team, consisting of one surgical assistant for slivering and five to six assistants for cutting, prepares the needed number of grafts using stereomicroscopes. Highly experienced cutters can each prepare 300–400 high-quality grafts in 1 h, depending on the donor material characteristics. Thus 2.5–3 h are needed to prepare 5000 grafts.

The final step is implanting grafts in pre-created recipient sites. Three assistants implant the grafts while one to two assistants keep the recipient area clean and dry. Highly experienced surgical assistants can implant at a rate of 10–15 grafts per minute (depending on bleeding and popping). If the team of implanters consists of three assistants for 5000 grafts, then 2.5–3 h are sufficient to complete the task.

Thus, a gigasession of 5000 grafts can take less than 6 h to compete, including several 5–10 min breaks for the patient, which avoids fatigue for both the patient and the staff. In our experience, the only obstacle for performing gigasessions are patients with a poor donor supply, either from low donor density or poor laxity of the scalp.

In patients with high donor follicular density (more than 80 FUs per cm^2), we need to harvest a strip not less than 60 cm^2 to obtain 5000 FUs. Usually strip length is limited to 30–35 cm in length, so the average strip width needs to be 2.0 cm. Since the strip ends are tapered, this means that the strip width in the center has to be extended up to 3 cm. It is possible to harvest a strip of this width only in patients with very good scalp laxity. This is quite rare, especially in Asian patients where hair density is lower on average, varying from 65–75 FUs (120 hairs) per 1 cm^2 [4, 5].

In addition, the Asian scalp tends to be more firm and tight compared to Caucasians. According to our study [6], Asian scalp laxity is 1.5 times less than Caucasians. In our experience it's impossible to transplant more than 3000–3500 grafts in Asians without a tight wound closure which may increase the risk of wide donor scar formation. Scalp stretching exercises before surgery are very helpful for this problem. According to J. Wong, scalp stretching can improve scalp laxity and may increase the ability to harvest up to 1500 additional grafts [7]. But often this is not enough and therefore additional time must pass before a subsequent surgery.

Another option is injecting hyaluronidase into the donor area before surgery, which significantly increases scalp laxity. However, this effect is temporary and gives a false impression of scalp laxity. After the hyaluronidase effect resolves, the scalp tightness returns, and the risk of ischemia increases (Figs. 35.1 and 35.2). We

Fig. 35.1 Donor area necroses

Fig. 35.2 Shock loss in donor area

have experienced complications such as donor area necroses and shock loss in the donor area using this approach.

In an effort to reduce the strip width without decreasing the total number of grafts transplanted during one operation, we decided to combine strip harvesting with FU extraction (FUE). For example, to obtain 5000 FUs for transplantation, we initially perform FUE of about 1500 FUs from the zones above and below the strip and then excise a 1.5–1.8 cm width strip, from which we obtain 3500 FUs. This technique was first tested in 2006 and soon we appreciated the obvious potential of such a synthesis. This method allows us to harvest the necessary quantity of grafts while substantially decreasing the closure tension on the edges of the donor wound.

Combining the techniques of FUE and strip excision is rather simple. First, the desired strip outline is marked. The strip width seldom exceeds 1.5 cm, with a strip length ranging from 25 to 30 cm. Next, between 500 and 2000 grafts are harvested using the FUE method above and below the strip edges. Last, the strip is excised, which generates between 2500 and 3500 grafts depending on the follicular density. As a result, between 3000 and 5000 FUs are obtained for transplantation.

We performed a study measuring scalp tension during the process of closing the donor wound using two dynamometers (Figs. 35.3 and 35.4) and concluded that if

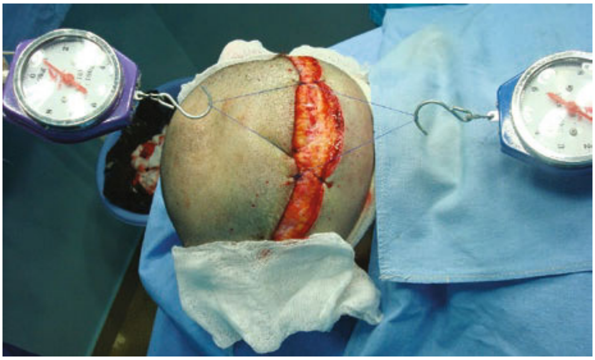

Fig. 35.3 Scalp tension forces measurement after strip excision

Fig. 35.4 Scalp tension forces measurement after strip excision and 1200 FU extraction

at least 30% of the grafts are obtained through FUE and the remainder are generated from a strip, the tension force decreases twofold during wound closure [8]. Using this combination in almost every patient, donor wounds were closed and cosmetically acceptable scars were obtained (Figs. 35.5, 35.6 and 35.7, 35.8).

While combining strip surgery with FUE increases the duration and cost of the procedure, we believe this is the optimal approach when attempting a gigasession in Asian patients with poor donor laxity and density.

Fig. 35.5 and 35.6 Donor area after combination of FUT and FUE

Fig. 35.7 and 35.8 Donor scars after combination FUT and FUE

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Chapter 36
Gigasessions with FUE: How to Avoid Complications

Erdogan Koray

36.1 Introduction

As a result of improved harvesting techniques, hair transplant surgeons specializing in FUE have been able to enhance the quality of grafts. Of course, these advancements are also able to improve the quality of the grafts that can be harvested and transplanted not only in megasessions but also in gigasessions. Nevertheless, there are complications that present themselves in these cases primarily due to the condition of the donor area and the overall coverage area required.

Given these variable factors, perhaps one of the greatest pitfalls in FUE surgery, but more especially in gigasessions, is the lack of a proper evaluation of the patient's donor and recipient areas and a carefully mathematically calculated surgical plan. Bearing this in mind, two important initial questions must be posed for each potential surgical candidate prior to commencing with a surgical plan:

1. What is the patient's total donor capacity?
2. How many grafts will be required to allow for acceptable coverage in the recipient area?

In order to accurately respond to these questions, the surgeon should identify the following (Fig. 36.1):

1. The donor area in cm^2
2. The average hair caliber in different parts of the donor area (temporal, parietal, and occipital)
3. The calculated density in different parts of the donor area (temporal, parietal, and occipital)

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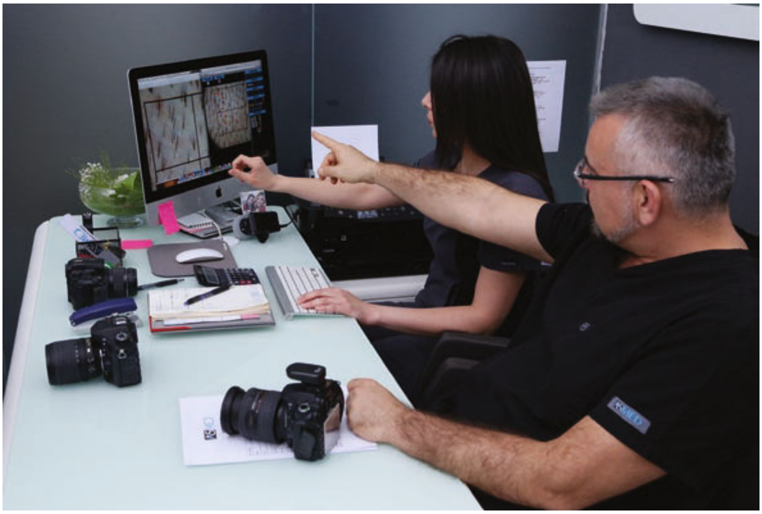

Fig. 36.1 Identification of the mathematical elements for the execution of a surgical plan

4. The estimated or targeted hairs per graft average for grafts that will be extracted
5. The projected extent and areas of future hair loss
6. The patient's "Coverage Value" in different parts of the donor area

36.2 Coverage Value

"Coverage Value" is nothing more than the ratio of the number of hairs per square centimeter to the average caliber of the hair. It is essentially an index used to determine the number of grafts required per cm^2 that will provide adequate and acceptable coverage in the recipient area without depletion or overharvesting of the donor area. It is an indispensible tool in determining the total donor capacity and one that is necessary to avoid gigasession complications.

Experience has shown that the "Coverage Value" should ideally be established at more than "5–7" in both the recipient and all the donor areas. However "6" is still considered acceptable coverage. Often forgotten is the ominous potential for senile alopecia and DUPA that should be considered in all cases. This suggests that a higher donor area number should often be contemplated to avoid future difficulties (Fig. 36.2).

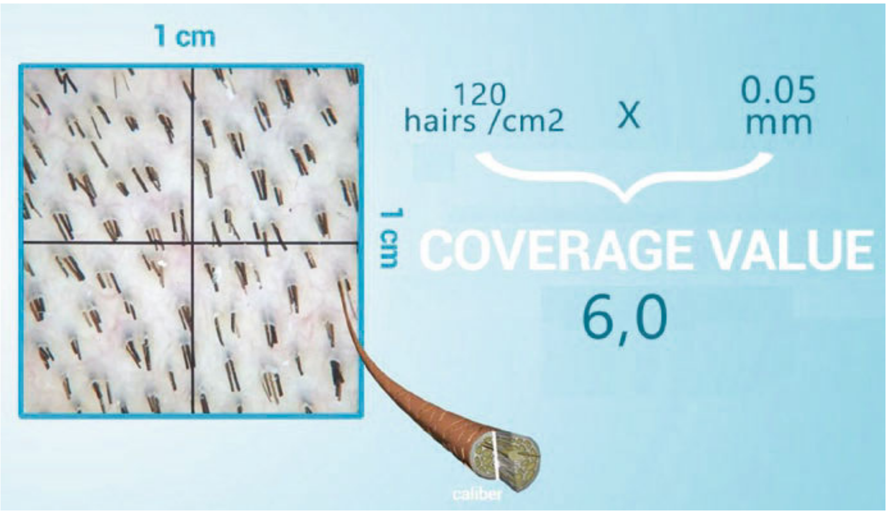

Fig. 36.2 Calculation of "Coverage Value." Identifying the mathematical elements for the execution of a surgical plan

36.3 Donor Capacity

Since donor capacity is the maximum number of follicular units that can be extracted without creating a density problem, it is one of the main determinants of hair transplantation planning. FUE surgery, within the limitations of donor capacity, is especially important in gigasessions to avoid overharvesting and to obtain natural-looking homogenization.

In order to determine donor capacity, the following must be determined:

1. The donor area (cm^2)
2. The average hair caliber in different parts of the donor area (temporal, parietal, and occipital)
3. The calculated density in different parts of the donor area (temporal, parietal, and occipital)
4. The estimated or targeted hair per graft average (Figs. 36.3, 36.4, and 36.5)

In the case illustrated in Fig. 36.5, the "Coverage Value" of the occipital donor area is "14.1" and the hair caliber is 55 microns (70 cm^2). Target Coverage Value "safety" margins are necessary for each donor area in order to address unpredictable future hair loss such as senile alopecia or DUPA (Fig. 36.6).

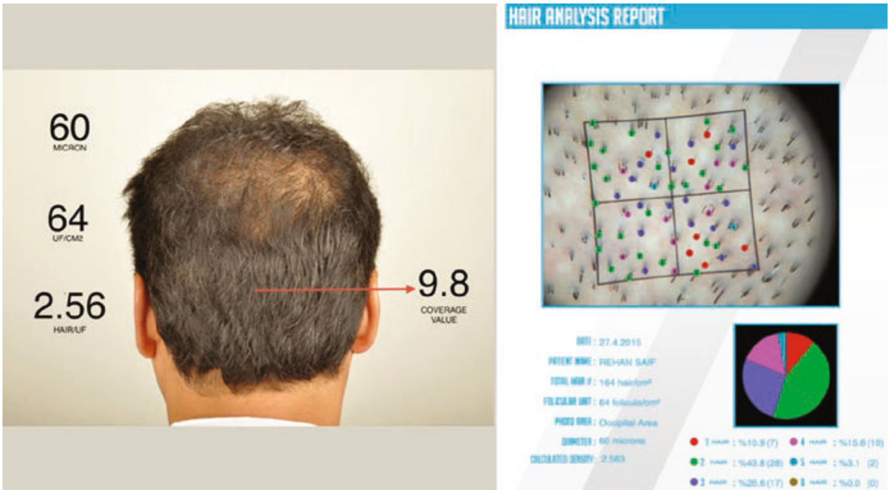

Fig. 36.3 A patient with a 9.8 "Coverage Value"

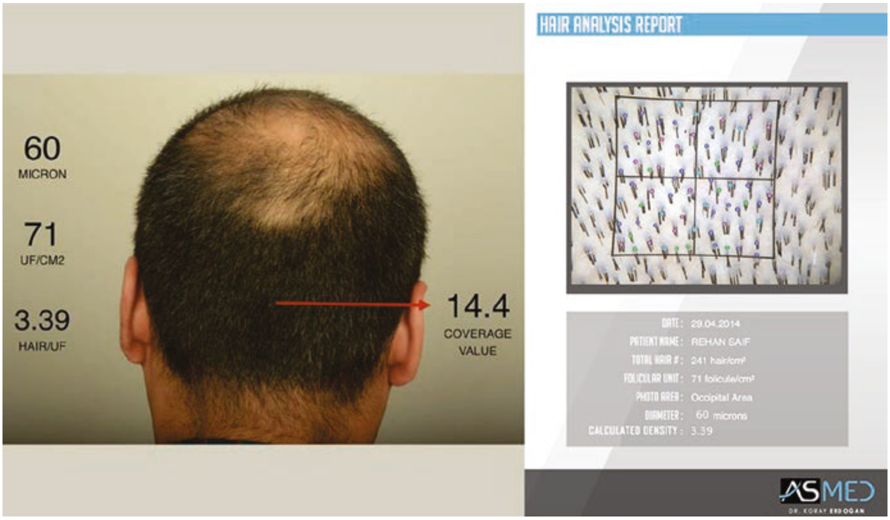

Fig. 36.4 A patient with a 14.4 "Coverage Value"

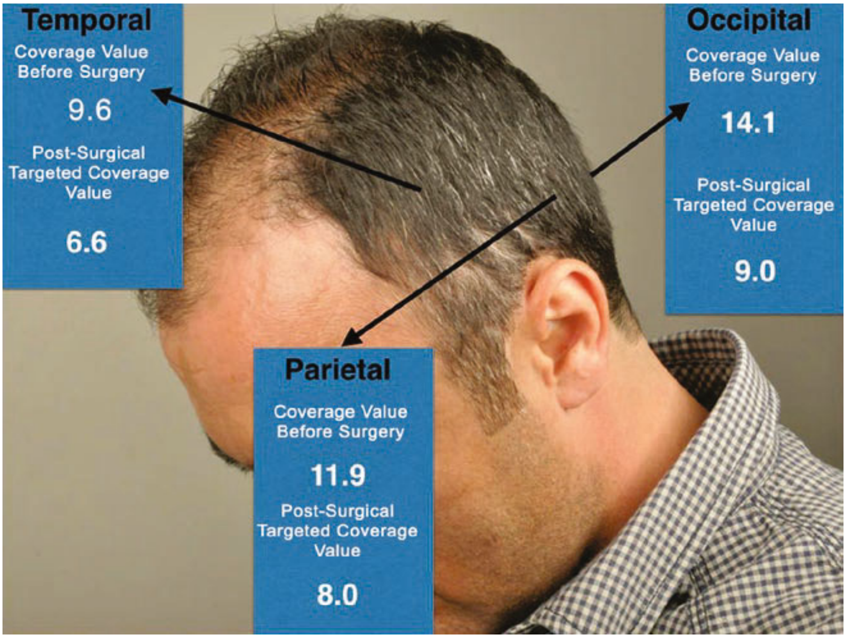

Fig. 36.5 Illustration of presurgical "Coverage Value" and postsurgical "Targeted Coverage Values" for each donor area: temporal, occipital, and parietal

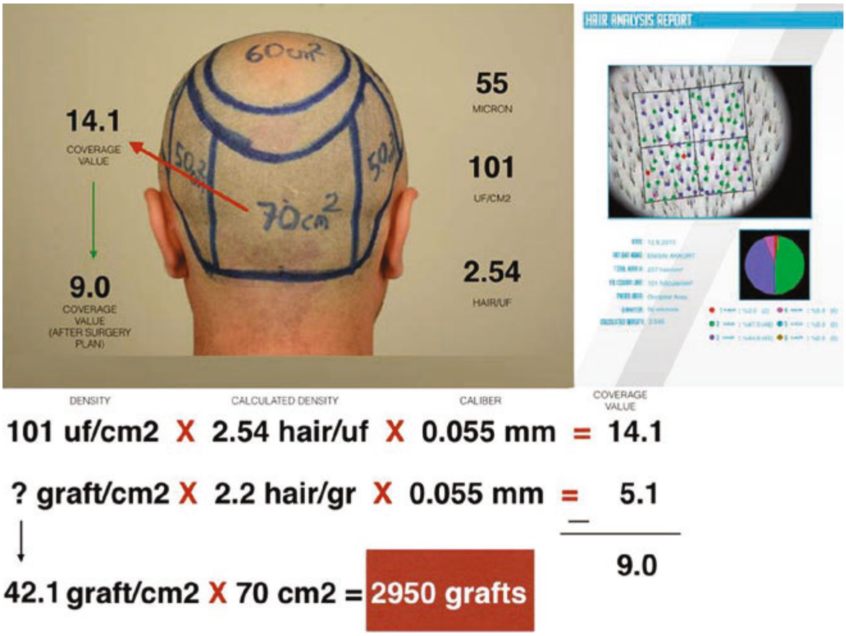

Fig. 36.6 Calculation of graft numbers required for a "Targeted Coverage Value" of "9" in the occipital area of the same patient shown in Fig. 36.5

Fig. 36.7 Calculation of graft numbers required for a "Coverage Value" of "6"

In the case illustrated in Fig. 36.6, the surgical plan was to establish a "Coverage Value" of "9" in the occipital area thereby falling into the range of what is considered "safe" for the donor area. Given a targeted or estimated hair per graft average of 2.2, the calculation equates to 2950 grafts. In other words, this means that after the extraction of this number of grafts, the "Coverage Value" of the occipital area will be "9." This number exceeds the minimal acceptable "Coverage Value" of "6" (Fig. 36.7).

The same calculations can be implemented for the recipient area where a "safety" range is unnecessary since there is no depletion or overharvesting potential involved (Fig. 36.8).

An index for different hair types including ethnic hair types can be created by FUE surgeons using the same metric system (curly, smooth, wavy, etc.) (Figs. 36.9, 36.10, and 36.11).

36.4 Homogenization

In the case of insufficient donor capacity patients such as Norwood VI patients, the homogenization is often a viable solution for acceptable outcomes. A targeted "Coverage Value" of "4" or "5" can be established for both the donor and recipient areas, thereby homogenizing both areas especially when color contrast between the hair and skin is optimum (Figs. 36.12, 36.13, 36.14, and 36.15).

In severe cases of baldness such as that indicated in Figs. 36.12, 36.13, 36.14, and 36.15), the intentional choice may be to maintain a "Coverage Value" lower than what is normally considered acceptable in order to effectively implement the

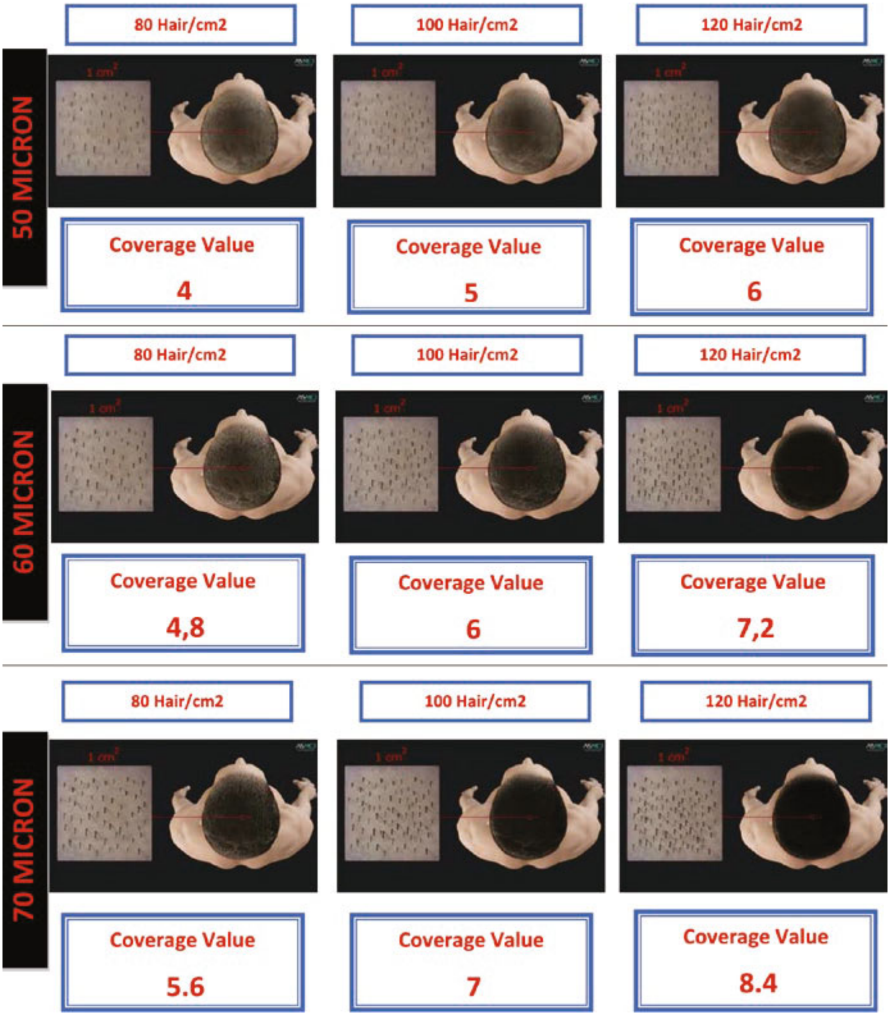

Fig. 36.8 Range of different "Coverage Values" for different hair types

concept of homogenization. In the long run, and considering the optimum skin contrast in this case, homogenization was indeed the preferred choice in order to obtain a more natural look (Figs. 36.16, 36.17, 36.18, 36.19, 36.20, and 36.21).

36.5 Graft Counter

Very recently, a computerized application called the "Graft Counter" was developed and implemented to assist in recording the number of grafts, the rate of production, the total number of hairs, and the hair per graft average for the surgeon. With the

Fig. 36.9 Demonstrates a graft requirement in a recipient area of 120 cm^2

Fig. 36.10 Postsurgical photo of the same patient shown in Fig. 36.9

assistance of this piece of technology, "real-time" data allows the surgeon greater control to adjust punch sizes and/or techniques during the extraction phase of the surgery that correspond to the targeted hair per graft average, thereby allowing for greater homogenization (Figs. 36.22 and 36.23).

The data produced by the Graft Counter will undoubtedly be utilized in the future in the quest for greater graft yields and to further enhance the results of mega- and gigasessions (Fig. 36.24).

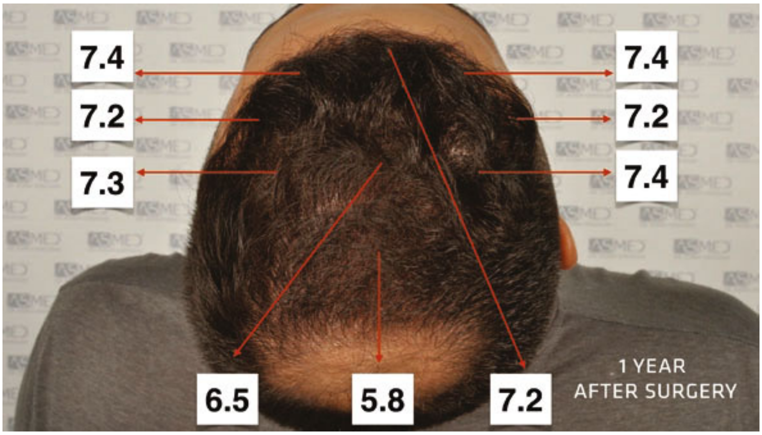

Fig. 36.11 Demonstrates the "Coverage Value" after 1 year in various recipient areas for the patient shown in Figs. 36.9 and 36.10

Fig. 36.12 Presurgical photos of a patient with a "Coverage Value" of "10.7" in the occipital area

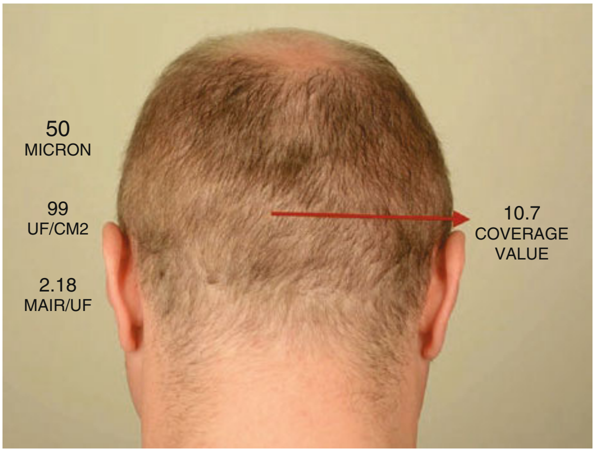

Fig. 36.13 Presurgical photos of the same patient shown in Fig. 36.12 with a “Coverage Value” of “6.6” in the temporal area

Fig. 36.14 Graft requirement calculation of the patient shown in Figs. 36.12 and 36.13. Due to optimum color contrast, homogenization is the preferred approach in surgical planning for this patient

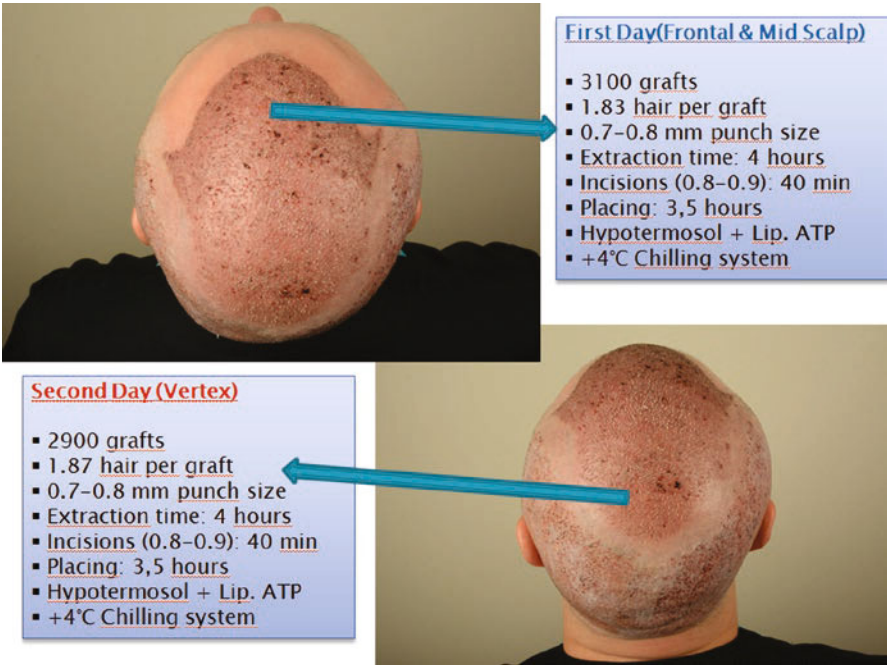

Fig. 36.15 Two-day gigasession postsurgical data of the patient shown in Figs. 36.12, 36.13, and 36.14 with a total of 6000 grafts

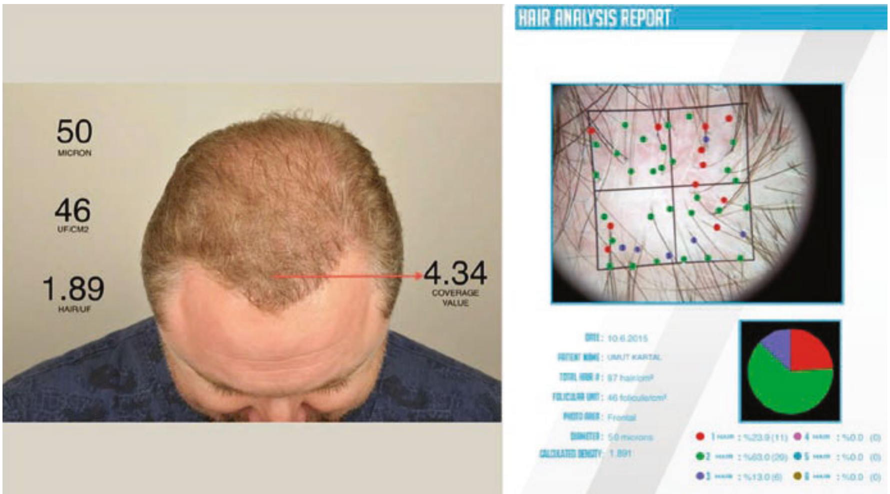

Fig. 36.16 Indicates the postsurgical "Coverage Value" of "4.3" in the frontal area of the patient shown in Figs. 36.12, 36.13, 36.14, and 36.15

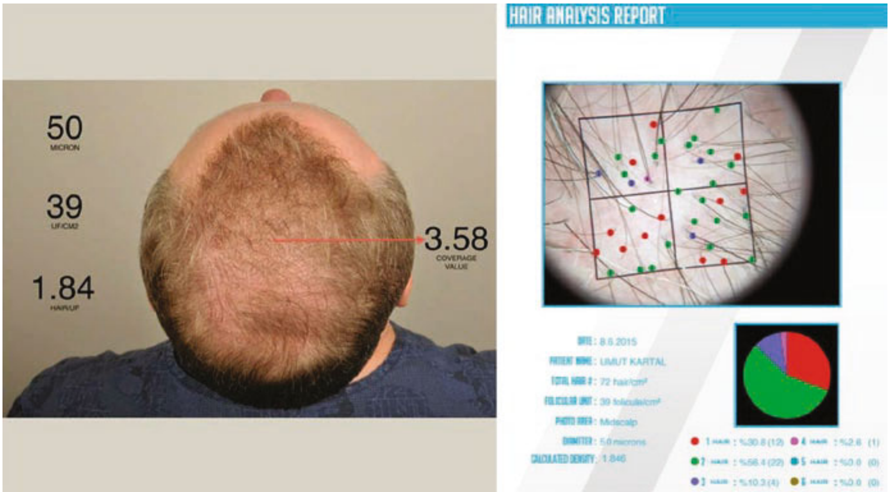

Fig. 36.17 Indicates the postsurgical "Coverage Value" of "3.58" in the mid-scalp area of the patient shown in Figs. 36.12, 36.13, 36.14, 36.15, and 36.16

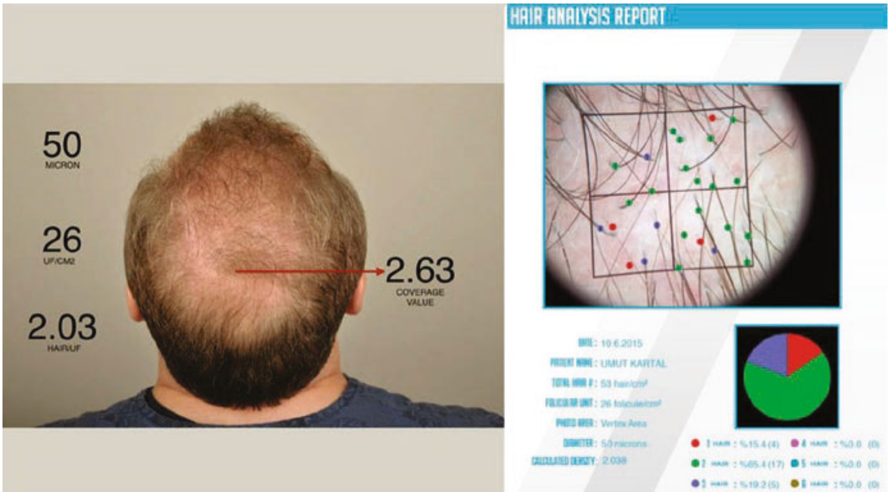

Fig. 36.18 Indicates the postsurgical "Coverage Value" of "2.63" in the vertex area of the patient shown in Figs. 36.12, 36.13, 36.14, 36.15, 36.16, and 36.17

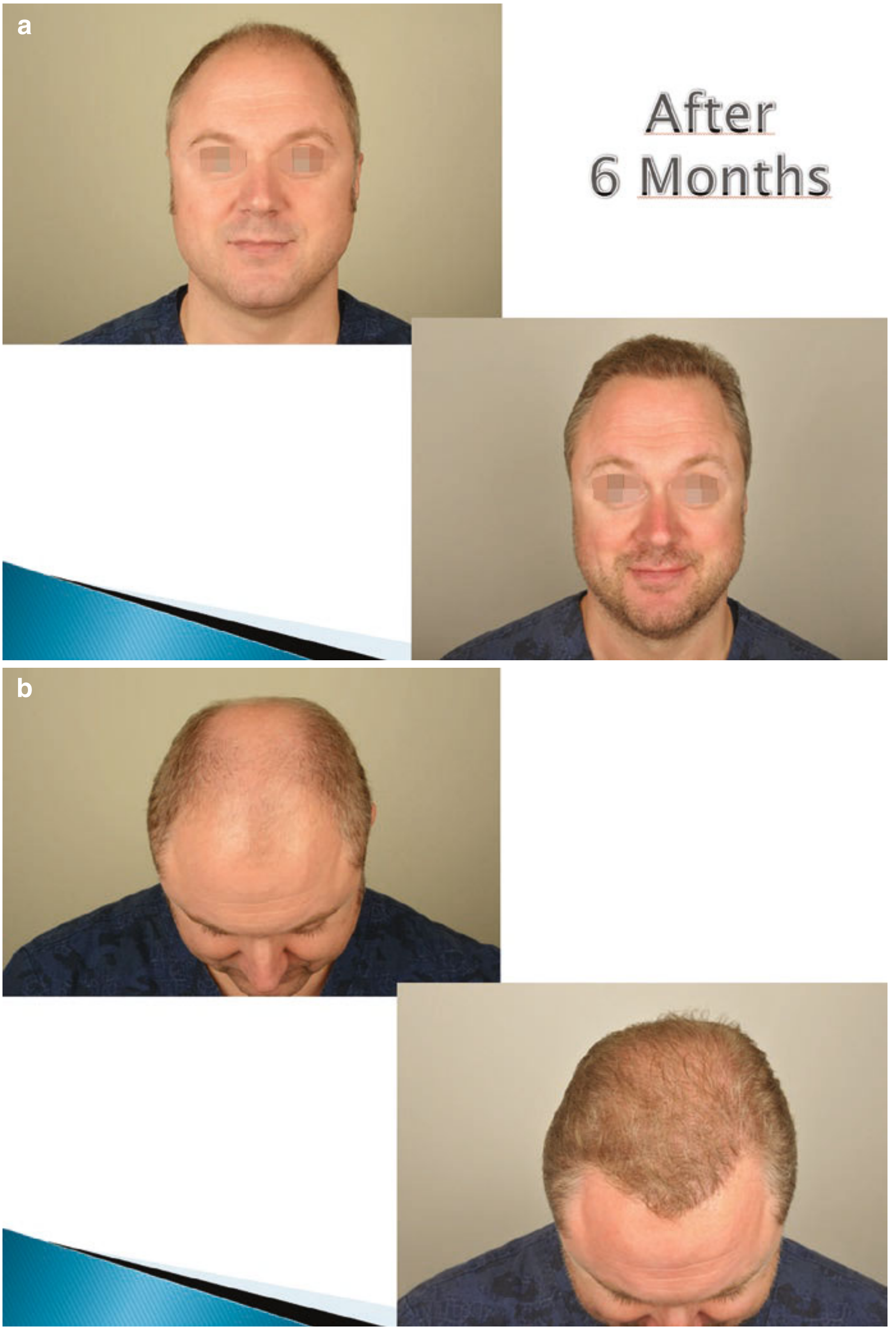

Fig. 36.19 (**a**) Demonstrates the postsurgical outcome of the patient shown in Figs. 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, and 36.18 6 months after surgery. (**b**) Additional views of the same patient. (**c**) Additional views of the same patient

Fig. 36.19 (continued)

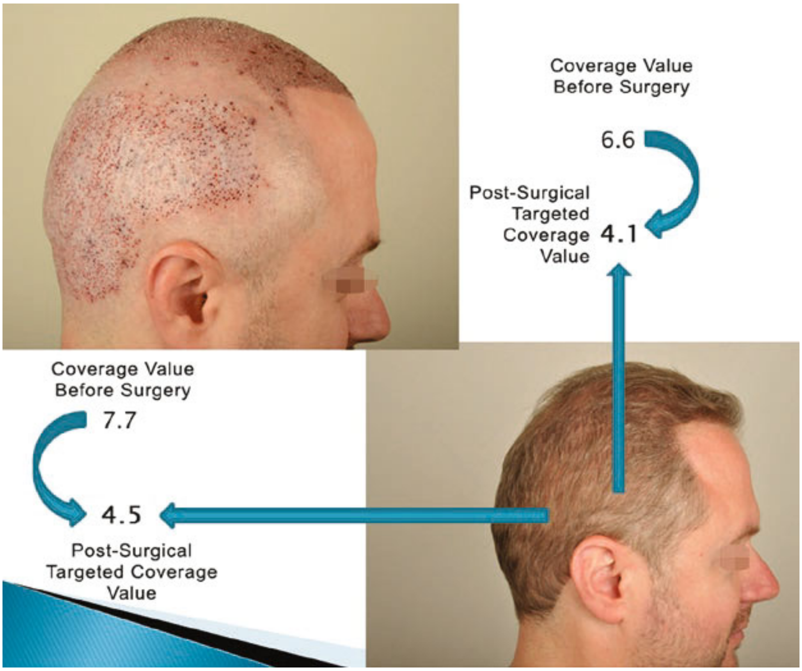

Fig. 36.20 Demonstrates the pre- and postsurgical "Coverage Values" in the temporal and parietal areas of the patient shown in Figs. 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.18, and 36.19

Fig. 36.21 Demonstrates the pre- and postsurgical "Coverage Values" in the occipital area of the patient shown in Figs. 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.18, 36.19, and 36.20

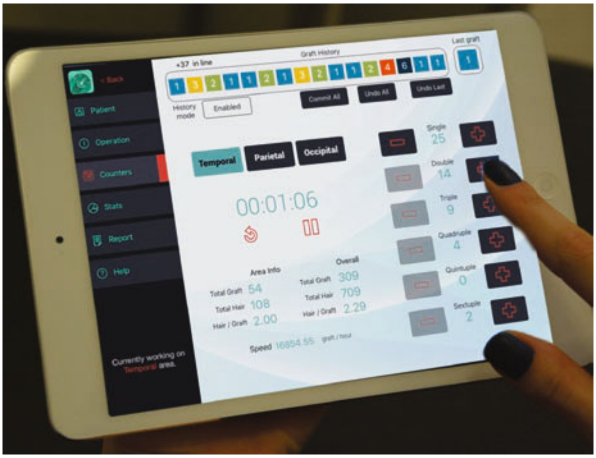

Fig. 36.22 The Graft Counter App

Fig. 36.23 The Graft Counter App provides "real-time" surgical data allowing the surgeon to make adjustments during the procedure

Fig. 36.24 Surgical assistants are responsible for the "real-time" input of surgical data into the Graft Counter

36.6 Conclusion

Gigasessions, as we have seen, are usually indicated for patients with cases of severe alopecia. Since the surgeries are of long duration, the surgical teams as well as the patient should be prepared for tedious sessions.

However, the fatigue of the patient and the surgical team is of lesser concern for surgeons than donor management and preservation, elements that can only be controlled through careful surgical planning and mathematical calculations such as the "Coverage Value" computation.

With these strategies in place, what remains is to find a way to address both senile alopecia and DUPA, variables that remain unpredictable in gigasession planning, as well as in all FUE surgical planning, as they may progress over a patient's life span. Surgeons must be prudent and conservative in determining adequate leeway for future natural hair loss when finalizing any surgical plan.

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Part VII
The Recipient Site

Chapter 37
Recipient Site Planning and Design

Damkerng Pathomvanich

37.1 The Recipient Area

The recipient area is often neglected at hair meetings and workshops and is of little interest for discussion since many surgeons might believe that placing the grafts is the assistant's job, and the duty of the surgeon is limited to harvesting by either FUT or FUE. I have to reemphasize that a satisfying recipient area that looks natural with high density, natural hair flow, and angling is difficult to master.

First of all, the patient needs to be assessed if he or she is a candidate for hair transplantation. The ratio of the recipient area versus the donor area, hair characteristics, and the ratio of miniaturized hair at the donor area need to be thoroughly evaluated. A complete physical examination of the entire recipient area noting any preexisting lesions including basal cell carcinoma, nevus, seborrheic keratosis, and squamous cell carcinoma should be performed and recorded. If lesions are noted at the time of consultation, they must be treated prior to surgery. It would be best to refer to an appropriate specialist if you think you're not comfortable treating the lesion. The patient must be informed that hair grafts will not exit the scalp until 3–6 months after the procedure [1], and of unpredictable shock loss of the native hair, and that it might not come back.

37.1.1 Recipient Area Planning

The recipient area is subdivided into many zones by Cohen [2], but this approach is not used by most hair surgeons. Most hair surgeons develop their own technique of dividing the area into many boxes based on the total availability of grafts (Fig. 37.1).

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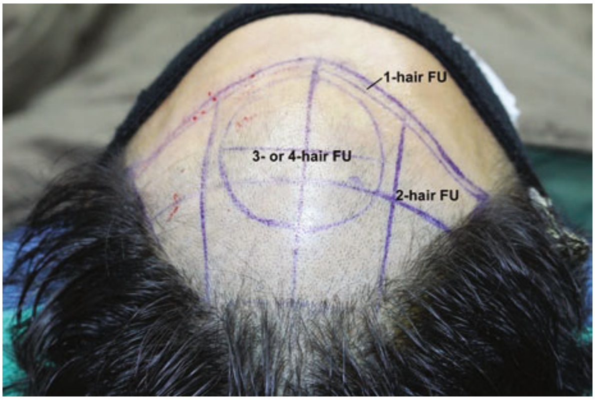

Fig. 37.1 Recipient area marked in boxes for one-hair, two-hair, and three-hair grafts

Recipient site planning needs accurate graft calculations to achieve a decent look [3, 4]. For younger age groups with extensive hair loss, most surgeons won't operate on a patient under age 25 since an unpredictable amount of future hair loss is expected [5]. In my practice, if the patient is very bald at age 20 but has good donor hair and is realistic about the outcome of the transplant, then I would proceed with restoring a decent hair line, placing it high and informing the patient of limited donor supply due to expected future hair loss. I would also recommend at this point that he should consider taking medications to prevent hair loss. If the younger age group is accepted as a candidate for surgery, the hairline again must be more conservative hence must be placed higher than the patients' preference due to concerns of future progression of balding, which limits the amount of donor hair available. I would caution not to reconstruct the temple points in the very young age group since the rapid hair loss will leave an isolated island of hair on both temples, necessitating the need for more grafts to unite the isolated island of hair to the main temple farther back (Fig. 37.2). On the contrary, for older age group patients with minimal hair loss or patients born with a naturally high forehead, a lower hairline can be placed since there is enough donor supply in most cases, and the hair loss progression is usually slow. The challenge lies in Norwood VII patients with the issue on planning the appropriate solution on how to properly utilize and strategically place the grafts to frame his face due to limited hair reserves.

In Norwood III patients with very dense hair behind the balding area for transplantation, a higher density of hair grafts is needed because once the hair grafts grow, it will compete with the existing native hair further back and the disparity in thickness might be obvious. It is safer to inform the patient that a second session after 12–18 months might be necessary if the density is not satisfactory. On the contrary, if he also ends up with Norwood VI later in life, too many grafts used will result in less donor supply in the future.

Fig. 37.2 The arrow shows the progress of hair loss, and the transplanted temple becomes the island of hair

In Norwood IV–V, one needs to assess the appropriate number of grafts and plan for future hair loss. High density at 35–40% at the forefront might be enough, and 30–35% at the back will give adequate coverage for the time being.

Norwood VI will need larger number of grafts and would require at least two to three sessions to cover the entire scalp, needing approximately 6000–8000 grafts depending on the donor availability. High density is placed in front at about 35–40% and 25–30% over the crown. Side weight might be considered to give a denser look on the part side.

Norwood VII should be treated conservatively since there will not be enough grafts to supply the demand. The grafts need to be placed starting at the front with a high hairline with a density of more or less 30%. The crown has to be left untouched until the front and mid-scalp is completed and reassessed (Fig. 37.3).

37.2 Should We Use Multifollicular Unit Graft?

The question of using follicular unit grafts (FUGs) versus multifollicular unit grafts (MUGs) in some areas especially at the frontal forelock to achieve a full lookup front is also an issue. FUG will look more natural when mixed with one-, two-, or three-hair grafts, simulating an individual's natural hair grouping. MUG solely placed over the forelock will create an illusion of high density [6]; however, if the patient will part the hair at the middle, it will create a pluggy look as compared to using only FUGs. However, if this is done, it should be placed at least 2 cm away from the hairline so it will not be detectable if the patient combs the hair backward.

Fig. 37.3 Good growth of hair grafts at the front and top, the crown was left untouched for further assessment

37.3 How Do We Plan Where to Place the Follicular Unit Grafts (FUGs)?

The first few rows should only be one-hair graft. Asians usually have strong coarse hairs. Selecting fine single hair grafts and planting them over the front and using the coarser single hairs at the back row would create a more natural look and softer hair line. Fine hairs are also used to restore the temple area. See detailed discussion on Chap. 55.

I use at least 60% of the available three- to four-hair grafts at the frontal forelock and two-hair grafts around its periphery. I use the leftover single hairs to blend in with two-hair grafts. To add on density at the forelock, I use two-hair grafts placed in between three hairs to soften the frontal tuft. The leftover three- to four-hair grafts can be added further backward or on the mid-forelock if there is still space available. The leftover one-hair graft can be placed at the front or mixed with two-hair grafts.

37.4 Density Gradient

Most surgeons place 35–50 grafts/cm^2 on the front and less further backward due to limited donor supply [7, 8]. Unger stated that even 25–30 FU/cm^2 could create relatively dense-looking hairline zones and entire frontal areas [9]. The hairline is the benchmark of the hair surgeon, and it needs to be irregular by placing a mound, widow's peak, or clusters of hair below the line every 1–2 cm^2 [10].

The density at the hairline for Asians to look natural based on the study of Dr. Tyng Yuan Tan, the average frontal hairline density in men is 77.8 FU/cm^2 and 110 hairs/cm^2. This translates to 1.4 hair/FU in the first 2 cm of the hairline. At the temporal region, the average density is 69.6 FU/cm^2 and 97.6 hairs/cm^2. This translates to 1.4 hairs/FU [11] (see Chap. 14). There are, however, several reports of super-dense packing of more than 50 grafts/cm^2 with adequate growth [12].

37.5 Hair Direction and Angle

The first inch of the hairline needs careful attention before making premade incisions especially for patients with ongoing hair loss but still with intact native hairs. This zone of the hairline has varying hair directions—it can go forward, sideways, and backward, and in some patients, a cowlick is present in front:

1. If there is minimal to absent native hair left, the best way to make the sites is to make the cut straightforward, turning the head sideways when approaching the temple.
2. If the patient still has lots of good native hair, the incision should be parallel to the native hair.

3. If the patient has only miniaturized hair left, it would be best to make the sites in forward direction. However, the hair direction must be discussed with the patient to determine if he or she insists on following the natural flow of miniaturized hair.
4. If the patient wants to add on density and still has coarse hair but is already thinning down, it would be best to follow the native hair.
5. If the cowlick is already miniaturized, expect it to fall out in the future. In these cases, it would be best to forget the direction of the cowlick and make the sites forward. However, if the cowlick is just thinning and will seem to stay, one might have to follow its natural flow and direction.

See detailed discussion on frontal hair direction and hair angle (see Chap. 14).

If the hair grafts at the temple gulf are placed sideways, it will create an illusion of more density since the hair will fall and shingle on one other. This is contrary to hair grafts placed forward which will look thin from light reflection although will look more natural.

Frontotemporal angle is also of concern. I usually transplant following a fan-shaped direction if the patient has no native hairs or has miniaturized hair. However, if the patient still has good strong hairs but that are already thinning, the grafts should be placed according to the existing hair direction.

37.6 **Transplanting Over the Crown** (See More Detail in Chap. 56)

It would be best if the crown is shaved prior to surgery because it will be more difficult and time-consuming to transplant without shaving.

In a brief pointer for East and Southeast Asian patients who only have baldness over the crown but with very thick hair at the front to mid-scalp, a density of 30% might not be satisfactory. One should wait for 1–1.5 years to see the final results if the patient is happy with the density. If not, he needs to come back for more sessions.

If the patient has miniaturized hair, it is best to mark the hair direction starting from the center of the cowlick then proceed to the periphery as a circle so it will be easy to make sites by following the line. If the patient is completely bald, there are still some hairs remaining that surgeon can follow in the majority of cases. The cowlick can be made at the center or more toward off center to the right (the most common location found) then mark the hair direction as described above.

I usually split the crown into quarters with a marker so it is easy for me to calculate how many grafts are needed in each box. Each box can be subdivided into more boxes for easy calculation and placement of grafts. In East and Southeast Asians, hair angle is generally not as acute as in Caucasians, and in most populations, the hairs are almost perpendicular to the scalp, ranging from 45–90°. The crown should not have MUGs because they will produce a pluggy look and will be visible to the naked eye. A blend of one-, two-, and three-hair grafts is best for this area.

37.7 Frontal Forelock in Asians

Isolated frontal forelock transplantation is not well accepted in Asians [13]. However, a well-designed wide forelock connecting the temporal fringe and mid-scalp can frame the patient's face well, ending with a happy patient even without touching the crown (Fig. 37.4).

Fig. 37.4 Before and after continuous forelock, transplanted in extensive baldness in one session

Fig. 37.4 (continued)

37.8 Recipient Area Preparation

The recipient area should be prepped after nerve and ring block (see Chap. 17) with Hibiscrub for 5 min then paint with Betadine and wipe off with 70% alcohol. Tools for insertion should be of good quality. Examples include extra fine forceps with soft handle to hold the graft when squeezed, right angle forceps, and/or curved forceps to open the incision and place the grafts. Quite often, a dilator with a blunt tip (Fig. 37.5) which comes in different sizes is used, with the graft placed after the dilator is removed from the incision.

37.8.1 Two Methods to Place the Grafts

37.8.1.1 Premade Incisions

Should premade incisions be carried out first followed by donor harvesting? Should it be done the night before or prior to FUT or FUE? Bernstein reported an experience that premade incisions created the night before harvesting created less bleeding and popping with easier graft insertion [14].

Premade incisions carried out by the surgeon should follow the native hair direction for easy insertion. If native hair is totally absent, it is best to make the slit incisions directed forward and turn the patient's head on the side when approaching the

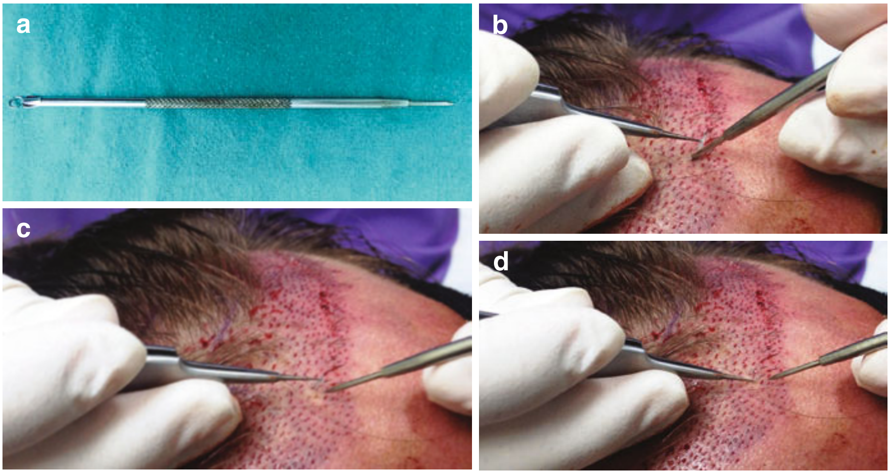

Fig. 37.5 (**a**) is recipient dilator, (**b**) dilator placed inside the premade incision, (**c**) dilator is removed, and 5.4 graft immediately placed

temples. This technique allows easier touch-ups for adding density during subsequent sessions. The best guide to achieve the appropriate angle is to follow the patient's native hair. Acute angles will create a shingling effect resulting in an illusion of more density when compared to obtuse angles. When the slits heal, there will be wound contraction of the exit angle of the hair shaft, thus causing the hair to be a little elevated [15]. The majority of the East and Southeast Asian population have straight hair, so the exit angle is not as acute as in Caucasians, with some patients having an almost pointed one. African-type hair exits more acutely due to its extreme curl. However in Middle Easterners with wavy hair, the surgeon can just follow the native hair angle as the best guide.

The benefit of premade incisions is to allow the assistants to place the grafts in the right direction and angle. Two to three assistants can insert grafts at the same time (Fig. 37.6).

The length of Asian follicles is longer and the diameter is larger [16]. Testing the grafts by making a few incisions and having the placer insert grafts of average length before proceeding with making all incisions is paramount for depth control adjustment. Tommy Hwang recommends that all the grafts be measured and grouped as 4 mm length grafts, 5 mm length graft [17], and so forth. This technique is done to prevent post-op folliculitis from buried grafts. He has made his own device to measure the grafts. However, Dr. Hwang uses implanters so it is easier to place the grafts at a specific depth. If you are using premade incisions, it is very difficult to make slits with different depths, and this will confuse the graft placers. As there is not much discrepancy in graft length or width, I have modified his technique by having my assistants eyeball and separate grafts that are too short or too long to be used later for stick and place. Sometimes two-hair grafts are the same or even bigger than three-hair grafts. These also need to be separated and inserted into larger size

Fig. 37.6 Three assistants placing the grafts

incisions so the grafts will have good contact and a snug fit in the slits. I usually make sites for about 70% of the estimated graft yield while the assistants are still cutting. Additional incisions are made later, or grafts are implanted with the stick and place method procedure as appropriate to add density.

For megasessions over 3000 grafts, it is best to leave 30% of the strip in place to be harvested about 4 h later. However, if the placers are fast and more than 70% of the grafts have been placed in the premade slits, the last section of strip can be harvested sooner. Theoretically, this technique prolongs graft survival of the last section of the strip and would be better than harvesting it and letting it sit in the Petri dish for extended periods of time. The grafts from the last harvesting should be placed last.

For small FUE sessions of 1500 grafts, surgeons can harvest first and make incisions later. Those who use implanters use this technique. The advantage of extracting the grafts first is for the surgeon to know the length of the follicle and estimate the amount of one-, two-, and three- to four-hair grafts to be made. The benefit of making site incisions first before extracting and placing the grafts later is that surgeons would know roughly how many grafts the patient needs, hence no downtime for placing the grafts. If the patient is in a sitting position, making sites first will allow the implanter to insert the graft at the same time the grafts are extracted.

For moderate to mega FUE sessions, half of the estimated number of grafts are extracted first and should be transplanted in the morning. Once completed, the patient as well as the assistants and surgeon are allowed to take a break. The other half is repeated in the afternoon. Megasessions also can be done subsequently the following day depending on the surgeon's preference and patient tolerability.

37.8.1.2 Stick and Place with Implanter Pen or Needle/Blade

The surgeon controls the hair direction and angle while the assistant places the graft upon removal of the needle/blade. The physician then adjusts the depth of insertion and hair direction.

For the final point, the grafts should rest just above the epithelium with the follicle directed forward. In the majority of situations, graft placement is performed by one physician and one assistant. However, two to three surgeons can perform stick and place at the same time if the patient is in the sitting position. The first surgeon stands on the front left, the second surgeon is at the front right, and the third surgeon stands at the back. Planning is very important so each surgeon will not interfere with each other.

37.9 Shaved or Non-shaved

It is best to shave the recipient area so the surgeon can see what he is doing especially over the crown with the hair direction in a centrifugal pattern. There are many patients unwilling to accept shaving and should be advised that the procedure can be more time-consuming especially with premade incisions and subsequently during graft placement and missing sites.

If the donor hair grafts are trimmed to at least 5 mm long, it will help identify the hair direction and angle after placement of the grafts and allow adjustment if needed. In case of buried grafts, they can be easily identified in a shaved recipient site and thus should be easy to remove.

37.10 Needle Versus Mini-Blade

Needles are easy to acquire, are less expensive, and come in sterilized packs. However, they becomes dull faster compared to blades after making 50–100 incisions hence need to be replaced.

Depth control is essential. There are several ways hair transplant surgeons improvise to achieve this. Marzola bends the needle like a gooseneck for depth control [18]. Shiao, on the other hand, uses elastic silicone sleeves [19]. I use Versi Handles made in different sizes (micro, small, medium, and large) to fit gauge 21, 20, 19, and 18 needles. The needle needs to be cut short to be able to fit inside the handle. The disadvantages of Versi Handle is at the junction of the needle and its bulky handle.

The needle will not be able to go all the way for incisions made at a 45 degree angle or less because the handle shoulder collides with the skin.

To correct this problem, the needle is bent so the surgeon can gently make the incisions in full depth along the way. However, precautions should be taken not to go deeper than the bevel of the needle when making the slits so the skin will not be cored.

Blades have been used for many decades. Different sizes of blades are made to accommodate grafts; however, the price is very expensive when compared with needles. Jerry Wong introduced the cutting-edge device which allows the surgeon to cut their own blade and adjust the size [20]. The blade is very sharp and can cut up to 500 grafts before it gets dull. I find it to be faster in making premade incisions, but there is more bleeding and bruising when compared to the needle.

37.11 Stamp for Making Accurate Density

Arturo from Mexico made a 1 cm stamp for easy calculation of recipient surface area and graft number. Francisco Jimenez refined the details by making stamps containing 20–50 dot/cm using a silicone block and painting it with gentian violet [21]. Surgeons can easily select the stamp with the density that he wants then make the slits. It is a great technique with precise density per square centimeter, but I found it technically difficult especially when the patients have existing or native hairs and are a bleeder. The marks might be erased eventually when the assistants wipe off the blood during slit making.

In practice, we mix two- to three-hair grafts and the size of the needles for each is different, so it is difficult to routinely use stamps especially in large balding areas with limited number of grafts.

Simplest Method to Do Is:

1. Draw the circle for mid-forelock about 1-3”, 2 cm behind the hairline.
2. Using a marker, draw the vertical line at the midline of the scalp dividing the head into two halves, and then draw another vertical line to split it into half on each side.
3. Draw multiple parallel horizontal lines about 2 cm^2 apart. Now we have multiple boxes equal on each side.
4. Estimate the number of grafts to be placed in each box according to the total number of grafts harvested.

Premade incisions are best started from the bottom up so the surgeon can press on the incisions to halt bleeding while proceeding anteriorly. However, since the total number of grafts is still not completed, the surgeon should not go too far at the bottom in case there won’t be enough grafts so as not to leave a gap devoid of hair at the front.

37.12 Coronal Versus Sagittal

There is no further debate that coronal slit incisions provide the best incision sites. The smaller incision size accommodates the grafts well with the chisel tip which gives better camouflage. However, it is sometimes difficult to find the slits and follow its direction compared with sagittal incisions, but with experience, the graft placer can learn quickly how to place the grafts in the right direction.

(a) Staining recipient site

Methylene blue and gentian violet have been used by many physicians [22]. However, if the placer wears loupes with 3.5–4.5 magnification power, most of the time there is no need to use the stain, hence avoiding toxicity from it. In darker-skinned individuals, slits might be more difficult to see, so staining might be more appropriate to visualize the incisions.

37.13 Graft Insertion

There are many techniques to insert the grafts following premade incisions:

1. Most physicians and assistants use single forceps on their dominant hand to hold the graft and place the graft inside the slit. The non-dominant hand holds the cotton bud or piece of gauze to stabilize the graft once it is placed inside the slit to prevent the grafts from dislodging when the forceps is removed. The advantage of this technique is fast placing, but it is quite traumatic for the grafts during insertion because the incision is not opened.
2. Another technique is the two-hand technique, where the dominant hand uses a straight or angled forceps to hold the grafts with the curve of the grafts in forward position. The non-dominant hand holds a curved or right-angled forceps to open the slit as wide as possible to allow the grafts to easily slide down the bottom of the slit with minimal trauma. Once the graft is inside the slit, the other forceps on the non-dominant hand holds the graft in place before the forceps is removed. In some instances, once the graft is partially slid inside the slit, the other forceps can push the graft so the graft will engage inside the slit faster. The final step is to make sure that the hair direction is facing forward. The forceps holds graft below the dermal papilla, at the middle, or sometimes at the dermal-epidermal junction if the graft is strong. Just to emphasize—the forceps are just used to support the graft but not to squeeze it, which may result to inadequate growth.

   Four placers can sometimes insert the grafts with ease with the two-hand technique in megasessions with two placers standing at the front and the other two at the back. When three to four placers are inserting grafts, the placers must coordinate with each other regarding the area for placing to prevent collisions which may slow down the insertion process.

3. Using dilator assisted for placing grafts (see Picture 5.1), it comes in different size for one and two-hair grafts. The non-dominant hand holds the dilator and places inside the slit; the dominant hand holds the graft at epidermis or mid-dermis then inserts the graft once the dilator is removed from the incision. This technique is excellent to place one-hair graft without trauma to the follicle.

Stick and place is employed at the end to add on density using the small caliber needle—e.g., two-hair grafts placed with 20/21G needle and three-hair grafts placed with 19/20 G and one-hair graft uses 22/23G needle except when the grafts are chubby.

My experienced placer can place an average of 10–12 grafts/minute except in patients with slippery grafts and heavy bleeding.

Slippery grafts are of concern because it delays the procedure. The grafts pop up, making it difficult to insert at the level just above the skin. The placer must use a good forceps with a very fine point to hold the grafts, and the graft should be inserted alternately skipping one or two slits to avoid pop-ups and just come back for them later when the first grafts are fully settled. Slippery grafts with bleeding is the worst scenario for insertion because its very time-consuming and, if not handled well, might potentially result in poor hair growth [23]. Luiz A. S. Pimentel recommended placing cyanoacrylate glue to the recipient area before premade incision and reported less popping [24].

37.14 The Implanter

The implanter will be discussed in detail in Chap. 42.

37.15 Follow-Up

In my practice the patient returns the next day for hair care and instructions. For megasessions, patients will have to do follow-ups for a few more days since sometimes a lot of pimples start on day 2 or day 3. See Chap. 18 for post-op care.

37.16 Summary

The recipient area management is one of the most important parts of hair transplantation and should not be neglected. Understanding the concept of proper assessment of the recipient site, incision making, placing of the density gradient with proper hair direction, avoiding pitting and cobblestoning, and avoiding graft desiccation will certainly provide an adequate graft growth with good results.

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Chapter 38
Optimizing the Efficiency of Recipient Area Estimation

Shobit Caroli

38.1 Introduction

An important question, "How many grafts do I need to have transplanted?" [1].

Rassman proposed the concept of "multivariant" analysis for the assessment of the number of grafts required to produce cosmetic fullness of hairs on the scalp with seven variables: (1) color contrast of hair and skin, (2) hair shaft thickness, (3) hair character, (4) size of the bald area, (5) donor hair density, (6) patient expectations, and (7) the available donor supply that will impact the analysis [2]. He also proposed the corrective esthetic multiplier for four of the seven variables [2].

Among the remaining three variables, the size of bald area is the multiplier that is most variable among patients. We must first calculate the total area of coverage as accurately as possible [3]. Based on the total area of coverage, we can decide the size of donor area that should be harvested [3]. This gives a guideline for planning the surgery session and also for the follow-up surgery sessions. If the estimated graft requirement is higher than the available donor, the derived estimate can become a valuable tool to show the patient what is surgically possible and reasonable [2]. In this way a reasonable budget of grafts can be developed for current or future surgeries for the cosmetic restoration of the bald area, and this can be explained to an anxious patient.

38.2 History and Advancement with Time

In the past, many hair transplant physicians have developed tools to measure the recipient area. Some used different shapes with a predetermined area to match the proposed recipient area over the scalp surface, and others developed complicated software-based calculators.

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Farjo et al. suggested the principle of measuring the size of the recipient area by dividing it into simple geometric shapes, including triangles, rectangles, squares, or circles [4]. John Cole proposed using the formula for the surface area of a sphere, pi (A) (B), where A is half the length and B is half the width, to estimate the bald surface area [5]. Farjo further accepted the suggestion of John Cole for this calculation [6]. The total recipient area includes both forelock and crown [5]. If it is only the forelock we need to measure, then simply divide the total of the above into two [6]. This method, although more complicated and requiring a calculator, may give a more accurate size of the forelock area [6].

Chang et al. in a hallmark study published in 2001 depicted the use of the polyurethane wrap (i.e., Saran wrap) mounted on a circular embroidery ring to trace the recipient area and utilized a 1 cm^2 grid for the area estimation [7]. The method described by Chang is simple and easy to apply [2]. One method is to count the intersections in the grid using the principle of morphometrics [7], as the number of intersections will closely approximate the area inside the tracing in centimeters squared [2]. However, for a more accurate estimation counting, the actual number of blocks is preferred [2, 3].

Many computerized photographic methods of area assessment are available, but most of them record measurements in two dimensions. This creates difficulty when reproducing the result on a three-dimensional scalp surface to the utmost accuracy. Devroye developed and proposed Hairmes as a computer-based surface area measurement tool [8]. Hairmes software has the capacity to correct the parallax errors caused by the curvature of the scalp. In addition it has a counter and can calculate follicular unit density, follicular unit tagging, expected donor yield, and incision density and can assist planning of recipient area [8].

In 2010, Pathomvanich and Caroli proposed the refinement of the Chang's method as a methodology. All available non-computer-based methods of area measurement were compared and statistically evaluated. Results showed a significant accuracy in measurement with the proposed methodology in comparison to other methods [9].

38.3 The Refined Chang's Method

The sequence of careful steps should be followed by the hair surgeon to find the area estimation to be valid, as precise as possible and reproducible at all the times [8]. This will further reduce the problems commonly faced by other methods of estimation.

38.3.1 Steps of Methodology

38.3.1.1 Step 1: Correct Visualization

For the assessment of the recipient area, the patient should be examined in an evenly bright illumination with or without magnification. The patient's hair should be made wet using normal saline or distilled water for better visualization of the area of hair thinning. Hair bands and hair clips can be used to hold existing hair out of the visual field.

Fig. 38.1 Hair examination under bright illumination and magnification

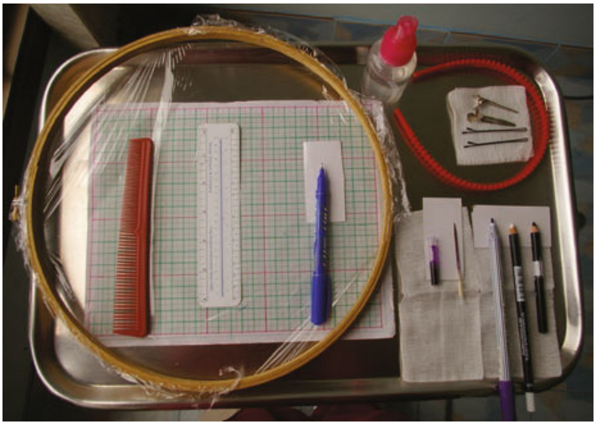

Fig. 38.2 Hair examination tray

A tray of items for hair examination should be available containing normal saline, comb, hair band, hair clips, skin-marking pencils (black and white), gentian violet marker, Saran wrap on embroidery loop, and a 0.25 cm^2 grid scale (Figs. 38.1 and 38.2).

38.3.1.2 Step 2: Skin Marking

The borders of the bald area should be marked with a fine point marker. The author prefers using a white eyeliner in dark complexion patients, surgical gentian violet in white skin patients with black hair, and the gentian violet or black eyeliner for patients with white skin with blond or gray hair. The marking material should be skin friendly, and permanent markers should not be used (Fig. 38.3).

Fig. 38.3 Contrast of the marking material on the skin and hairs. (**a**). White skin with blond/gray hair, (**b**) white skin with black hair, (**c**) black/brown skin with black/gray hair (Photographs courtesy to DHT Clinic, Thailand)

38.3.1.3 Step 3: Zoning and Tracing

The bald area should be divided into small zones wherever the curvature of the scalp changes sharply. Each of the zones should be traced separately on the Saran wrap. Rocking of the wrap on the three-dimensional scalp curvatures limits the precise tracing of marked line (Figs. 38.4).

38.3.1.4 Step 4: Grid for Area Calculation

The grid scale of squares with minimum area of ¼ cm^2 should be used. In the grid scale, we have made quadrants with an area of 1/4 cm^2, 1 cm^2, and 2 cm^2 for fast and precise calculation. The total number of small (0.25 cm^2), medium (1 cm^2), and big (25 cm^2) boxes in each zone is counted, and the area is estimated. Always try to align Saran wrap tracing to the grid scale as close as possible with minimal pleating. Estimation especially at periphery of the marking is better via small boxes (Fig. 38.5).

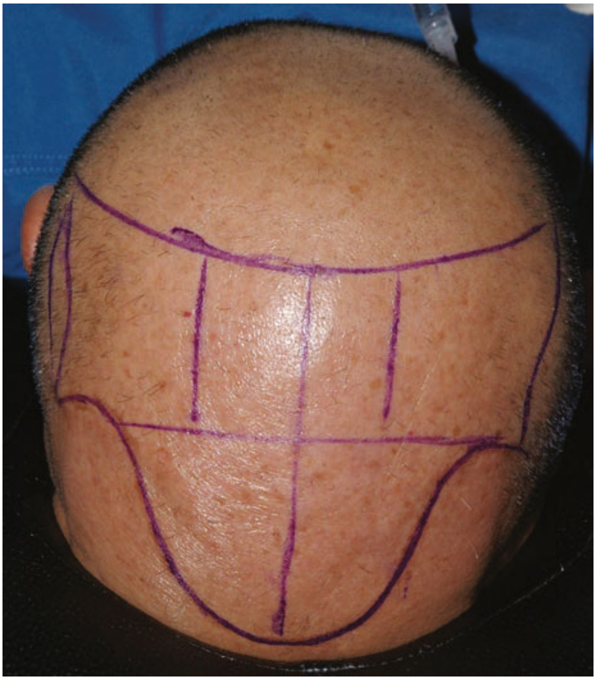

Fig. 38.4 Zoning of the area of baldness around sharp scalp curvatures

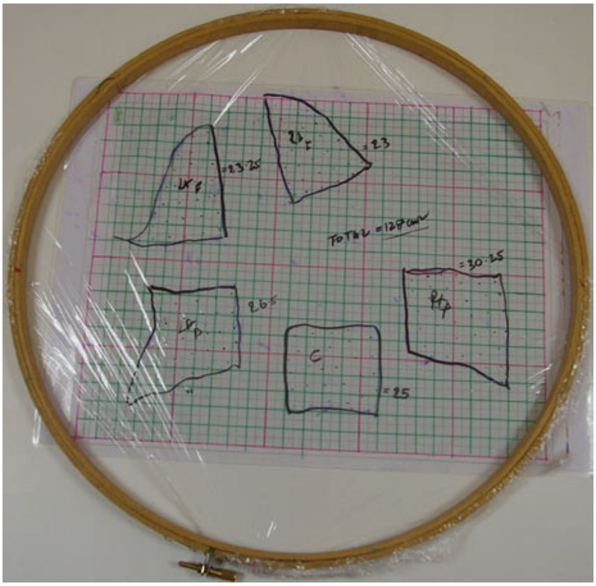

Fig. 38.5 Individual zone tracing on the Saran wrap with ¼ cm^2 graft paper for calculation

38.4 Interesting Findings

The author observed a few interesting findings while comparing different methods for measurement of the area in the study done at DHT Clinic in 2010 among 71 volunteer patients.

- With the Chang's method for tracing the marked line on a Norwood Class V or more patient, while rocking from one side to the back and then to the other side of the head, most of the time, the material shifted, causing an increase of the estimated area.
- Near the hairline or on the flat scalp surface, the measurement was found to be very predictable, as the Saran wrap stretches to flat and eliminates the error of rocking.
- For area measurement of an irregular area, Farjo's method was found to be very complicated as we have to split the scalp into many boxes and shapes.
- For area estimation for the frontal area and the hairline with Farjo's method with triangle simulation, we underestimated the hairline area and needed to add more by simulating with half of the circle.
- The use of a transparent shower cap for tracing the area marked on the scalp was economic, was convenient to carry, and fits well to the scalp curvature, but the method was limited due to moderate pleating of the material along the scalp curvature which adds to the error in area estimation.
- Lastly, the hairline height and design reflect the art and experience of the hair transplant physician which is different and needs to be tailored to each patient. This factor also leads to differences in the area assessed and the number of grafts required for surgery.

For a session with dense packing planned at 40 grafts per cm^2, an error of only 5 cm^2 in measurement can result in a graft error of 200 grafts. Thus, area estimation should be valid, as precise as possible, and reproducible at all the times. Area calculation after zoning of the recipient site with a fine point marker that contrasts the skin in good lightening and with the use of a quarter grid scale appears more reliable and efficient than the currently available methods.

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Chapter 39
Graft Preparation with Digital Video Microscope

Dae-Young Kim

39.1 Digital Video Microscope

During the graft dissection process of hair transplantation, binocular optical microscopes are widely used as a method to reduce follicle transection rates [1].

However, long working hours at the microscope stand and limited range of motion causing stiffness in the neck and shoulder areas both hamper work efficiency. To address these shortcomings, hair transplant surgeons started using Mantis microscopes (Fig. 39.1). Keene introduced the CCD video camera with LCD monitor and discussed the benefits of ergonomics, quality assurance, and easy teaching [2–4]. However, the resolution of the viewing screen was less than that of the optical microscope. With rapid development of technology, upgraded models of digital microscopes and LCD TV monitors are now available. I set up digital microscope systems for graft dissection by connecting handheld digital microscopes employing a 1/4-inch-type Sony CCD chip (410,000 pixels) with a 19-inch Samsung LCD TV monitor (Fig. 39.2).

Handheld digital microscopes were installed on a multi-stand. They could be moved vertically to change magnification, which was adjustable between 10× and 20×. The points of evaluation of this system were resolution, magnification, brightness, dynamic contrast ratio and response speed, scope of an area viewed on screen, availability, cost, and the need for illumination.

The optical image was viewed directly on the CCD camera, transmitted through a composite output, and projected on the monitor. The Samsung 933HD (16:9 Wide Vision) 19-inch LCD TV monitor had 1360 × 768 resolution, 10,000:1 dynamic contrast ratio, 250 candles in brightness, and a response speed of 5 ms. Linear LED lamps set up 50 cm above the dissection surface provided sufficient illumination for the dissection process.

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Fig. 39.1 Mantis microscopes

Fig. 39.2 Slivering the donor tissue with 20× magnification of the digital video microscope and graft cutting with loupes magnification

39.2 Benefits of Digital Video Microscope

Compared to LCD computer monitors, LCD TV monitors provide higher-quality, moving images without losing focus by instantly capturing rapid movement. Handheld digital microscopes were adjusted to 20× magnification for best visibility. The visual working field viewed on the LCD TV monitor was about 2.5 cm. We did not utilize the integral light sources of the digital microscope because of the light reflected on the liquid used for hydration of hair follicles during dissection and decreased visibility. The working distance was about 20 cm. The handheld digital microscope and thin, wall-mounted 19-inch LCD TV monitor allowed more working space. Because technicians could move the digital microscope and adjust focus with the zoom lever easily, work efficiency improved [5].

39.3 Work Efficiency of Slivering Under Digital Microscope and Graft Dissection with Loupes Magnification

To verify the work efficiency of the digital video microscope system, a comparative study was performed on the transection rate and the work time of slivering and graft dissection using only the digital microscope system versus using a combination of the digital microscope system and loupes.

The process of dissection was divided into two steps: the first step is separation of the donor strip into slivers with 10–12 follicles each, and the second step is dissection of the slivers into the follicular units. I compared the work efficiency of dissection with only the digital microscope system on both of the steps with the use of the digital microscope system on the first step and loupes on the second step. To maintain objectivity, I used donor strips from the same patient, and the two technicians performed follicular dissection in the same working environment. In this study, slivering and graft dissection using the digital microscope system on the first step and loupes on the second step was twice as time efficient with a similar transection rate. This combined method proved to be more effective at dissection than using the digital microscope system alone [6]. I also have used this effective combined method since 2009.

39.4 Practical Application of Digital Video Microscope

When technicians look at an LCD TV monitor, they find that the three-dimensional effect is less than what they would get from looking through a binocular optical microscope. Being accustomed to working with the binocular optical microscope, they did not welcome this change in technology. To overcome this problem, I set up two digital microscope systems first, and 3 months later, having convinced the technicians of the ergonomic benefits and good visibility, I was finally able to set up four more systems (Fig. 39.3).

The cost of setting up the whole digital video microscope system including multi-stand was reasonable. Moreover, handheld digital microscopes employing the Sony CCD chip and Samsung LCD TV are easily available worldwide and can be easily installed without the assistance of an expert. Thus, in terms of cost-efficiency, ease of use, and availability, this equipment was found to work well.

Fig. 39.3 Six technicians are slivering together with the digital video microscopes

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Chapter 40
Depth Control Scalp Board

Sungjoo Tommy Hwang

40.1 Depth Controlled Transplantation

The average length of hair follicles in Asians is greater than that of Caucasians [1]. In addition, the intra-patient length difference is also greater in Asians compared to Caucasians [2], and there is a significant difference in graft length in the same individual (Fig. 40.1a, b). No matter how carefully the author controlled incision depth, patients often developed folliculitis and pitting due to the deep location of some of the grafts in the recipient sites. Since October 2011, the author has utilized the depth controlled transplantation (DCT) according to the graft length technique. With the DCT method, the author has reduced or prevented folliculitis, cyst, and pitting in most of his personal cases (see Chap. 49).

At first, graft length was measured on 1 mm graph paper coated with vinyl by my surgical assistants using magnifiers (Fig. 40.2), and then each individual hair folli-

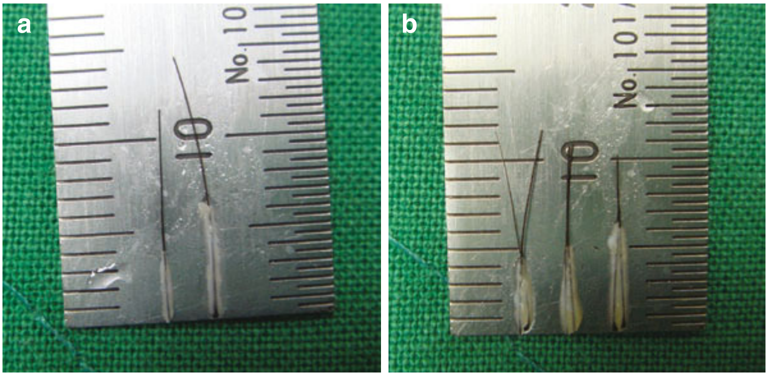

Fig. 40.1 The length difference of graft in the same individual; (**a**) single-hair FU, (**b**) two-hair FU

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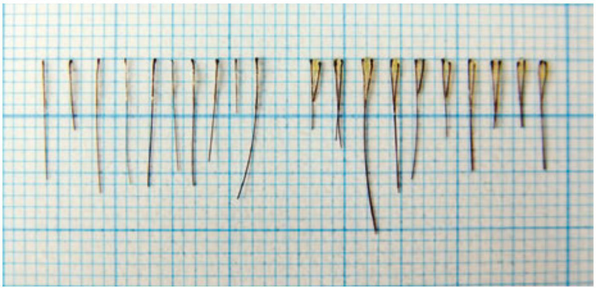

Fig. 40.2 Graft length measurement on the 1 mm graph paper coated with vinyl

Fig. 40.3 One-, two-, three-hair FUs were grouped by length

cle was grouped by length (Fig. 40.3). This was a very time-consuming task for non-experienced hands, and there was a high risk of drying of grafts. Therefore, I developed a tool, named "Hwang's board," to help measure the graft length faster and more efficiently for the assistant [3] (Fig. 40.4).

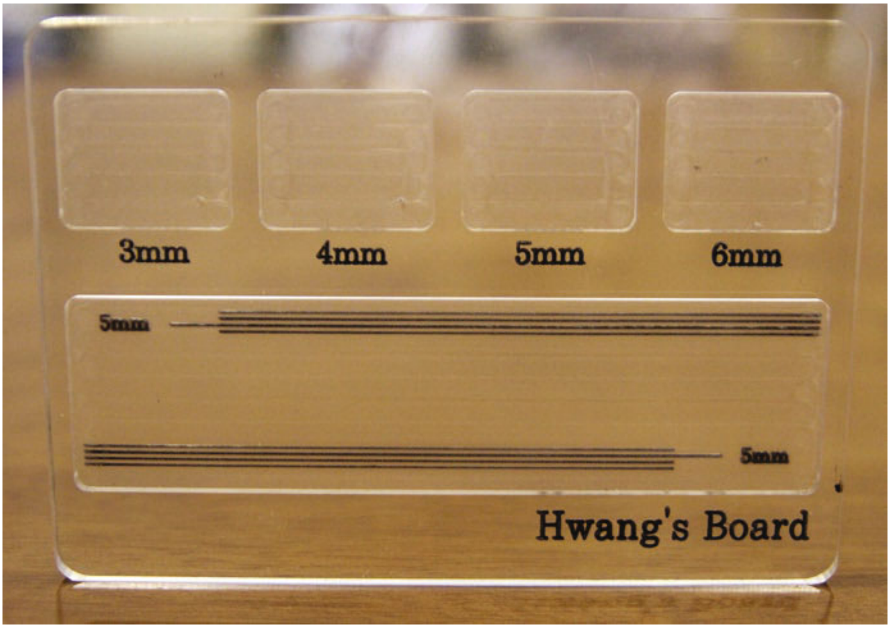

Fig. 40.4 Hwang's board: there is a ruler on the back of the board

40.2 How to Use the Hwang's Board?

Hwang's board is made from the polymethyl methacrylate, and it can be reused after gas sterilization.

There is a ruler on the back of the board (Fig. 40.4) and a furrow on the front of the board (Fig. 40.5). With the bulb or the end of the graft placed on the upper or lower ledge of the furrow, the length of each individual hair follicle can be measured. Follicles of identical length can be grouped and moved to the upper small furrows (Fig. 40.6). Because there is a furrow on the board, normal saline or storage solution can be kept in the furrow to prevent drying of the grafts.

The DCT technique is very useful to minimize complications such as folliculitis, pitting, and poor survival. The Hwang's board for graft length measurement is a very useful device for measuring the length of grafts more efficiently.

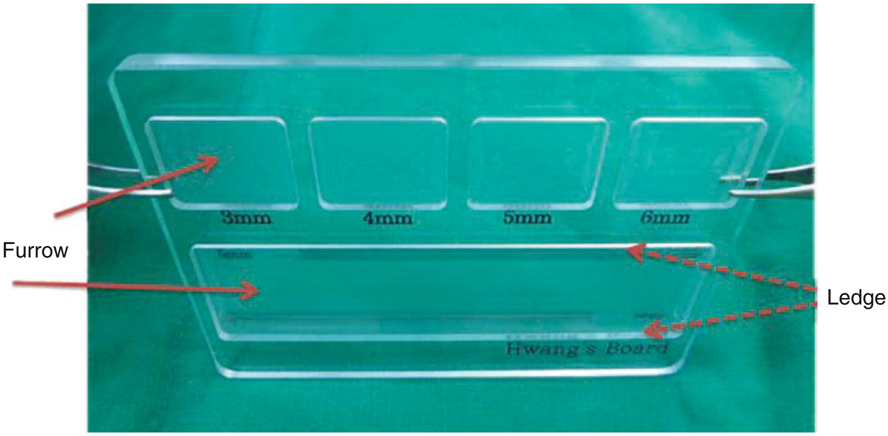

Fig. 40.5 Furrow on the board. It keeps graft storage solution

Fig. 40.6 Follicles moved to the upper small furrows according to length

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Chapter 41
How to Manage Slippery Grafts?

Shobit Caroli

41.1 Introduction

Slippery grafts indicate that there is a liquid or sludge of mucoid consistency coating the surface of the graft. This makes the graft holding solution very viscous, and when attempting to hold them with regular jeweler's forceps, these grafts very often slip (Fig. 41.1). There is little in the published literature addressing this topic.

Unger et al. postulate that slippery graft is due to oil, a relatively dense liquid, whose resultant cohesive forces manifest as "beading" when placed on a flat surface and is "slippery" to the touch [1]. Pathomvanich and Caroli in 2010 performed a

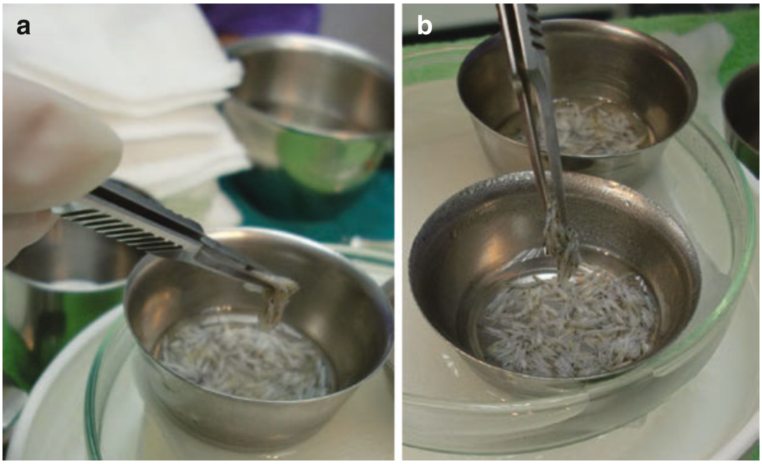

Fig. 41.1 Hair grafts slip when tried to hold with conventional jeweler's forceps. (**a**) View angle—90° to forceps. (**b**) View angle—parallel to forceps

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retrospective study at DHT Clinic (Thailand). The records of all surgeries during a 2-year period were evaluated. Thirty-eight cases with findings suggestive of slippery grafts were carefully studied and followed up, and the significant common findings were summarized [2].

41.2 Observations for Slippery Grafts

For ease of understanding, the common observations have been divided as primary, secondary, and tertiary signs. These signs should alert the physician regarding the possibility of slippery grafts while performing the surgery.

41.2.1 Primary Signs

These are the most consistent signs present in every studied case. They are pathognomonic and hence can also be regarded as definitive for the diagnosis of slippery grafts.

- Slippery tissue during donor harvesting, slivering, and graft cutting (Fig. 41.1).
- Oily coating over the normal saline in slivering tray and graft holding cups (Fig. 41.2).
- Turbidity and mucus consistency of saline in the graft holding trays. This sludge returns even after repeated rinsing (Fig. 41.2).
- Difficulty in graft holding and grafts slip from forceps with excessive sludge.
- The observation of “beading” of blood on nylon (nonabsorbable sutures) during closure of the donor site as an important indicator [1].

41.2.2 Secondary Signs

Most of the patients studied have these findings. But many other routine cases who also had these signs did not present with slippery grafts during surgery. Thus, these appear to be findings in slippery grafts patients, but vice versa may not be true.

- Observation of very oily scalp
- Coexisting features of seborrheic dermatitis

Fig. 41.2 Turbid oily mucous coating layer over the surface of normal saline in the slivering tray and graft holding cups

41.2.3 Tertiary Signs

These observations are consistent among all cases and can be considered as the common effects or sequelae of slippery grafts on the surgery and, thereby, the results.

- Difficulty in graft holding and insertion. This slows down the performance in surgery leading to disappointment of the inserter [3].
- Increased graft trauma due to repeated handling, rinsing, and more force usage. This may lead to poor growth (graft yield) [4].
- Intraoperative and postoperative popping of the grafts [4].
- Surgery session lasts longer than the usual.

41.3 Expert Suggestions

Early recognition of this situation and proper communication between surgeon and technicians will help in planning for fast supportive action [1]. Important adjustments should be made to avoid complications.

- Unger et al. propose creating small recipient slits to maximize the lateral force of friction on each graft. This could effectively lodge it securely within the site [1].
- The patients should be always counseled regarding less than expected results [1].
- Grafts should not be repeatedly handled and rinsed to avoid trauma. Rinsing once just before the insertion is suggested.
- Even highly trained and experienced assistants agree that there is an increase in the surgical time by almost 50% [3]. Thus, it is better to reduce the graft session size [2]. This improves the work efficiency and reduces frustration.
- Dense packing should never be planned in such cases [2].

Follow-up sessions can be suggested to achieve the required density, number of grafts, and finally the cosmetic outcome.

41.4 Modified Forceps

This author with Pathomvanich worked upon and proposed two designs of jeweler's forceps [2].

- The first design has a notch of a hair graft size on both the edges. The notch is a hair graft space away from the distal tip (Figs. 41.3 and 41.4).

The second design has very fine serrations (or diamond dust) on both the graft holding edges of the jeweler's forceps (Figs. 41.5 and 41.6).

The efficacy and ease in the usage of these jeweler's forceps were assessed during five prospective cases. The modified designs of both forceps were found to be effective in holding grafts more securely and with minimal trauma (crush or force or repeated handling). Extra fine-pointed forceps, either straight or right angled, can also work well in experienced hands [2].

Storage solutions like HypoThermosol, Custodiol, and Moser's solution have been found to increase graft viability but make grafts more slippery [3]. The author recommends more research on this topic to assess the biochemical basis of slippery grafts and "why" the mucus returns back after repeated rinsing. New instruments and techniques are needed to handle these grafts more securely and with minimal trauma.

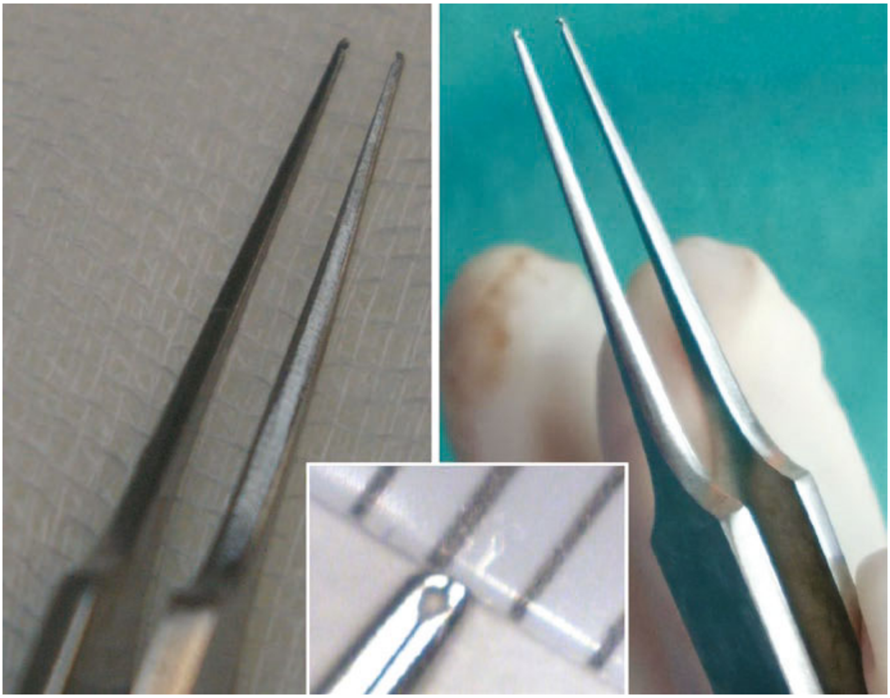

Fig. 41.3 First design of modified jewelers in two different backgrounds. View is further enhanced under 10× magnification of the tip of forceps in behind 1 mm scale

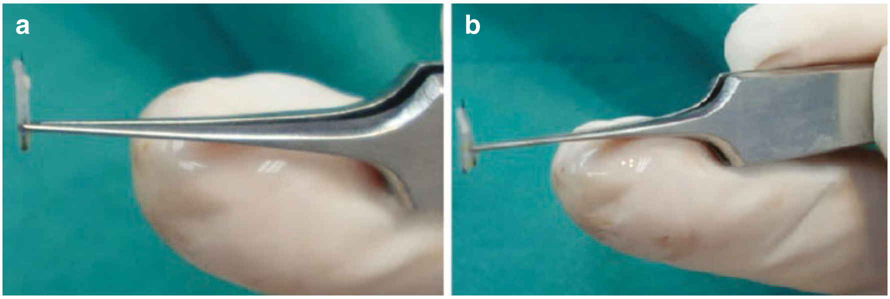

Fig. 41.4 Hair grafts holding with first design of forceps. (**a**) One-hair graft, (**b**) two-hair graft

Fig. 41.5 Second design of modified jewelers. (**a**) Very fine tips of graft holding forceps, (**b**) routine flash to show serrations or diamond dust, (**c**) slow flash lightening to enhance contrast on the diamond dust edges

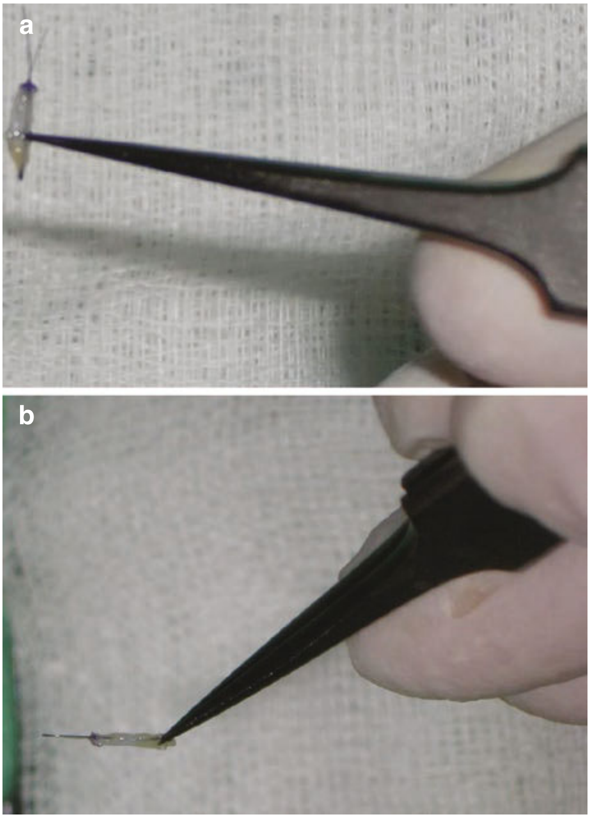

Fig. 41.6 Hair graft holding with second design of forceps. (**a**) Two-hair graft, (**b**) one-hair graft

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Chapter 42
Implanter Pen: How to Use It

Sungjoo Tommy Hwang

42.1 Why Are Implanters Popular in Korea?

In the 1960s, Mr. Paek, who worked at the Hansen's disease camp as a medical assistant, developed an instrument for single-hair graft placement and performed about 3000 cases of eyebrow hair transplantation for patients with madarosis over a 20-year period [1] (Fig. 42.1). In the 1980s, Dr. Choi and Dr. Kim developed the Choi implanter, which was modified from Mr. Paek's instrument. Since then, most Korean doctors have used implanters in the field of hair transplantation, and many kinds of implanters are available now. Recently, as FUE surgery increases in the hair surgery, more doctors are interested in using implanters in their practices.

42.2 How to Use Implanters

The implanter technique is a kind of stick and place method. The main difference is that the incision is made and the graft is placed simultaneously with the aid of a special mechanical device [2]. There is no risk that the recipient site is left empty, thus the bleeding with implanter is even less than with the traditional stick and place method. The implanter is shaped like a pencil and has a needle with a beveled cutting edge on the end [3].

A follicular unit is placed onto the needle of the implanter using jeweler's forceps. The graft should be loaded fully within the needle and should not protrude beyond the bevel level. If the end of graft is located on the bevel level, the graft may bend during the insertion of needle into the skin (Fig. 42.2). To minimize trauma to the graft, it must be grabbed by the end of the hair shaft and not by the body of graft

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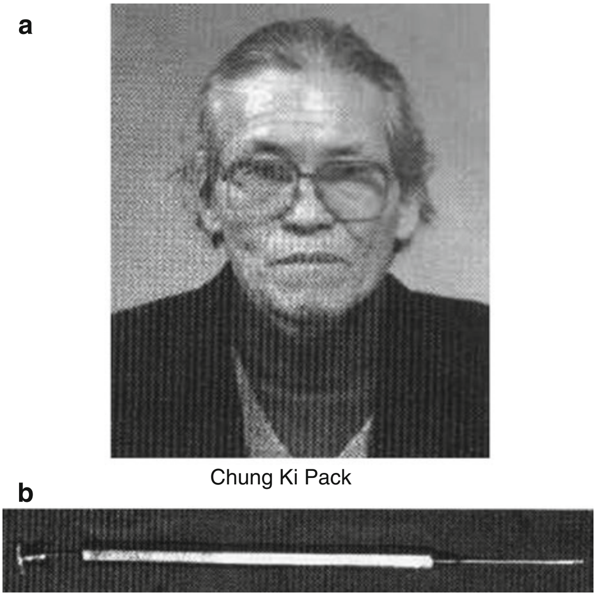


Fig. 42.1 (**a**) Mr. Paek, (**b**) the device which Mr. Paek used for the graft implantation in 1960s

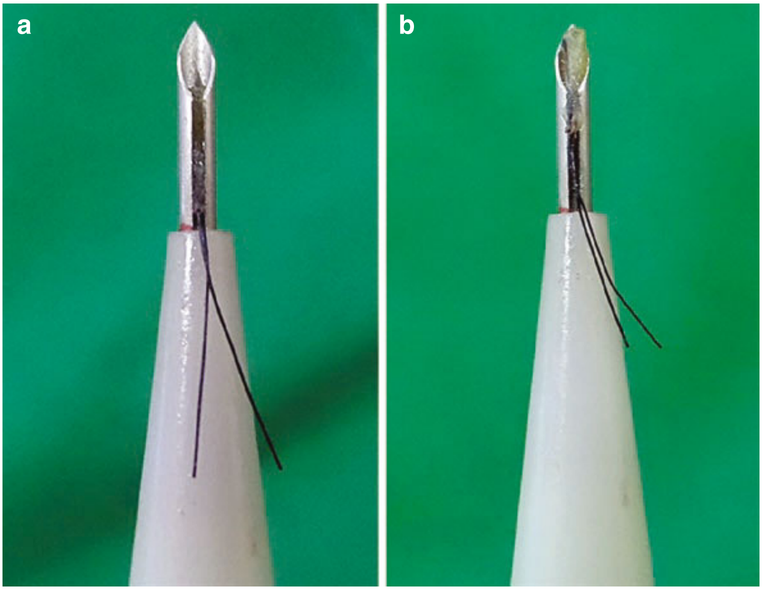


Fig. 42.2 (**a**) Correct position of the graft: the graft is located within the needle without being seen on the bevel. (**b**) Incorrect position of the graft: the end of graft is located on the bevel

(Fig. 42.3). Therefore, leaving 3–4 mm or more of hair shaft length on the graft makes it easier to grasp than with very short hairs.

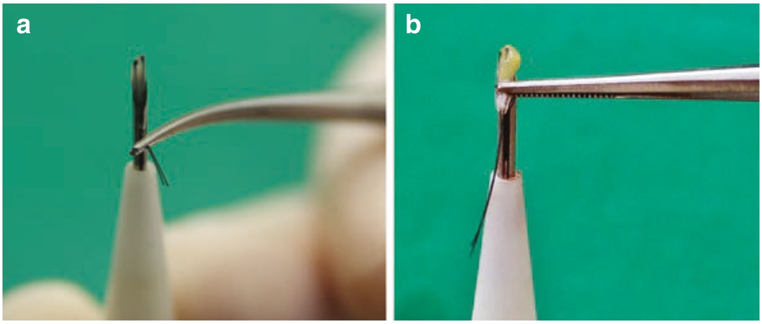


Fig. 42.3 (**a**) Grasping the hair is correct. (**b**) Holding the body of the graft can damage the graft

Fig. 42.4 The second assistant takes the empty implanter from the operator and delivers the loaded one to the operator at the same time

The assistant's major task is to quickly load and reload the graft into the implanter without trauma. The procedure time is highly dependent on the assistant's skill and experience. In the past, the assistant placed the loaded implanter onto the table and picked up the empty one used by the operator. At the same time, the operator picks up the newly loaded implanter and places the empty one that he has used back in the table for the assistant to reload. However, this process is time-consuming.

Recently, for efficiency and speeding up of the procedure, one more assistant participates. The second assistant takes back the empty implanter from the operator and delivers the loaded one to the operator at the same time (Fig. 42.4). Therefore, the operator's eye can remain focused on the recipient sites without having to look up at the table or moving his arm back and forth to the table in order to pick up and replace the implanters, reducing the operation time.

The operator inserts the needle into the skin and pushes the plunger of the implanter. The implanting rod holds the hair graft in place while the needle is withdrawn, but it leaves the hair graft in the incision site (Fig. 42.5).

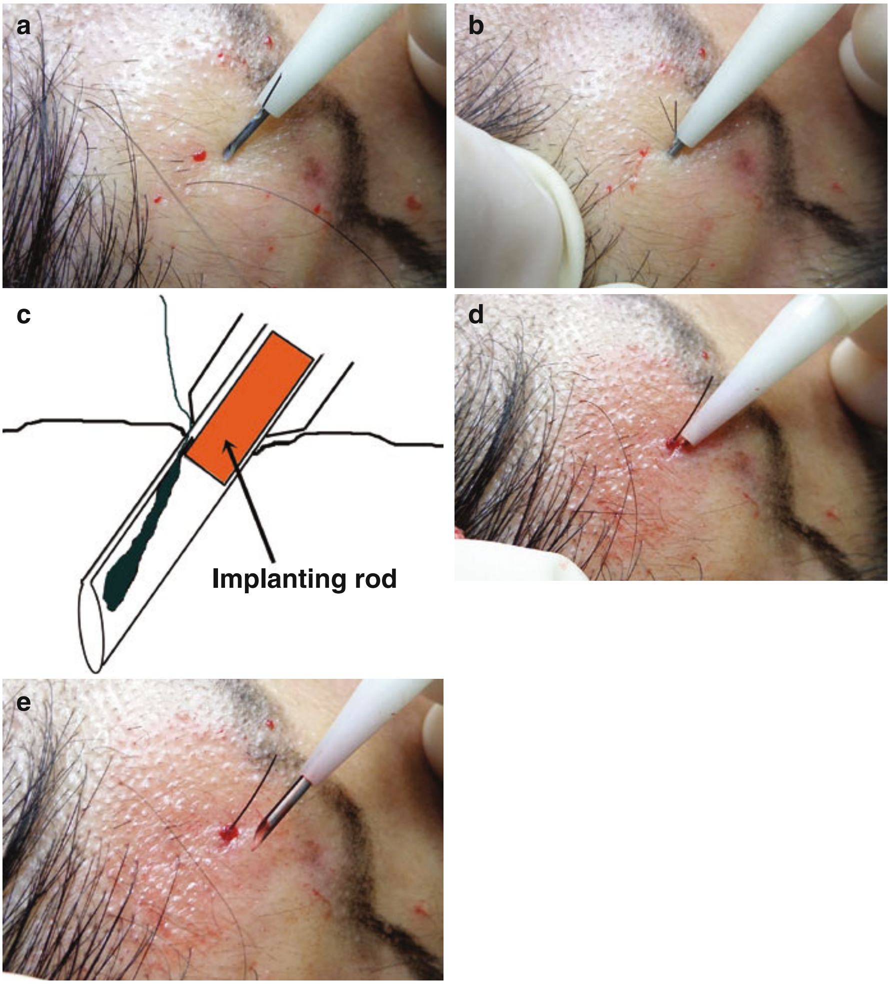


Fig. 42.5 Technique in using an implanter. (**a**) Loaded implanter. (**b**) Needle is inserted in the recipient skin. (**c**) Implanting rod holds the graft inside the skin. (**d**) The plunger is pushed, and the needle is withdrawn. (**e**) The graft was tucked under the skin

The implanter technique may eliminate or reduce crushing, squeezing, bending, piggybacking, and over-manipulation that can potentially reduce the graft survival rate. Making the proper direction and angle by using the implanter is relatively easy (Fig. 42.6). The direction of the graft placement follows the existing hair and is very similar to the finger direction when the palm is put on the scalp. The average angle of needle insertion is 45–70 degrees. This angle of insertion can reduce bleeding and popping [3].

Fig. 42.6 (**a**) The angle of implanter should be controlled according to the curvature of the scalp. The average of angle is between 45 and 70°. (**b**) The hand is put on the scalp. The finger direction is similar to the direction of the graft. (**c**) The proper direction of the needle of implanter

The brief sequence of graft insertion using implanter:

1. Check the follicular unit either from FUE/FUT under the microscope to see any graft damage and discard.
2. Do not cut the hair too short. Keep the hair long between 5 and 10 mm.
3. Trim epidermis of the graft.
4. Group the grafts according to the follicular unit. In order to avoid pitting and folliculitis, also group the grafts by length (see Chap. 40).
5. Match the FU and needle size of the implanter. Usually 0.8 mm needle for one FU, 1.0 mm needle for two FU, and 1.2 mm needle for three FU.
6. Insert follicle completely inside the needle of the implanter.
7. Check graft for angle and direction. Angle the implanter between 45 and 70°, and stab the scalp in full depth of the graft.
8. Press the plunger and release the plunger while withdrawing the implanter and the graft is implanted.

Five to seven implanters are used on average for one session of hair transplantation. If the scalp is very tough, the implanter needle gets dull easily, and thus it is necessary to change the dull needle with a sharp one. Sometimes the author prefers making slits with a 21-gauge needle before inserting the needle of implanter into the recipient area for patients with very solid scalps. The needle is disposable, and the body of the implanter can be reused after sterilization.

Compared to the slit method, implanter technique has some advantages and disadvantages [2, 3] (Table 42.1).

Table 42.1 Advantages and disadvantages of implanter technique

Advantages	Disadvantages
Less crushing, squeezing of the graft	Only physician can perform graft placement
No missed sites	More expensive equipment
Less piggybacking	
Less bleeding	
Less forceful handling—less trauma to the hair follicle grafts	
Shorter operation time	
Easier identification of the remaining empty skin	

Table 42.2 The comparison of four kinds of implanter

	Brand name			
Characteristics	Hwang®	KNU®	OKT®	Smart Hair®
Sharpness of needle (at normal skin/at solid skin)	+++/+++	+++/++	+++/+	+++/+
Needle size (mm)				
Outer size/inner size	0.6/0.55	0.6/0.52		
	0.70.64		0.72/0.56	
	0.8/0.73	0.8/0.64	0.82/0.62	0.8/0.62
	0.9/0.83		0.92/0.76	
	1.0/0.92	1.0/0.82	1.0/0.82	1.0/0.82
	1.1/1.02		1.08/0.94	
	1.2/1.11	1.2/0.99		
Price of implanter (USD)	70	35	88	32
Price of needle (USD)	20	10	18	7.8

+++: very good, ++: good, +: normal

42.3 After-Use Comparison of Four Different Kinds of Implanters

I have used four different kinds of implanters on the same patient to compare the differences of each implanter. I also compared the specifications according to the company (Table 42.2) (Fig. 42.7). There is no significant difference in the length and weight between these implanters. The main differences are the sharpness of needle, needle sizes, and price. Four implanters have similar sharpness when inserting the needle into the normal scalp, but the Hwang® implanter showed superior sharpness when inserting the needle into very solid skin. The KNU® implanter also showed good sharpness on solid skin. The needle of the Hwang® implanter is made in Japan and has cutting edges on both inner and outer surfaces of the needle. The other implanters have the cutting edge on the inner surface of the needle and are made in Korea. Hwang® has seven sizes of needle, KNU® has four sizes, OKT® has

Fig. 42.7 The four brands of implanter: from the left, Hwang®, KNU®, Smart Hair®, and OKT® in order

five sizes, and Smart Hair® has two sizes. If the needle size is bigger than the graft size, the graft can easily pop out. Therefore, it is necessary to match the graft size and the needle size. Therefore, Hwang® is superior to other implanters since it has various sizes of needles which are compatible to each size of the graft. OKT® and Hwang® are relatively expensive compared to KNU® and Smart Hair®. All implanters are easy to assemble (Fig. 42.8).

42.4 Depth Control Transplantation Using Implanter

Due to the bevel of the needle, the length of the needle exceeds the length of the graft by the length of bevel while using the implanter (Fig. 42.9). Therefore, the full length of the needle should not be inserted into the skin. Instead, the needle of the implanter should be inserted less by the length of the bevel in order to avoid deep placement of the graft. This is not easy to do properly every time. The newly developed Hwang® implanter has a depth control unit to prevent the deep insertion of needle and the deep placement of the graft (Fig. 42.10).

It is known that there are significant differences in the length of grafts in the same individual. Therefore, the length of the needle should suit the length of the graft to avoid the improper incision depth (Fig. 42.11) [4]. It is very useful to measure the length of all grafts and then divide the grafts into the same length group for the depth controlled graft placement [5] (see Chap. 40).

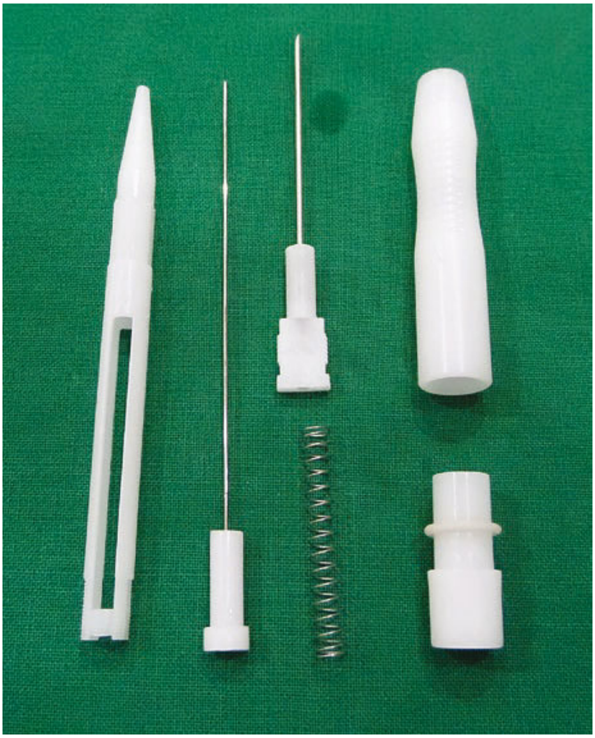


Fig. 42.8 The component of KNU® implanter. Every implanter is easy to assemble

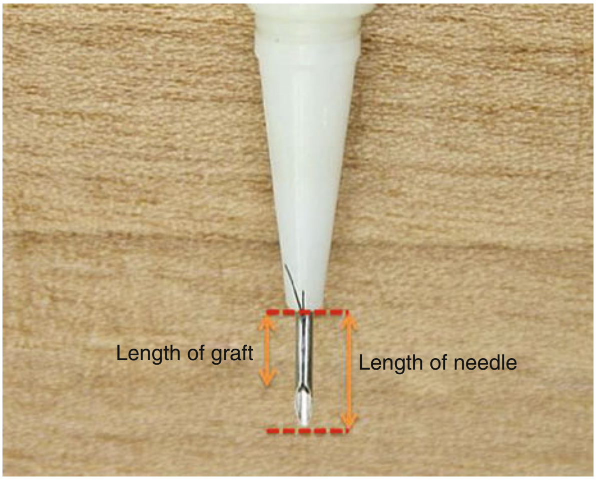


Fig. 42.9 When the graft is loaded within the needle, the needle length exceeds the graft by the length of the bevel

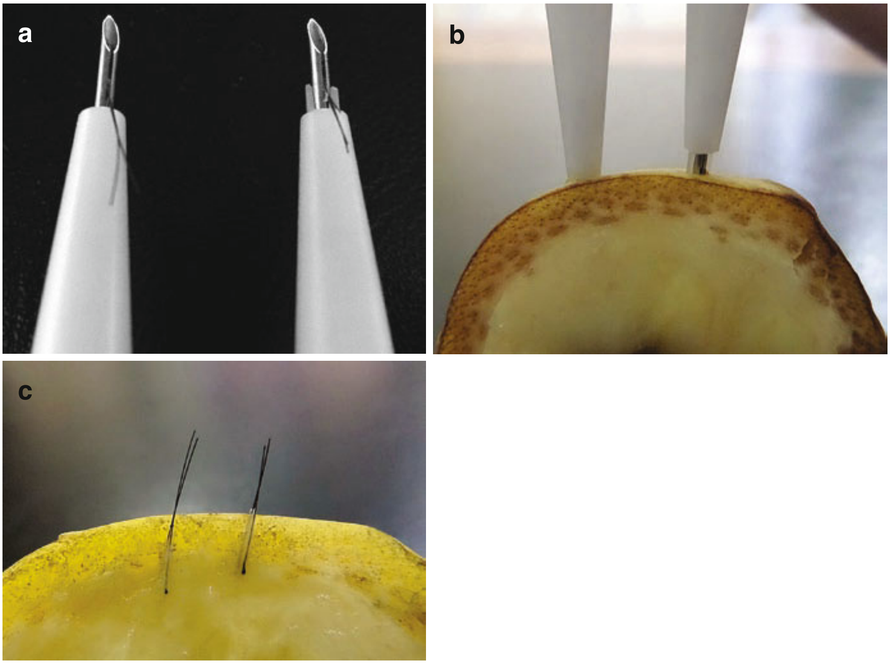
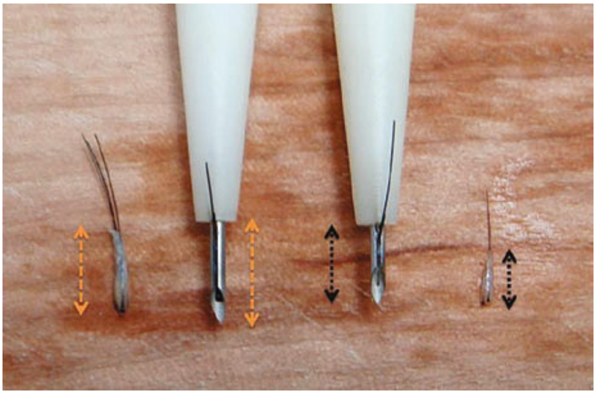


Fig. 42.10 (**a**) Hwang® implanter (*right*) has the depth control unit or stopper. (**b**) The stopper (*right*) prevents the deep insertion of the needle. (**c**) Hwang® implanter (*right*) can prevent the deep placement of the graft. The others cannot avoid the deep placement of the graft

Fig. 42.11 The length of the needle should suit the length of the graft to avoid the improper incision depth



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Chapter 43
Different Techniques of Graft Insertion

Check for updates

Sanjiv Vasa

43.1 Introduction

For implantation, three basic methods are employed:

Method 1 (placing into preformed slits): The surgeon first makes all of the slits using a blade or a needle, and then the grafts are placed in these sites.

Method 2 (stick and place): The surgeon makes a slit with the help of the needle or blade, the needle is removed, and a graft is immediately placed into the freshly made site.

Method 3 (implanter): In a single move with one instrument (implanter), a site is created, and without removing the implanter from the site, the graft is placed immediately. Both steps of making slit and placement of graft are combined and performed in a single step. The implanter can also be used to place grafts using method 1 above.

43.2 Difficulties Encountered Using Method 1

1. How to determine the number of sites to make before the dissection of grafts is complete.
2. If the number of sites is insufficient, time must be spent making new ones.
3. If excess sites are created than unnecessary, trauma to scalp has occurred.
4. Identification of sites becomes more difficult over time, slowing implanting process.

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5. How to determine the correct number of sites for one hair, two hair, and three hair grafts.
6. Bleeding from created sites may continue throughout the procedure.
7. Bleeding from the sites creates messy, wet, and slippery field.
8. More time needed to keep sites clean by washing and frequent dabbing.
9. Local anesthetic may leak out from these sites making pain relieving effect unpredictable.
10. Additional local anesthetic may be required.
11. Injecting more fluid leads to more post-op swelling.
12. Once they are identified, they are closed due to fibrin glue.
13. More time is spent trying to open them.
14. Once they are open, they may start bleeding again.
15. Tissue damage is more during placement if multiple attempts are required during insertion of grafts into site.
16. Increased difficulty when implantation is required between existing or previously planted hair.
17. Time required for counting, isolating, and trimming grafts to fit the sites leads to more mechanical damage of grafts and more drying.

43.3 Difficulties Encountered Using Method 2

1. Bleeding, lack of depth control.
2. Limitation of creating sites in close proximity to create dense packing.
3. Inability to decide the exact size of cavity required for the selected graft.
4. Mechanical damage from grabbing, holding, pinching, and dragging grafts.
5. Drying of grafts while being stored on finger or hand.
6. During placement, grafts may be crushed, squeezed, bent, destroyed, or pushed too deep, producing pitting.
7. Rough placing with multiple attempts will produce graft damage.
8. Graft popping may be the biggest overall problem.

43.4 Difficulties Encountered Using Method 3

1. While loading into implanter, the graft may fold, jam, distort, or fly off requiring reloading.
2. While planting, damage to the neighboring follicles may occur if one is not careful.

43.5 Criteria of Ideal Transplanter

1. Small, lightweight, and of convenient length
2. Composed of minimum joints, disposable, and works without electricity, suction, or spring device
3. Available in various sizes, with long life span
4. Able to plant large number of grafts with single implanter
5. No maintenance required and no need of cleaning or plug removal
6. Maintains integrity of graft, with no flying off of grafts
7. Easy to maneuver and not producing any heat
8. Able to create suitable opening size and depth of the cavity
9. Should have depth control, have easy learning curve, and be economically viable

43.6 Different Implanters Have Been in the Market

The following have not been accepted by many as they did not fulfill the abovementioned criteria (Figs. 43.1, 43.2, and 43.3).

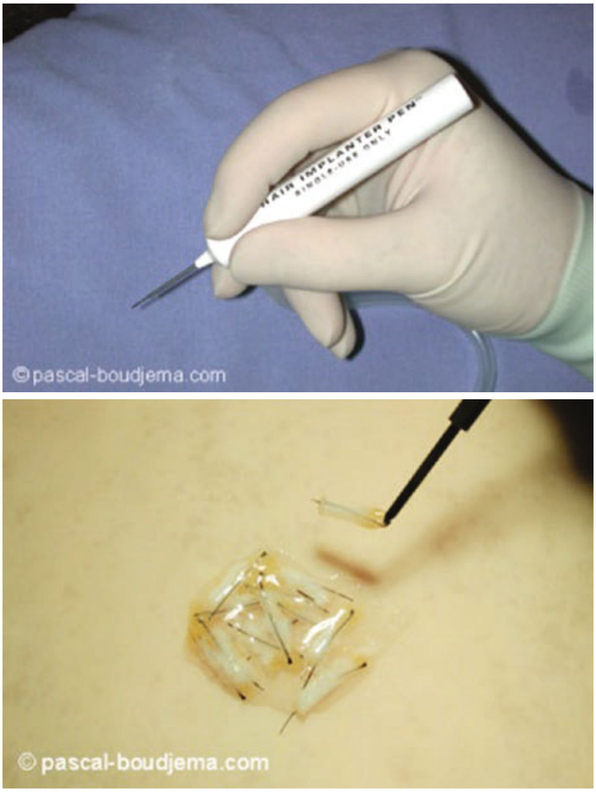

Fig. 43.1 Dr. Boudjema implanter pen

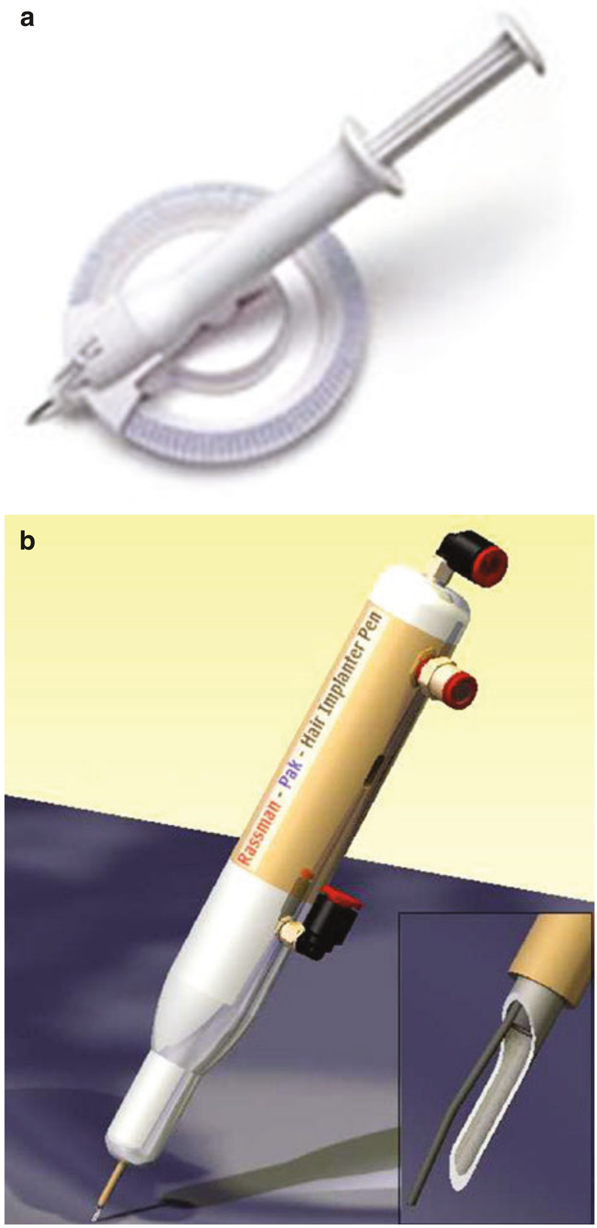

Fig. 43.2 Dr. Rassman implanter with Carousel (**a**) and implanter pen (**b**)

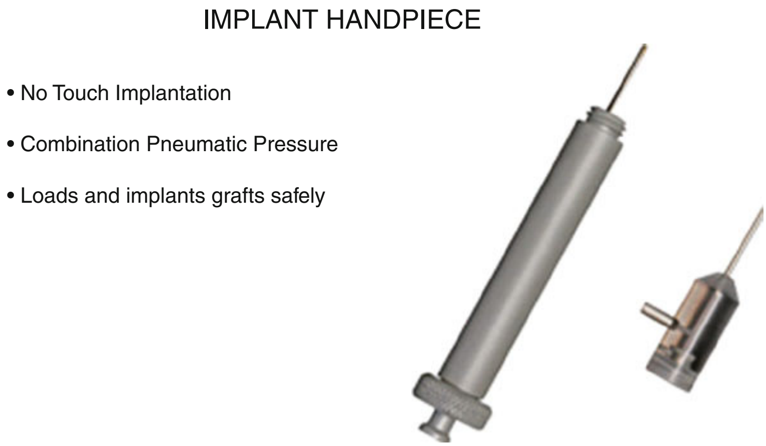

Fig. 43.3 NeoGraft implantation device

Dr. Choi implanter (Fig. 43.4) became very popular, and few modifications like Lion, KNU, and Lead M implanters are available in the market.

Too many parts, difficulty changing needle, not truly disposable, expensive due to multiple units required per operation. Blind implantation because needle assembly is withdrawn (Figs. 43.5 and 43.6).

"SAVA" implanter (Figs. 43.5 and 43.6) fulfills all criteria for ideal implanter.

It performs six functions at a time: (1) creates the site, (2) controls depth, (3) makes a spiral cavity, (4) keeps the mouth of cavity open, (5) stretches the cavity walls apart, and (6) acts as a slide during implantation.

Accurate forceps-free implantation can be performed at desired angle, direction, orientation, and proximity with effective speed.

"SAVA" Plus (Fig. 43.7) is an upgraded version where implantation can be done (without introducer) under vision with accuracy, density, speed, and safety with only few minutes learning curve.

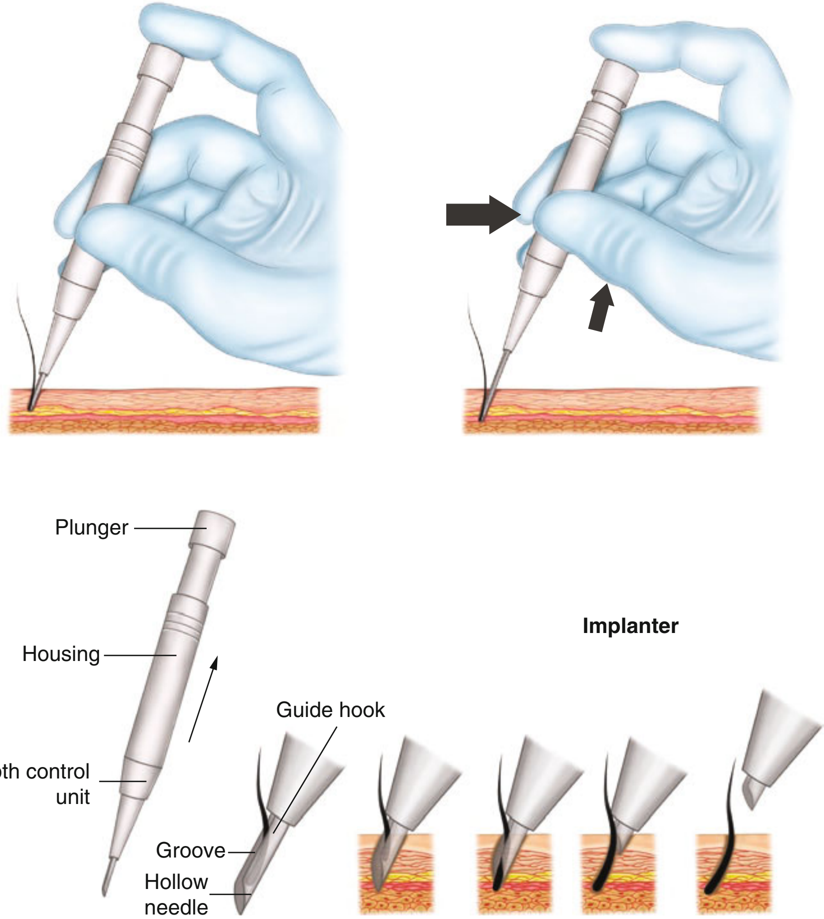

Fig. 43.4 Diagrams explaining the functioning of implanter

Fig. 43.5 Dr. Vasa transplanter

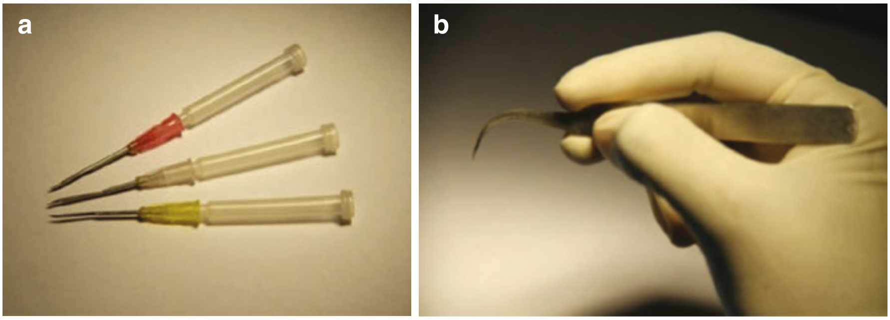

Fig. 43.6 "SAVA" implanter (**a**) and "SAVA" introducer (**b**)

Fig. 43.7 "SAVA" Plus implanter

Part VIII
Complications in Hair Transplantation

Chapter 44
Complications in General

Damkerng Pathomvanich and Jocelyn Theresa P. Navalta

44.1 Preventing Complications

It is possible to encounter complications after hair transplant surgery even under experienced hands or in spite of the procedure going as planned. Physicians must be diligent in taking a complete history (past, present, family medical and personal history), most importantly inquiring about history of allergies, comorbidities, current medications, and doing a thorough physical examination of all patients.

44.1.1 Patient Selection

44.1.1.1 Medical Considerations

Comorbidities

Prior to surgery, patients with diabetes and hypertension must maintain controlled blood sugar and blood pressure levels. Cardiovascular problems must be stabilized with clearance from a cardiologist. Although having diabetes, hypertension, or cardiovascular diseases is not an absolute contraindication to having hair transplant surgery, proceeding with the surgery among patients with these comorbidities should be done with caution.

Blood dyscrasias, liver and kidney problems, and presence of infectious skin diseases also need to be identified prior to surgery. This is to prevent excessive intraoperative and postoperative bleeding, ensure proper delivery and excretion of medications, avoid prolonged absorption and drug accumulation, and avoid aggravation

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of skin infections, which may adversely affect the growth of transplanted grafts or healing of donor sites.

Patients with cicatricial alopecias need to undergo a scalp biopsy and referral to a dermatologist. Wait for at least 2 years after being treated and diagnosed with stable or inactive disease before considering surgical intervention in these cases (for details, see Chap. 7).

Maintenance Medications

Blood thinning medications such as aspirin, warfarin, vitamin E, herbal medications, etc. must be stopped at least 2 weeks prior to surgery, if possible, upon the consent of the patient's cardiologist. Many physicians do operate on patients taking baby aspirin, while others would not. Having personally performed surgery on patients taking aspirin without experiencing excessive bleeding, patients who cannot be taken off this medication can still undergo surgery albeit with utmost care.

Smoking and Alcohol Intake

Smoking should be stopped at least 2 weeks prior to surgery due to its vasoconstrictor effect, which may cause a delay in wound healing, promote poor wound healing, and cause wound dehiscence or poor growth of grafts. Replacing cigarettes with electronic cigarettes or nicotine tablets or patches can help. Abstaining from alcohol is advised at least a few days prior to surgery to lessen bleeding and swelling.

Preexisting Lesions

Preexisting scalp lesions such as actinic keratoses or basal cell carcinoma need to be treated or removed before surgery. Presence of folliculitis or skin infections should also be treated accordingly.

Keloid formers are to be advised regarding the possibility of larger scar formation from hair transplant surgery. Proceed with caution, and arm yourself with the tools to help prevent poor wound healing with techniques such as trichophytic closure, utilizing scar gels/creams or steroid injections, or possibly including PRP (platelet-rich plasma) or ACell into your armamentarium (for details, see Chap. 9).

44.2 General Complications

Hair transplant surgery is considered a generally safe procedure with relatively few complications. This can be attributed to the highly vascular scalp, aseptic techniques used, and continued improvements made in the surgical techniques.

44.2.1 Intraoperative Complications

44.2.1.1 Drug Hypersensitivity

Drug reactions during surgery are uncommon if patients are properly evaluated with a complete history and physical examination prior to clearance for surgery. During the initial patient consultation, elicit any history of allergic reactions to local anesthetics and to medications. Common medications used pre- and intraoperatively in hair transplantation include anxiolytics (i.e., diazepam), pain medications, and antibiotics.

Allergic responses to local anesthetics are rare. Amide local anesthetics (lidocaine, mepivacaine, bupivacaine, articaine, and prilocaine) are found to be statistically less allergic than the ester types (benzocaine, procaine, tetracaine) [1]. Allergic reactions to local anesthetics involve type IV hypersensitivity responses, particularly in the ester group [2], usually after topical application of the drug [3]. Immediate IgE-mediated allergic reactions to local anesthetics are uncommon to amide anesthetics; however, case reports suggest a type I hypersensitivity reaction including urticarial (Fig. 44.1), angioneurotic edema, wheezing, sneezing, pruritus, or anaphylactic shock occurring within minutes of injection of the drug [4]. Anaphylaxis manifests as respiratory symptoms (dyspnea, wheezing, upper airway obstruction, and edema), gastrointestinal symptoms (nausea, vomiting, diarrhea, abdominal pain), and cardiovascular symptoms (dizziness, syncope, hypotension) [5].

For patients with a history of a hypersensitivity reaction to a local anesthetic, an intradermal skin test prior to surgery has been advocated as a proper diagnostic tool [6].

If in spite of a thorough screening for allergic reactions during the pre-op consultation and adverse drug reaction during surgery, any suspected inciting drug must be discontinued, medications including antihistamines like diphenhydramine must be on hand, and emergency care must be administered. Albuterol inhalers should be available in the event of bronchospasm. In the case of anaphylactic shock, epinephrine must be readily available [7] (see Table 44.1). Ensure that all staff as well as the clinic are well equipped to deal with emergencies such as allergic reactions. Performing the surgery in a hospital setting may be more appropriate for patients you suspect to be at risk for hypersensitivity reaction.

44.2.1.2 Local Anesthetic Toxicity

Local anesthetics cross the blood-brain barrier and systemic toxicity can manifest as CNS or CVS symptoms. CNS toxicity is dose dependent, with low doses resulting in depression and high doses resulting in CNS excitation and seizures [8]. Local

Fig. 44.1 Urticaria

Table 44.1 Intraoperative complications, prevention, and management

Complication	Prevention	Management
Drug hypersensitivity	Skin testing (if suspecting allergy to local anesthetic) History of previous drug allergies	Discontinue inciting drug Antihistamines, i.e., diphenhydramine 50 mg tab oral, 50 mg/mL single dose IM via the deltoid muscle Albuterol inhaler 2–4 inhalations (for bronchospasm and laryngeal edema) Epinephrine 0.30 mg (0.30 mL of SD 1 mL or 1 mg vial) IM via the lateral thigh or deltoid
Local anesthetic toxicity	1. Inject anesthetics in 3–5 mL aliquots pausing per circulation time between injections 2. Aspirate the needle prior to each injection 3. 10–15 μg/kg in adults for large volumes of anesthetics	Intralipid Emulsion therapy (ILE) • Large bolus injection of 20% lipid emulsion at 1.5 mL/kg over 1 min and then infusion of 15 mL/kg/h, with max. of three boluses • Max. cumulative dose, 12 mL/kg
Hiccups		Drink water or ice Hold breath Brown bagging Chlorpromazine 25 mg oral every 6 h for 7–10 days
Vasovagal reflex	Avoid precipitating factors, i.e., prolonged sitting or standing, emotional stress, pain, heat, venous puncture, alcohol use, dehydration, and the use of vasodilators and diuretics	Patient in supine (legs elevated) or squatting position (prodrome) Aerobic and isometric exercises of the extremities Fluid hydration (2–2.5 liters per day and sodium supplementation) Pharmacologic (1) Fludrocortisone 0.1–0.2 mg/daily for younger healthy patients (2) Metoprolol for patients >40 years or has hypertension
Excessive bleeding	Stop blood thinning meds 1–2 weeks prior to surgery Stop alcohol intake days to weeks prior to surgery Control blood pressure	Direct pressure and coagulating, clamping, and/or suturing the bleeder Injecting/wet gauze with local anesthetic + epinephrine IV fluids for large volume loss
Hyper- hypotension	Avoid precipitation factors for vasovagal reflex Avoid intravascular injection of local anesthesia (with epinephrine) Monitor blood pressure throughout the surgery	Hypertension • Pain management • Continue antihypertensive meds, (except non-cardioselective β-blockers) Hypotension • Bradycardia: atropine injected sublingually or IM in doses of 0.5 mg (0.5 mL) • Normal HR: ephedrine injected sublingually or IM in doses of 25 mg (0.5 mL)

Table 44.1 (continued)

Complication	Prevention	Management
Pain	Give pre- and intraoperative pain medications	Pain management using local anesthetics and distraction maneuvers (ice pack, massages, etc.)
Nausea and vomiting	Eat a light meal prior to surgery Avoid vasovagal precipitating factors Control diabetes, hypertension Screen for allergies to avoid anaphylaxis	Antiemetic medications (Table 44.2)

anesthetic toxicity is biphasic and initially starts as CNS excitation (agitation, auditory change, and metallic taste), progressing to seizures or CNS depression (drowsiness, coma, and respiratory arrest), followed by CVS excitation (tachycardia, ventricular arrhythmia, and hypertension), and finally depression (bradycardia, conduction block, asystole, and cardiac depression) [9].

Prevention of local anesthetic toxicity can be achieved by (1) injecting the anesthetic incrementally in 3–5 mL aliquots and pausing to allow circulation time between each injection, (2) aspirating the needle prior to each injection to avoid intravascular injections, and (3), for large volumes of anesthetics, not exceeding the toxic threshold of 10–15 μg/kg in adults [10].

In hair transplant surgery, local anesthetic toxicity is rarely encountered as long as one does not go beyond the maximum dose (see Chap. 38) and keeps in mind the preventive measures mentioned. For cases of severe toxicity, treatment with Intralipid Emulsion (ILE) is indicated [10] (see Table 44.1).

44.2.1.3 Hiccups

Hiccups can appear during surgery and can last from 48 h up to a week. They can be initially treated by home remedies and physical maneuvers such as rapidly swallowing water or ice chips, breath holding, or rebreathing from a paper bag. Chlorpromazine, a phenothiazine, is an antipsychotic medication given for hiccups with side effects such as dizziness, drowsiness, insomnia, and blurred vision [8, 9, 11].

Hiccups occurring during surgery can cause difficulty during insertion of the grafts due to head movements. If it continues through the night of surgery, patients may have difficulty sleeping, feel restless, and feel unrested. Single-dose oral chlorpromazine promptly aborts the symptoms; however, the side effects listed above must be considered.

44.2.1.4 Vasovagal Reflex

Syncope is a common medical problem, with a frequency between 15 and 39%, equally occurring among men and women, with increasing incidence after 70 years of age. Symptoms of syncope include nausea, pallor, diaphoresis, muscle twitching, confusion, physical injury, palpitations, dyspnea, chest pain, and cyanosis [12].

The most frequently occurring cause of syncope is the mediated neural reflex known as neurocardiogenic or vasovagal reflex. Other causes of syncope are from cardiac origin, orthostatic hypotension, carotid sinus hypersensitivity, neurological and endocrinological causes, and psychiatric disorders [12].

Vasovagal reflex is precipitated by prolonged sitting or standing, emotional stress, pain, heat, venous puncture, alcohol use, dehydration, and the use of vasodilators and diuretics. Symptoms include a prodrome of nausea and vomiting, abdominal pain, diaphoresis, pallor, palpitations, and dizziness. This is then followed by loss of consciousness and short duration (<15 s) of tonic-clonic contractions [13]. The mechanism of vasovagal syncope is not completely understood but has been explained as a reflex (Bezold-Jarisch reflex) triggered by a decrease in venous return causing inadequate ventricular filling and vigorous cardiac contractions via action of the mechanoreceptors (C receptors) located in the left ventricle, the atria, and the pulmonary artery. Changes in the peripheral vascular resistance occur. The autonomic nervous system fails resulting in the inability of the sympathetic vasomotor pathways to increase the peripheral vascular resistance when a person gets into an upright position. There is also impaired baroreceptor-mediated heart rate response to hypotension via the vagus nerve [14].

Avoiding the precipitating factors and placing the patient in a supine position or to sitting down on the ground in a squatting position during the prodrome, fluid hydration, and aerobic and isometric exercises of the extremities are the recommended initial management. Pharmacologic treatments include fludrocortisone and metoprolol [15] (see Table 44.1).

44.2.1.5 Excessive Bleeding

Excessive bleeding is uncommon in hair transplant surgery especially with the incorporation of epinephrine in both local and tumescent anesthesia, with higher risks among patients taking aspirin, heparin, vitamin E, herbal medications, and other blood thinners, or in patients who had alcoholic beverage intake days prior to surgery. High blood pressure also aggravates bleeding. Blood coagulation tests can be used to screen patients to determine presence of bleeding disorders [16].

Use of tumescent anesthesia and care in avoiding vascular structures from being incised during donor harvesting are important and help prevent excessive bleeding. Minimizing the depth of incision during recipient slit creation [17] also helps control bleeding which prolongs insertion time and ultimately the entire procedure. This increases the risk of poor growth of the transplanted grafts due to the increase in out-of-body time of the grafts.

Intraoperative bleeding can be controlled by applying direct pressure and coagulating, clamping, and/or suturing the bleeder [17]. Injecting additional local anesthetic with epinephrine into the bleeding area can also help control the bleeding. Application of gauze pads soaked with anesthetic containing epinephrine may also stop bleeding [17]. IV infusion may be necessary in cases of severe volume loss associated with hypotension.

Careful inspection of the donor area should be done prior to wound closure to minimize postoperative bleeding or hematoma formation [17]. Postoperative bleeding rarely occurs as pressure dressings, and the use of snug headbands over the forehead extending circumferentially over the donor area several days postoperatively to control facial swelling also helps prevent further bleeding from the donor wounds.

44.2.1.6 Hyper- and Hypotension

In an otherwise healthy individual, hypertension during hair transplant surgery is usually caused by pain (for details, see Sect. 44.2.1.7).

Patients with known hypertension should continue antihypertensive medications. Patients on nonselective β-blockers should be advised to shift to cardioselective β-blockers (acebutolol, atenolol, betaxolol, bisoprolol, esmolol, metoprolol) because the combination of non-cardioselective β-blockers and large amounts of systemic epinephrine increases the risk of acute hypertension (systolic above 200 mmHg), which can inadvertently lead to a stroke. Epinephrine has both alpha-adrenergic effects (producing vasoconstriction) and beta-adrenergic effects (producing vasodilation). Nonselective β-blockers prevent vasodilation, leaving the vasoconstriction effect of epinephrine unopposed, causing the hypertensive reaction. Nonselective β-blockers also can inhibit the response to epinephrine in anaphylaxis [18, 19], which can cause fatal repercussions.

Hypotension may be related to an impending vasovagal reflex or due to volume loss from excessive bleeding (for details, see Sects. 44.2.1.4 and 44.2.1.5).

If hypotension is associated with bradycardia, atropine is administered sublingually or injected IM. If hypotension is accompanied by normal heart rate, ephedrine is administered sublingually or injected IM [20] (see Table 44.1).

44.2.1.7 Pain

Surgical pain is due to the disruption of the nociceptive signals from severed peripheral nerves and is managed with usual NSAIDs or stronger pain medications preoperatively and intraoperatively. Some surgeons have opted not to give medications in their practices and to use alternative methods such as massaging the body as a distraction, applying cold packs as additional numbing aids, listening to music, watching videos, or conversing with the staff while relying on the effectiveness of the local anesthetic to keep the patient comfortable and pain-free [16]. Injecting local anesthesia every 2 h onto the donor and recipient areas through nerve and field blocks provides continuous numbing effect until the completion of surgery.

44.2.1.8 Nausea and Vomiting

Nausea and vomiting can be troublesome if it occurs during surgery as it may increase operative time and cause more bleeding and popping out of the grafts and subsequent facial edema. However, the incidence is more common after surgery, either immediately after or the following day. Intractable vomiting, although rare, may need IV fluid replacement. Patients who experience nausea and vomiting may decide not to want to pursue subsequent sessions as a result. Medications such as metoclopramide (Plasil) or domperidone (Motilium) do not seem to help. Although expensive, ondansetron (Zofranc) [21] has been effective in my practice in treating vomiting from post-chemotherapy and can be an excellent choice for severe postoperative vomiting. Other antiemetics can be used as well (see Table 44.2).

Nausea and vomiting can also be signs of anaphylaxis (see Sect. 44.2.1.1) or of hypoglycemia which can be treated by giving sweetened beverages or viscous glucose concentrates for severe cases [21]. Nausea and vomiting associated with hyperglycemia among diabetic patients can be avoided by patients continuing their prescription medications even while in surgery and keeping their glucometers and insulin readily available.

Table 44.2 Antiemetic drugs, mechanism of action, and some side effects [21]

Antiemetic drug	Mechanism of action	Side effect
Promethazine 12.5–25 mg IV/25 mg PO	Dopamine antagonist	EPS (extrapyramidal syndromes, i.e., akathisia, Parkinsonian symptoms, tardive dyskinesia)
Prochlorperazine 2.5–10 MG IV/5–10 mg PO	Dopamine antagonist	EPS (extrapyramidal syndromes, i.e., akathisia, Parkinsonian symptoms, tardive dyskinesia)
Metoclopramide 10–20 mg IV/10–20 mg PO	Dopamine antagonist (good for patients with GERD)	Confusion, sedation
Droperidol 0.625 mg IV/NA	Dopamine antagonist	Prolonged QT interval
Ondansetron 1 mg for rescue, 4 mg for prophylaxis IV/6 mg PO	5-HT_3 (serotonin) blockers	Anxiety, restlessness, irritability, hyperventilation
Hydroxyzine 25–100 mg PO	Antihistaminic > antimuscarinic	Sedation
Diphenhydramine 25–50 mg IV/25–50 mg PO	Antihistaminic > antimuscarinic	Sedation
Scopolamine 1.5 mg transdermal patch	Antimuscarinic > antihistaminic	

44.2.2 *Postoperative Complications*

General postoperative complications considered as mild and temporary are to be anticipated as part of the postoperative course and include the following:

44.2.2.1 Persistent Hiccups

Possible causes of hiccups after a hair transplant surgery are (1) diazepam administration, (2) irritation of the phrenic nerve that innervates the postauricular area that can be affected during strip harvest [11], (3) dorsal placement of the patient during surgery, and (4) excessive air aspiration as a consequence of stimulation of diaphragmatic muscle movements by very excited or vocal patients [9].

"Bouts" of hiccups may last for a day or two, whereas "intractable" hiccups last longer than 48 h and are persistent and long-lasting (more than 2 months) [8] (for management, see Table 44.3).

44.2.2.2 Hyperesthesia (Pain, Skin Tightness) and Hypoesthesia (Numbness)

Postoperative pain usually occurs on the night of surgery and lessens in the following days. Patients who undergo FUT usually experience more pain compared to FUE due to stitching, having a tight scalp, and undergoing a wide excision. In FUE, pain after the procedure is far less severe and subsides a few hours after surgery or

Table 44.3 Postoperative complications and management

Complication	Management
Persistent hiccups	Chlorpromazine 25 mg oral every 6 h for 7–10 days
Hyper-hypoesthesia	Hyperesthesia (pain) • Pain medications (NSAIDs, paracetamol, opioids) • Cold packs Hypoesthesia (numbness) • Resolves spontaneously after several months
Facial edema	Triamcinolone acetonide into recipient anesthesia Oral steroids Ice packs Head elevation (45°) Head positioning (head supine, on lateral decubitus, or head back parallel to the floor whenever possible for 1.5 days) Snug headband over the forehead
Nausea and vomiting	Antiemetic medications
Effluvium or shock loss	Minoxidil 5% solution BID
Folliculitis	Warm compresses Antibiotics (topical, oral)

feels like a mild discomfort on the night of the surgery. Postoperative pain is due to the disruption of the nociceptive signals from severed peripheral nerves during surgery and is managed with usual NSAIDs or stronger pain medications like oxycodone or paracetamol with codeine 30 mg.

Skin tightness felt across the donor wound after surgery that is not relieved by typical NSAIDs may be lessened by soaking the donor area two to three times daily [11]. Cold packs to the donor area at least 15 min four times a day help decrease the pain. Hypoesthesia (numbness) most commonly occurs on the forehead (after supraorbital/supratrochlear nerve block) or on the midscalp and vertex after a strip FUT harvest. Numbness normally resolves within 3–6 months but can last up to 18 months and rarely causes permanent sensory loss [11].

44.2.2.3 Facial Edema

Facial edema starts as swelling over the forehead occurring on day 3 of surgery (Fig. 44.2), extending to the periorbital areas down to the face. Some patients experience swelling and ecchymosis around the eyes, and this poses a great concern to patients especially as this subsides 3 to 4 or more days later, often by seventh day post-op. Edema is usually due to the injection of large amounts of saline in the anesthesia or caused by seroma or hematoma from slit incisions. Postoperative edema was found in a study to be the most common complications in hair restoration [9].

Triamcinolone acetonide is administered intradermally when first incorporated into the anesthetic solution. Short courses of oral corticosteroids have also been included in postoperative care [17, 22], i.e., Dr. Tommy Hwang prescribes betamethasone IM—1 mg/10 kg body weight—for 2 days and then oral prednisolone at 20 mg per day for 2 days [23]. Although evidence remains unclear, some have claimed that systemic corticosteroids and 50 mg triamcinolone acetonide added to 50 mL of lidocaine mixture have decreased swelling postoperatively from 20% down to less than 5%. The Abbasi solution (100 mL of NSS, epinephrine 1 mL (1:1000), and triamcinolone 40 mg) is said to decrease postoperative swelling by 95–97% [24]. Triamcinolone 40 mg IM might also help decrease swelling and lessen its severity [22].

However, even after using steroids and doing all these preventive measures, once the periorbital swelling sets in, there is little we can do to stop its progression. Thus, a method of positioning the head supine, on lateral decubitus, or head back parallel to the floor whenever possible for 1.5 days was proposed by Dr. Hwang. This experiment resulted in 94.5% of patients enrolled in his study ($N = 1200$) without swelling or swelling extending to 1 cm below the anterior hairline (grade 0 swelling) with 80.7% patient compliance rate [23].

Wearing a snug headband on the forehead above the eyebrows, a turban-style wrap, or a compression tape below the hairline is helpful in controlling the edematous fluid from progressing downward to the forehead due to gravity. Keeping the head elevated above the level of the heart for the first week or leaning back at least 45° for the first 24 h after the transplant has been recommended to reduce venous

Fig. 44.2 Forehead edema

and lymphatic pressure [25]. These methods should be extended several more days if swelling persists. Postoperative edema can also be controlled with cold packs placed on the forehead after the procedure.

44.2.2.4 Nausea and Vomiting

Postoperative nausea and vomiting typically occur on the night of surgery possibly as a side effect of the medications given during surgery such as sedatives (diazepam, midazolam), analgesics containing codeine, antibiotics, and anesthetics. Most intra-op and immediate postoperative nausea is commonly due to vasovagal reaction [26] (for details, see Sect. 44.2.1.4).

Postoperative nausea and vomiting are multifactorial with patient-related factors influencing patients' susceptibility, and these are female gender, nonsmokers, anxiety, prior history of post-op nausea and vomiting, motion sickness, and migraine.

Prolonged exposure to emetogenic anesthetics (i.e., opioids) has the strongest evidence for risk of postoperative nausea and vomiting [20] (for management, see Table 44.2).

44.2.2.5 Effluvium or Shock Loss

Postoperative effluvium (shock loss) can either be anagen or telogen, can involve both donor (Fig. 44.3) and recipient sites (Fig. 44.4), and usually occurs one to three weeks post-hair transplant surgery (see Chaps. 45 and 46). According to Dr. Robert True, shock loss may be affected by factors such as trauma or direct injury to the follicles, vascular disruption with the use of epinephrine in the tumescent solution, dense packing into the area of thinning hair, stopping existing medical treatment for hair loss, and failing to resume its posttransplantation [27]. It is considered temporary wherein terminal hairs are expected to regrow 2–3 months later, whereas miniaturized hairs may not. Minoxidil has been advocated by some surgeons to reduce the incidence of effluvium, while the use of camouflage agents such as hair fibers [11], wigs, and extensions and even changing of hairstyle, if possible, can help.

It is important to inform patients of the possibility of shock loss post-surgery. Patients who are well informed and who anticipate possible complications such as this are less likely to litigate.

Fig. 44.3 Postoperative effluvium on the donor area

Fig. 44.4 Postoperative effluvium on the recipient area

44.2.2.6 Folliculitis

Folliculitis starts as sterile erythematous papules due to the inflammation surrounding newly erupting hair follicles and can occur over the donor and recipient areas. In a retrospective study in 2012–2013 of 30 patients who underwent FUT, folliculitis-like lesions over the donor area were observed as the most common occurrence accounting of 54.33% of patients [28]. In another retrospective study analyzing 73 hair restoration cases (7 FUE, 65 FUT, 1 BHT) from 2010–2014, sterile folliculitis in the recipient area was the second most common complication at 23.29% [9]. Warm compresses usually help manage this problem unless infection sets in for which antibiotics are then prescribed (for details, see Chaps. 48 and 49).

44.3 Summary

Prevention is worth a pound of cure; so it goes with any surgery. This starts from the very moment the patients walk into your clinic. From history taking to physical examination, you should already be searching for "red flags" that could possibly cause you headaches and unwanted sleepless nights. However, in spite of our due diligence, complications may still be encountered once we start the surgery, and the risk continues after the patient leaves our clinic. It is, therefore, crucial that we are not only familiar with the myriad of possible complications but also that we should be prepared to deal with them when we encounter them. There is no need to press the panic button as long as we are fully equipped and confident in our management.

Here is a summary of the general complications in hair transplant surgery and their appropriate management:

44.3.1 Tips and Pearls

1. To prevent complications, perform a complete history and physical exam, and select patients wisely. If necessary, obtain medical clearance, perform skin tests, and discontinue all medications that can be discontinued that can affect the surgery. Always review the chart before the procedure.
2. Update yourself and your staff with BLS and ACLS training. Ideally, a crash cart complete with all appropriate medications for emergencies should be present in the clinic.
3. The total volume of anesthesia used is widely affected by the duration of the procedure. The more efficient the team is in performing the surgery, the faster the surgery will finish, the less anesthesia is needed to be injected, and the less the risk for local anesthetic toxicity.
4. Know the simple maneuvers that alleviate hiccups and vasovagal reactions. When these fail, use the appropriate medications accordingly.

5. Have phone numbers of internist/internal medicine specialist, cardiologist, pulmonologist, or anesthesiologist readily available for prompt referral if needed.
6. Thoroughly explain to all patients both the common and uncommon complications that can be encountered prior to surgery. All information should be completely written down in the pre- and postoperative instructions and in the consent forms. A well-informed patient is usually a less problematic one. Patient rapport is imperative.
7. Giving pre- and post-op antibiotics is dependent on the surgeon's discretion. To avoid infection, emphasis should be placed on aseptic techniques during surgery. If infections occur, broad-spectrum antibiotics are first line. For recurrent and severe infections, always do a culture and sensitivity test to guide you in the medical management.
8. Don't be afraid to ask your mentors and colleagues in the field of hair transplant surgery. Their wisdom and experience are invaluable.

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Chapter 45
Complications from Strip Harvesting

Kenichiro Imagawa

45.1 Background

FUT is the current gold standard in graft harvesting and produces excellent cosmetic results with minimal donor scarring in most cases. However, the frequency of this procedure being performed has decreased to 51% of all hair restoration surgeries due to the increasing popularity of FUE, which is advertised with exaggerated claims as being scarless and pain-free [1]. FUT is considered a relatively safe procedure, but as with any surgery, common and uncommon complications can occur even with an experienced doctor. In this chapter, the unexpected complications specific to FUT donor site and their avoidance are reviewed.

45.1.1 Bleeding and Hematoma

No surgery can avoid unexpected bleeding and hematoma, and the incidence of these in FUT is less than 1%.

45.1.1.1 Prevention

Preoperatively, it is important to identify patients with high blood pressure and inherited bleeding disorders such as Willebrand's disease.

Patients should also be asked to discontinue nutrients like vitamin E and medications that enhance bleeding such as aspirin and warfarin at least 1 week prior the

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procedure. It is also important to coordinate with the attending doctor to determine if discontinuing these medications would aggravate preexisting medical conditions.

During the procedure, it is helpful to prevent bleeding by injecting sufficient amounts of tumescent solution, making the slits and dissection as superficially as possible, using tension clamps and forceps, avoiding electrocautery for coagulation, and making accurate approximation during suturing.

45.1.1.2 Treatment

Most bleeding can be stopped with gentle pressure lasting 10 min. If that is not sufficient, additional sutures may be required. With delayed bleeding due to hematoma with localized swelling and tenderness, the wound should be opened and drained, and the bleeding vessel should be coagulated and re-sutured.

45.1.2 Infection

Infections of FUT donor wounds are extremely rare and the incidence is only 0.1%.

45.1.2.1 Prevention

It is important to identify patients with uncontrolled diabetes and immune-compromised diseases.

Intraoperatively, the donor wound should be cleaned with disinfectants and washed with saline to remove debris and fragments of transected hairs.

Many hair surgeons don’t recommend the use of prophylactic antibiotics, but the author routinely gives oral antibiotics right before the procedure.

45.1.2.2 Treatment

If the donor area becomes inflamed with tenderness, painful swelling, purulent discharge, and redness, a bacterial culture should be taken from the wound, and topical and systemic antibiotics (e.g., cephalosporin, penicillin, and tetracycline) should be started, but this is extremely uncommon.

45.1.3 Pain

Pain from FUT is worse than that from FUE and this is the major reason for the rise in popularity of FUE. The pain is caused by tension and inflammation around the wound, but this is mostly negligible even in megasessions and can be managed accordingly. Less than 10% patients need to take analgesics for over 3 days, and the analgesics used widely are acetaminophen with codeine. However, NASIDs (non-steroidal anti-inflammatory drugs) are the author's preferred medications because narcotics have more restrictions and the side effects of nausea and hypotension are more serious [2].

45.1.4 Neuralgia and Neuroma

Although extremely rare, there are patients who suffer from throbbing pain and tenderness immediately after or while undergoing FUT. This is caused by damage to the sensory nerves, particularly the greater, lesser, or third occipital nerve while showing no abnormal appearance of the donor wound. The author once encountered a patient who had undergone FUT by another doctor, complaining of severe tenderness and a resilient mass around the donor wound. A biopsy revealed a traumatic neuroma upon, which is a rare lesion.

45.1.4.1 Treatment

The following strategies have been reported to relieve neuralgia, but a surgical approach should be considered for neuroma [3]:

- Local anesthesia and steroid injection
- Botulinum toxin type A injection
- Radiofrequency neuromodulation

45.1.5 Hypoesthesia

Temporary numbness involving the upper part of the donor incision inevitably occurs because superficial sensory peripheral nerves have been cut. This symptom normally resolves within a few months but can last up to 2 years. It is possible to have permanent numbness if the main branches of the nerves are cut, but fortunately the author has never encountered this.

45.1.6 True Keloid/Hypertrophic Scar

The frequency of true keloids and hypertrophic scars involving the scalp is lower when compared with other body parts, although the incidence in Asians is higher than that of Caucasians. The author has encountered only two true keloid formers in the past 25 years, but hypertrophic scars are not so infrequent in Asians (Figs. 45.1 and 45.2).

Fig. 45.1 True keloid scar

Fig. 45.2 Hypertrophic scar

45.1.6.1 Prevention

In the absence of a history of prior keloids or hypertrophic scars, it is impossible to identify patients who will develop these preoperatively, and it is impractical to perform preoperative testing for all patients.

45.1.6.2 Treatment

A series of intralesional steroid injections and the application of medical grade silicone gel are recommended. Hypertrophic scars will be mostly resolved within 2 years. For subsequent procedures, FUE may be a preferred option, but the patient may prefer to undergo subsequent sessions with FUT again due to financial reasons or being unwilling to shave. On these occasions, it is important to get the patient's consent for the recurrent risks and schedule frequent follow-up visits. Intraoperatively it is critical to be as careful as possible to avoid tension and minimize bleeding in order to reduce the risk of scarring.

45.1.7 Wound Dehiscence and Necrosis

This is an extremely rare complication caused by local ischemia due to tight closure compounded by other conditions including infection, bleeding, and other circulatory disruptions due to uncontrolled diabetic or other conditions (Fig. 45.3).

Fig. 45.3 Necrosis and effluvium

45.1.7.1 Treatment

The wound should be cleaned and re-sutured. When infection can't be excluded and strong tension exists, systemic antibiotics are mandatory, and the wound should be opened and allowed to heal by secondary intention.

45.1.8 Effluvium

Occasionally, hairs around the donor area will suddenly shed, the so-called "shock loss at the donor site." It occurs from 1 to 9 weeks after the procedure but is most common between 3 and 5 weeks. It is generally associated with a tight closure but can occur even during the first session with a loose scalp and is more commonly seen with women. Bertram states that this phenomenon represents an anagen rather than telogen effluvium and is due to tight closure, local circulatory disruption, and local ischemia caused by tumescent fluid, adrenaline, and the toxic effect of absorbable sutures. It is explained to the patient that this condition will improve spontaneously after 100 days and no treatment is required [4] (Fig. 45.4).

45.1.9 Stretched and Widened Scar

This problem is the patient's biggest concern for FUT, though most linear scars are undetectable unless the hair is cut very short. Recent techniques minimize scarring (Table 45.1), but scars measuring over 3 mm occur in 5% of patients after the first session and 10–15% after subsequent sessions due to the following factors (Figs. 45.5 and 45.6):

Fig. 45.4 Effluvium

Table 45.1 Techniques and management to avoid wide scars

• Identify the patients who are prone to have wide scars
• Evaluate scalp elasticity
– Mayer laxity scale [5]
– Cross beam laser [6]
– Rassman laxometer [7]
• Avoid excessive suture tension
– Scalp excise
– Intraoperative use of hyaluronidase [8]
• Minimize follicular transaction
– Open technique [9]
• Trichophytic closure [10]

Fig. 45.5 Wide scar and stitch marks

Fig. 45.6 Wide scar after numerous sessions

- Patient's predisposing conditions
  - Younger patients with elastic scalp tend to have a wider donor scar than older patients with tight scalp
  - Ehlers-Danlos syndrome
- Faulty design
  - Too low position /bad shape
- Faulty techniques
  - Suture with too strong tension/too much bleeding/too many follicular transections

45.1.9.1 Treatment

- Re-suture
  - There are numerous reports about how to improve donor scars (with/without tissue expanders, linear/zigzag, single layer/two layers/three layers), but none can guarantee the best solution.
- Camouflage with FUE
  - Placing the grafts into widened donor scar is a good option, but many patients rather prefer to place the grafts into thinning areas than into the FUT scar.
- Scalp micropigmentation (see Chap. 74 by J. Kim in this volume)

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Chapter 46
Recipient Site Complications

Theresa Marie R. Cacas

46.1 Complications Within the First Few Weeks (First to Fourth Week)

Post operative complications is defined as any undesirable, unintended, and direct result of an operation affecting the patient [1]. In hair transplantation, post operative complications are not very common with one report estimating an overall complication rate of only 4.7% [2].

46.1.1 Pain

After my hair transplant procedures, some patients complain of bearable pain, more commonly in the donor area than in the recipient site. The pain can be controlled by oral analgesics, and I prescribe paracetamol 500 mg every 4–6 h together with etoricoxib 120 mg tab once a day for 2 days. Thereafter patients discontinue their medications and report no further discomfort.

It is unusual that I encounter patients complaining of excruciating pain, and in these situations, patients will be given opioids together with the NSAIDS.

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46.1.2 Pustules/Pimples

I always see my patients the day after surgery, for their first post-op shampoo and examination of the donor and recipient sites. Occasionally, minute follicular pustules and small reddish papules are noted over the recipient area. At day 5, post surgery, patients return again for suture removal, and a few also show the same pustular and papular lesions.

Patients generally don't complain of any pain or tenderness over the affected area but do experience itching. While an infectious origin might be suspected, these lesions are believed to be sterile pustules since attempts in isolating pathogenic organism on gram stain and culture are negative [3]. Possible explanations for the formation of these pustules and pimples include foreign body reactions possibly from glove powder, small spicules of hair, etc. [4]. In a study of the incidence of bacteremia in skin surgery of the head and neck, it was found that out of 45 patients, 2 patients grew cultures of *Propionibacterium acnes*, and only 1 grew a culture of *Staphylococcus hominis*, yielding only a 7% incidence. This supports the current recommendation of the American Heart Association against the use of prophylactic antibiotics in patients without prosthetic heart valves for skin surgery of the head and neck [5].

Management includes draining of the pustule by nicking it with a sterile needle and applying gentle pressure using cotton tips to express contents. Patients should then be advised to apply warm compress for 3–5 min twice a day. These two modalities usually control the problem. When an infection is suspected, a gram stain, wound culture and sensitivity should be done. The use of antibiotics such as penicillins, cephalosporins, or macrolides is reserved for those resistant to usual modalities and if documented with evidence of infection by gram stain or culture [6].

46.1.3 Swelling

One of the most common complications in the recipient area is swelling and edema, most evident within 3 days to a week after the procedure [7]. Patients would often complain of edema along the frontal scalp, forehead, and periorbital area extending to the upper cheek, and excess edema may sometimes be accompanied by the inability to open their eyes. The edema is not red, warm, nor painful. Whether some patients experience edema and others do not may depend on the tumescent cocktail mixture used over the recipient area, the amount injected, and the length of the procedure.

Postoperatively, measures to control edema include short-course oral steroid treatment, sleeping at a 45° angle, adhesive tape or headband applied below the hairline, and ice packs or bags of frozen peas applied every 20 min [7]. Among all measures to control post-op periorbital edema, the method found to be most effective was using an intraoperative tumescent mixture of 100 mL normal saline + xylocaine 2% + 1 cc of epinephrine 1/1000 + 40 mg of triamcinolone in the recipient area [8].

46.1.4 Redness of the Recipient Skin

During the first week posttransplant, the recipient site will have a slightly erythematous hue. This is nontender and may be accompanied by minimal swelling and will spontaneously resolve in 2–4 weeks.

46.2 Complications During the First Month

46.2.1 Cyst Formation

Cysts may appear in the recipient area approximately 4 weeks after the hair transplant procedure and appear as soft doughy nodules measuring 0.5–1 cm in diameter. They are skin colored or slightly erythematous, devoid of any hair growth above the lesion, and the overlying skin may appear stretched and shiny. Patients generally do not complain of pain, but they may experience some itching. Cysts are believed to be due to entrapment of micrografts in the subcutaneous tissue, so oil secreted by the sebaceous glands accumulates without any exit point since at this time, the hair shafts have already been shed [9]. Piggybacking of grafts is one alternate explanation as a cause of these cysts [10].

Most resolve promptly with the application of warm compresses twice a day for a week. Some would require drainage of contents by incising the top part of the cyst with blade #15. Extrusion of an oily exudate that is sometimes accompanied by pus will be noted. The presence of erythema, pain, and tenderness could indicate an accompanying infection in which case I begin antibiotics. My choice of antibiotics is generally penicillin to cover gram + bacteria.

46.2.2 Postsurgical Effluvium/Shock Loss

All hair transplant doctors experience this complication which is described as the shedding of resident hairs within and around the recipient grafted area as well as the donor area. This happens between 2 and 4 weeks after the hair transplant procedure and is unpredictable [11]. The size of the affected area varies from a small patch to an area as big as 4 cm × 5 cm.

Postsurgical effluvium may either be an anagen or telogen effluvium [12]. The cause of this effluvium is believed to be due to trauma to the existing hairs during creation of holes and compromised blood supply [13, 14]. Postsurgical effluvium resolves spontaneously 4 months after the shedding is seen; however, some miniaturized hairs may not be able to recover and may be lost permanently.

46.3 Complications During the Fourth Month

46.3.1 Retained Hair Fragments (Stubbles)

At around the fourth to sixth month after the hair transplant procedure, patients may note small stubbles of nongrowing hair measuring 1–2 mm. These hairs neither shed during the telogen process nor grow along with the other grafts. When these retained fragments are removed, one sees nonviable transected hair shafts, and thus, it is advisable that they all be removed since they look unnatural and might initiate an inflammatory response.

If your patients frequently have retained hair fragments, it's important to evaluate the way your team has been cutting grafts. Ideally, follicular unit micrografts are pear shaped with a trimmed epidermis close to the hair, include a white cap of tissue present over transparent dermal papillae, and have a small amount of fat deep to the dermal papillae for grasping with jeweler's forceps [15].

46.3.2 Numbness

This is the loss of sensation most commonly noted involving the recipient area and commonly persists for several weeks up to a few months (2–3 months) post procedure. The patient should be reassured that the sensation will come back with time. To minimize numbness, it is important to incise only as deeply as necessary just below the hair bulbs so as to avoid unnecessary nerve damage.

46.3.3 Tenting/Cobblestoning

When the recipient area is fully healed and the grafts begin to grow starting at the fourth month post surgery, some patients may notice grafted perifollicular skin that is somewhat more elevated than the surrounding tissue. This is called cobblestoning when large round grafts are used and tenting when micrografts or follicular units are used. This is caused by surgeons using large round grafts, using poorly prepared grafts with an attached epidermis, and holes that are too shallow causing elevation of the inserted graft at least 1/3 of its entire length.

To avoid this, the correct hole depth should be made in relation to graft length. Upon insertion, just slightly elevate the graft from the surface of the hole, and only use properly prepared and dissected grafts. Measures to improve cobblestoning and tenting include electrodessication of excess tissue, microdermabrasion, or shaving the elevated portion off [16].

46.3.4 Pitting

As opposed to cobblestoning, pitting is the depression of perifollicular skin of grafted hairs in relation to the surrounding tissue. It presents as a depression, a dell, or a pit as seen on an orange peel skin. The cause of this is placing grafts deep within the holes or making the recipient site holes too deep so that the graft slips or falls within the hole.

To avoid pitting, slightly elevate grafts above the surface of the holes when inserted. Pitting is a difficult problem to correct and usually requires punch excision, electrodessication, or dermabrasion of the skin surrounding the pits [17].

46.3.5 Keloid/Scarring

A keloid is a type of scar which is an overgrowth of granulation tissue that is slowly replaced by collagen type 1. They present as pinkish, rubbery, shiny plaques initially found within the area of the wound but then extending beyond the wound's original borders. Keloids are found only in humans and occur in 5–15% of wounds. They tend to affect both sexes equally, although a higher incidence exists in women presenting with keloids, possibly secondary to the cosmetic implications associated with the disfigurement. The frequency of keloid occurrence in persons with highly pigmented skin is 15 times higher than in persons with less pigmented skin [18]. However, scalp has good blood supply, and the chance to have keloid is quite low. It is essential that this information be gathered during history taking so that patients can be properly advised.

Current management of keloids includes intralesional injection treatment with corticosteroids, 5-fluorouracil, bleomycin, interferon, cryotherapy, and verapamil [19]. Other modalities of treatment include topical silicone gels/sheets or the use of lasers like the pulsed dye laser and long-pulsed Nd:YAG [20, 21]. I usually use intralesional triamcinolone injection 40 mg/mL with amounts depending on the keloid size injected 1 month apart for about 2–3 months, and this would flatten out small- to moderately sized keloids.

46.4 Complications Seen at the Sixth Month and Beyond

46.4.1 Unnatural Looking Hair Growth

When the hair begins to grow at the fourth month mark, there initially is an unnatural appearance before normal length, density, and thickness appear. Grafts may initially be curly or kinky when they start growing, but after a few more months of growth, they start to straighten and assume the normal texture of the patient's hair. Initial growth may also have a different caliber, mostly with finer strands but occasionally with thicker strands [22].

46.4.2 Grafts with Different Direction

The rule for a hair transplant procedure is to follow the natural angulation of nearby resident hairs as we place grafts in the scalp. Normally hair shaft angulation changes from 90 degrees in the crown to 30° in the frontal hairline. In the posterior scalp and sides, the hair angulation is very acute and may emerge almost flat against the scalp [23]. I look for fine resident hairs within the recipient area and just follow their direction and angulation.

46.4.3 Unnatural Hairline

Hair transplant hairlines placed either too high or too low will produce an unnatural appearance. For a symmetrical and appealing face, try to follow the rule of thirds, which is chin to tip of the nose is 1/3, tip of the nose to top of glabella is another third, and top of glabella to hairline is another third [24].

It is easier to correct a high hairline because it can be lowered during the next hair transplant session. A hairline placed too low is more difficult to correct because the remedies include punch removal of grafts, excision with a #11 blade, and magnification [25]. One may also consider laser hair removal to remove unwanted grafts or soften the hairline [26].

Another common mistake in creating a hairline that is too straight is that the hairline is in fact not really a straight line but a jagged randomly placed zone, and aligning and inserting grafts along a straight line will result in an artificial look. In addition only single hair grafts should be used for the hairline. Placing two or three hair grafts in the hairline will make the hairline appear clumpy and therefore make it easy to tell that a hair transplant has been performed.

46.4.4 Poor Graft Growth

The results of a hair transplant procedure can be best assessed within 6–8 months after surgery although some doctors believe that hair growth can still improve until the twelfth month mark.

When recommended conditions during the procedure and aftercare are not properly met, patients may have poor growth.

Poor growth in hair transplant is defined as having less than 90% growth evaluated at least 8 months after the procedure. In a survey done by Dr. Jerry Cooley, he found that in private practices, poor growth averaged 6% with a range of 0–25% [27]. The most important factors determining graft survival are avoiding physical trauma to the grafts and ensuring that the oxygenation needs of transplanted follicles are met [28, 29].

46.4.5 Conclusion

The complications reviewed above are those more commonly seen in a hair transplant practice. The principle message for all surgeons is to master our craft well and be well versed on the requirements, guidelines, procedures, and care required for a successful hair transplant procedure. In this way, we can minimize complications and give our patients the best results that they deserve.

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Chapter 47
Complications in FUE

Kapil Dua, Aman Dua, and Monica Chahar

47.1 Introduction

Follicular unit extraction or FUE technique is preferred by most patients today owing to its less invasive nature when compared to the strip or FUT technique. It has the advantage of having diffuse microscarring instead of a linear scar as well as avoiding sutures. However, FUE is not entirely free of complications, and there are quite a few problems that can occur in this procedure which can be divided as follows:

1. Donor area complications

   1.1 General postoperative complaints.
   1.2 Complications specific to extraction

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2. Recipient area complications
   2.1 Complications due to recipient site creations
   2.2 Implantation-specific complications
   2.3 Aesthetic complications
3. Medical complications

In this chapter, we will restrict ourselves to the complications occurring in the donor area only.

47.2 Donor Area Complications

47.2.1 General Postoperative Complaints

FUE is a relatively noninvasive and a safe cosmetic procedure. However, some of the following complaints are reported by the patients: [1, 2]:

47.2.1.1 Postoperative Discomfort in the Donor Area

There is minimal postoperative pain and discomfort in patients undergoing FUE surgery in the donor area. Pain may occur on the evening of the surgery but usually disappears over the next couple of days. The authors prescribe mild analgesics like paracetamol, especially for the first 5 days, to decrease pain and inflammation.

47.2.1.2 Oozing

When the patient lies down on a pillow, pressure is exerted on the donor area which results in oozing in the form of serosanguineous fluid. The patient may worry when he sees this fluid on the first postoperative day morning. Therefore, we advise the patient to keep a dark-colored towel on the pillow to avoid any soiling of the latter. In the rare cases of donor area bleeding, the patient should apply firm pressure with gauze for a few minutes. No further action is usually required.

47.2.1.3 Numbness/Paresthesia

Numbness or paresthesia in the donor area after FUE is uncommon, and when it occurs, it is limited to small areas.

47.2.1.4 Pruritus

Some patients experience itching in the donor area when healing begins. Itching will usually improve after proper scalp cleansing. However, sometimes we have to advise the patient to apply aloe vera gel to make the area soft which reduces the sensation of itching. If the itching is severe, steroid lotions and antihistamines are also recommended [1].

47.3 Complications Specific to FUE in the Donor Area

47.3.1 Visible Pinpoint White Scars in the Donor Area

Many people have a misconception that FUE is a scarless procedure; however, that is not accurate. FUE donor sites usually heal as pinpoint atrophic white macules—contracted circular scars which are hairless, depigmented, fibrotic, and palpable to the touch [3]. Although these scars are not usually visible unless the overlying hair is completely shaven off, in some cases scars can be seen on close inspection with short hair, especially if overharvesting has been done. Also, if continuous follicular groups are taken out, some of these scars can coalesce and form a larger scar that is more visible. In order to decrease the visibility of these scars, certain measures have been devised by physicians which have been found to be helpful in healing the donor area. These are:

- Use of ACell MatriStem at donor sites. ACell improves healing of scars by reducing or eliminating fibrotic scarring [3].
- Subfollicular unit harvesting. This means deliberately removing only a few hairs from each follicular unit, leaving the rest of the hairs behind. These remaining hairs continue to grow, producing a more aesthetic donor area as the area does not become hairless [4].
- Use of smaller punches to give a better cosmetic scar. A punch size bigger than 1 mm leads to a more perceptible scar when compared to punches smaller than 1 mm. However, smaller punches result in higher transection rates and fewer numbers of hairs per graft. With a punch size of 1 mm, the average hairs per follicular unit can exceed 2.5 whereas with a punch size of 0.75 mm, the average number of hairs decreases to 2.1 per graft [5]. Therefore a balance must be found between the size of the punch and the number of hair per follicular unit in order to achieve the best results.

The authors do not use the first two options. They use the third option of using smaller punches (0.8 or 0.9 mm) to keep a balance between the number of hair per graft (which they try to keep around 2) and the size of the scar. They do not use

1.0 mm punches, as the hypopigmented scars are more prominent in the Indian subcontinent patients due to higher contrast when compared to Caucasians (Figs. 47.1 and 47.2). They do extractions in a zigzag manner, making sure that no two holes coalesce in the donor area to avoid any overlap of the removed grafts. This approach makes the appearance of the dots less prominent then when grafts are removed in continuity.

Fig. 47.1 Greater contrast of scar in Indian patient

Fig. 47.2 Less contrast in Caucasian patient

47.3.2 Moth-Eaten or Pseudo-Syphilitic Appearance [2]

Some overly aggressive physicians overharvest grafts from the donor area. This can result in a moth-eaten (Fig. 47.3) or pseudo-syphilitic appearance, which becomes very prominent when the patient wears very short hair. Hence, it is important to space extraction appropriately in a zigzag manner to avoid areas of patchy hair loss (Fig. 47.4).

47.3.3 Post-op Effluvium

Donor hair effluvium (Fig. 47.5) can occur after surgery, but it is less common than recipient hair effluvium. It presents as diffuse or localized hair loss 4–6 weeks after FUE [6]. It is temporary and resolves over a period of 3–4 months. The cause for

Fig. 47.3 Moth-eaten appearance

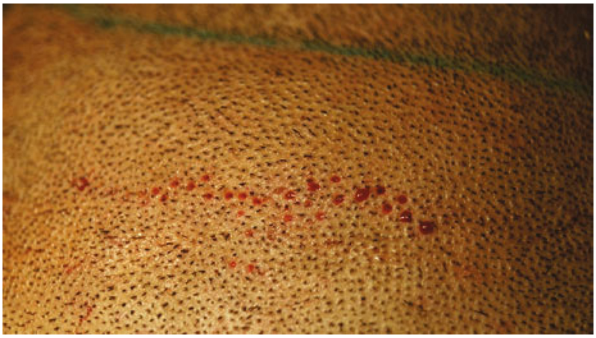

Fig. 47.4 Zigzag pattern in extraction

Fig. 47.5 Donor area effluvium

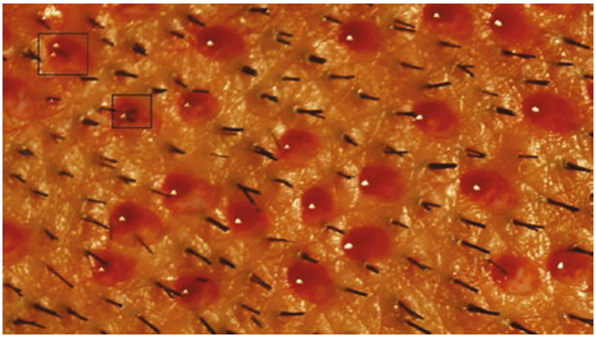

Fig. 47.6 Buried grafts

this phenomenon could be the interrupted blood supply due to overharvesting. Thus, the authors limit their graft harvesting to 2000–2200 in one session and as a result do not see donor effluvium.

47.3.4 Buried Grafts

This is usually seen with dull punches. During extraction, when the punch is inserted rapidly into the dermis without proper engagement, the follicle is pushed inside the dermis where it becomes embedded. The authors have the assistant remove buried grafts at the time of extraction; otherwise, cyst formation may occur (Fig. 47.6).

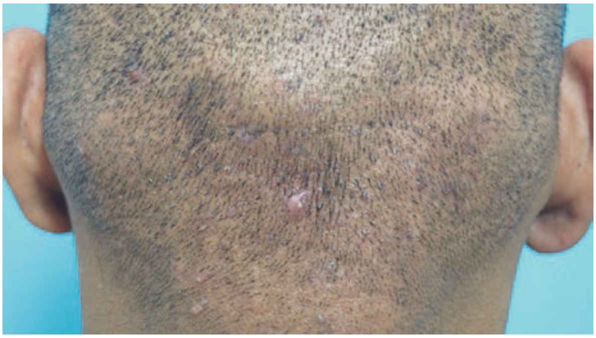

Fig. 47.7 Folliculitis in donor area

Fig. 47.8 Epithelial cysts in donor area

47.3.5 Folliculitis

Folliculitis can occur in the donor area if the grafts are not taken out completely and fragments remain buried in the dermis (Fig. 47.7).

47.3.6 Epithelial Cysts

Sometimes FUE grafts can subluxate below the surrounding dermis. If they are not removed, they may later form cystic masses producing multiple painless swellings on the donor area [7] (Fig. 47.8). The possible reasons for the formation of these subdermal cysts are: [7]

- *Deep coring through the entire reticular dermis*: FUE punches should be used to score around the individual follicular unit only down to the mid dermal level, so that the grafts are still attached to the reticular dermis. If deep coring is done through the entire depth of the reticular dermis, they will lose these attachments and can easily subluxate below the dermal level.
- *Overtumescence* can cause expansion of the subdermal layer, which makes it easier for the detached grafts to slip down.
- *Missing buried grafts during extraction.*

Blunt punches through deeper penetration can cause cutting of the deeper dermal attachments and subluxation of the grafts.

47.3.7 Necrosis of the Donor Area

Necrosis of the donor area can also occur rarely if the extraction of grafts is not properly spaced out [8].

47.3.8 See-Through Appearance of the Donor Area

If greater than 20% of the scalp donor hairs are harvested in one session, this is considered overharvesting, and may lead to visible thinning and a see-through appearance of the donor area and patches of hair loss (Fig. 47.9). The authors choose

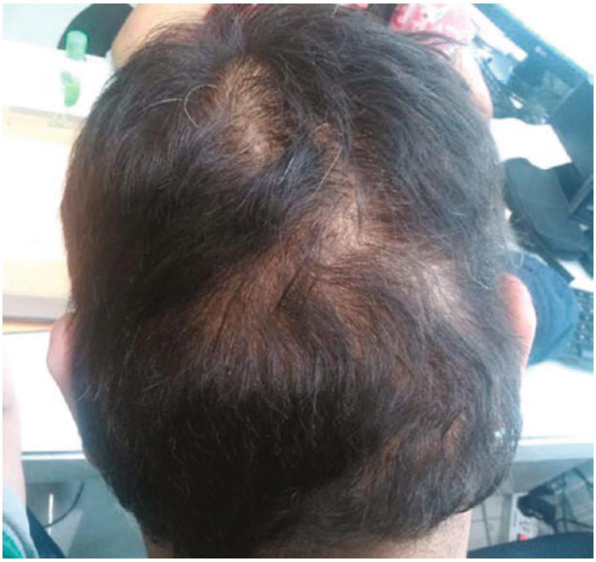

Fig. 47.9 See-through appearance because of the overharvesting of donor area

to remove grafts in multiple sessions spaced 6–8 months apart. They usually harvest 20% during the first session, 15–20% during the second session, and 10–15% in the third session, leaving behind 50% of the hair in the donor area to avoid any visible thinning.

47.3.9 Loss of Implanted Hair

When grafts are harvested from outside the safe zone, especially in younger patients with ongoing hair loss, these grafts can later be lost due to the natural progression of pattern hair loss [2]. This usually occurs with the grafts harvested from the margin of the posterior occiput and results in unnatural patches of baldness or thinning over the recipient areas when these transplanted hairs are later lost. This can also lead to white dots on the crown area, which become visible as the hair loss increases and the hair-bearing margin drops down. It is always safer to only extract grafts from the safe donor area, which has been divided into eight major and six minor areas by John Cole [4]. While the above method is quite useful, the authors have devised their own method of defining the safe donor area in the occiput region through their observations of the grade VII patients. They have determined that the safe donor area is delineated by two parallel lines drawn in the upper and lower parts of the occiput. The upper line connects the upper border of the two pinnae, and the lower one connects the lower part of the two external auditory meatus. It is always important to limit the number of grafts being taken from outside these areas to reduce the risk of future thinning of these areas.

47.4 Summary

A thorough understanding of the possible complications relating to FUE is important in order to avoid them and achieve better results. Proper selection and counseling of the patient, using adequate precautions during each and every step of the procedure, and following good postoperative measures can ensure the best possible outcome for the patient as well as the surgeon.

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Chapter 48
Folliculitis in Hair Transplantation: Dermatologist's Point of View

Dell Kristie A. Ortega-Castillejos

48.1 Folliculitis in Hair Restoration Surgery

Folliculitis is a folliculocentric infection which typically starts with the superficial portion of the pilosebaceous unit [1], mainly the infundibular opening of the hair follicles [2]. It usually presents as an erythematous pustule in any hair-bearing areas of the body. It can be classified according to the depth of invasion (superficial and deep) and microbial etiology [2, 3].

In hair transplantation, the type of folliculitis that we usually see is the superficial type (Fig. 48.1) which appears as small pustules at the ostium or opening of the hair follicle. These may rapidly evolve into multiple lesions (Fig. 48.2) after just a few days. According to Bunagan and Pathomvanich the onset of lesions ranged from

Fig. 48.1 Superficial folliculitis

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Fig. 48.2 Multiple folliculitis

2 days to 6 months after follicular unit transplantation [4]. Laboratory cultures of these lesions may turn out to be negative; hence, they may be termed as "non- infectious folliculitis" [5]. It may be associated with mechanical factors such as friction, occlusion, or follicular trauma, of which hair transplantation and epilation are examples [5]. A study by Loganathan, et al. in 2014 stated that sterile folliculitis, as a post-hair transplantation complication, accounted for 23.29% of their cases [6]. Similarly, Salanitri et al. have cited that the overall complication rate for a series of 533 hair transplantations done from 1995 to 2006 was 4.7%, for which folliculitis accounted for almost a fifth of the cases at 1% [7].

However, folliculitis after hair transplantation may also be caused by bacterial infection. *Staphylococcus aureus*, among other causes, is the most common pathogen found in scalp folliculitis [8]. This may be treated with evacuation of the pustule, topical antibiotics, and if the lesions are multiple, the physician may opt to start the patient on systemic antibiotics. Please refer to part 18, Chap. 49 for the treatment of post-hair transplantation folliculitis.

Superficial folliculitis may progress to deeper layers and may evolve into furuncles. These lesions present as deep-seated nodules which may be painful to touch. Occurrences of such lesions, even in instances where the surgery is carried out with meticulous sterility, should prompt the hair transplant surgeon to dig into the medical history of the patient and look for possible predisposing factors like diabetes, blood dyscrasias, and the more complicated defects in neutrophil function [2]. Please refer to Part 18, Chap. 50 for further discussion.

Pseudofolliculitis is a type of non-infectious folliculitis more commonly seen in Blacks secondary to shaving. This occurs when the growing hair follicle becomes trapped and, instead of exiting the scalp, curls and grows into the follicular wall [9].

This pathology of folliculitis continues to be the debate whether transplanted grafts are buried and trapped deep inside the scalp, thus giving rise to the so-called "ingrown hairs." Management for such conditions is simply plucking out the involved follicle.

Folliculitis decalvans is another challenging type of folliculitis that may occur over the donor as well as the recipient site [10]. The lesions usually start out as erythematous, follicular-based pustules with some hyperkeratotic, greasy scales around the affected ostia [11]. The lesions may start over the areas of the vertex and may evolve to alopecic patches [12]. This condition may also be referred to as "tufted folliculitis" because many hair follicles may grow in one single, dilated follicular orifice [11–13]. Otberg et al. in 2009 have described a case of folliculitis decalvans developing in punch grafts 20 years after hair transplantation [12]. This disorder may be called "Quinquaid's decalvans," for which the cause is still unknown [10]. The symptoms involve inflammatory alopecia leading to bogginess and induration of the scalp with the development of pustules, erosions, and crusting. The staphylococcal infection associated with this disorder was thought to be not the causative agent but rather an opportunistic infection due to the pre-existing inflammation [10].

Management of this condition is generally difficult, as the disease progression is characterized by waxing and waning and can span a few years. Systemic antibiotics geared toward the eradication of *Staphylococcus aureus* are recommended. However, relapses are noted upon discontinuation of the drug. Medications to address the relapses can range from rifampicin combined with minocycline, oral fusidic acid combined with topical mupirocin, and fusidic acid combine with erythromycin which may be given. Intralesional steroid injections may help reduce the redness and alleviate the symptom of itching. Intranasal application of topical antibacterials to eradicate the staphylococcal reservoir can also be useful [12].

48.2 Summary

NB the table of summary is shown below (Table 48.1).

Table 48.1 Summary: folliculitis in hair transplantation

Summary of different types of folliculitis in hair transplantation surgery with its pertinent features:	
1. Superficial folliculitis • Sterile folliculitis • Bacterial folliculitis	– 2 days–6 months post-hair transplantation – Associated with friction, occlusion, follicular trauma – Associated with perspiration, *Staphylococcus aureus* infection
2. Deep folliculitis	– May evolve into furuncles – Look for predisposing factors such as diabetes, blood dyscrasias, immunosuppressive disorders
3. Pseudofolliculitis	– Due to ingrown hair/trapped follicles
4. Folliculitis decalvans • Difficult to treat	– AKA "tufted folliculitis" – Erythematous follicular pustules over the vertex – (+) tenderness, bogginess, erosions, crusting

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Chapter 49
Post-op Folliculitis: Another Perspective

Sungjoo Tommy Hwang

49.1 Folliculitis Due to Deep Placement of the Graft

Follicular Unit Transplantation (FUT) constitutes the primary method of hair restoration practiced worldwide [1]. To perform FUT properly, the importance of matching the graft size/length and the incision size/depth is well known. Follicles vary in length from 3 to 6 mm between patients and can vary according to one's race and personal characteristics [2]. Therefore, the incision depth should be assessed for each individual patient. A blade that is of fixed length or is used with no depth control can penetrate more deeply into the subcutaneous fat in some patients. Improper depth-controlled graft placement can yield problems such as pitting, tenting, folliculitis, epidermal cysts, ingrown hairs, and other problems (Fig. 49.1) [3, 4]. Wong measures several grafts to determine an average depth when setting blade depth [5], but he does not measure the exact intra-patient variation of graft length. Correct incision depth varies from patient to patient, but previously it was believed that there would be little difference in the graft length in the same individual. Despite performing proper surgical techniques of hair restoration to create the appropriate depth for recipient sites, failed depth-controlled problems still occur in some patients.

One study was performed to evaluate whether there is a significant difference in intra-patient graft length [6]. According to this research, the length of the graft can vary significantly in the same individual: the majority of Korean patients showed a 1–1.5 mm length difference, but 18.5% showed a 2 mm difference, 4.2% showed a 2.5 mm difference, and 1.7% showed a 3 mm difference between the longest and shortest graft in 1-hair FU (Table 49.1). These differences are also seen in 2-hair

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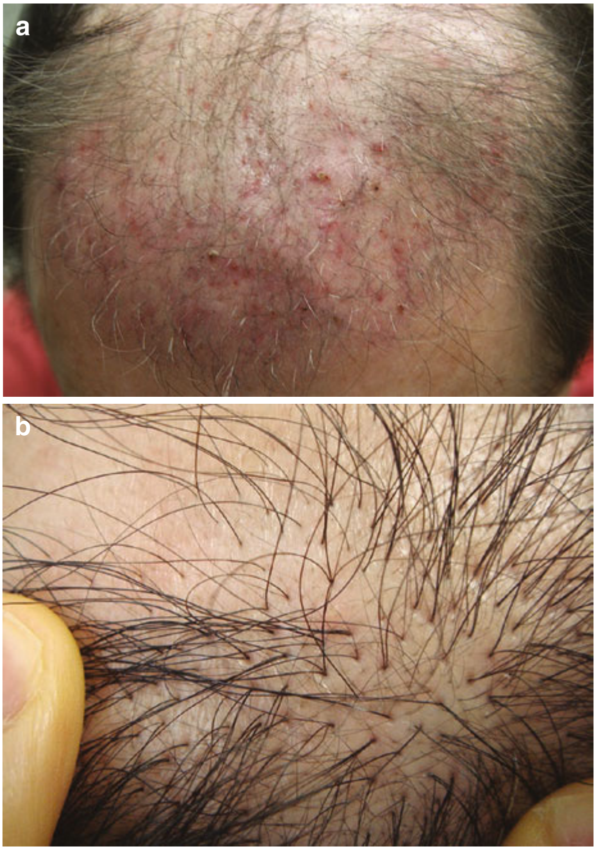

Fig. 49.1 (**a**) Folliculitis, (**b**) pitting. The cause is deep location of the graft

Table 49.1 The intra-patient length difference between the longest and shortest grafts in 119 MPHL Korean patients

FU	0.5 mm	1.0 mm	1.5 mm	2.0 mm	2.5 mm	3 mm	Totals
1-hair FU	2(1.7%)	42(35.3%)	46(38.6%)	22(18.5%)	5(4.2%)	2(1.7%)	119(100%)
2-hair FU	12(10.1%)	57(47.9%)	36(30.3%)	10(8.4%)	1(0.8%)	3(2.5%)	119(100%)
3-hair FU	43(36.1%)	43(36.1%)	26(21.9%)	7(5.9%)	0(0%)	0(0%)	119(100%)

FUs but less in 3-hair FUs. The majority of Caucasian patients showed a 1–1.5 mm difference in 1-hair FUs, but 4.2% showed a 2 mm difference, and 8.3% showed a 2.5 mm difference in 1-hair FU as well as a significant difference in 2–3-hair FUs but less than Korean patients (Table 49.2). Therefore, the intra-patient graft length difference is seen in both Asians and Caucasians, with greater differences found in the Asian patient compared to the Caucasian patient. The causes of intra-patient

Table 49.2 The intra-patient length difference between the longest and shortest grafts in 24 MPHL Caucasian patients

FU	0.5 mm	1.0 mm	1.5 mm	2.0 mm	2.5 mm	3 mm	Totals
1-hair FU	5(4.2%)	12(50.0%)	4(16.76%)	1(4.2%)	2(8.3%)	0(0%)	24(100%)
2-hair FU	5(20.8%)	9(37.5%)	8(33.3%)	2(8.4%)	0(0%)	0(0%)	24(100%)
3-hair FU	9(37.5%)	11(45.8%)	4(16.7%)	0(0%)	0(0%)	0(0%)	24(100%)

graft length differences are (1) genetically determined length difference, (2) length difference according to the hair cycle, and (3) transection during graft preparation.

Therefore, if we make only one depth incision in an individual, then the long grafts will fit in the incision site but the short grafts will be placed into the deeper layer. For example, if a single patient has 6 mm, 5 mm, 4 mm, and 3 mm length grafts in the donor area, and if we make incisions at a 6 mm depth, then a 6 mm graft will fit in the incision site adequately, but a 3 mm graft will be located at 3 mms deeper than the proper depth and could result in folliculitis, cysts, and pitting (Fig. 49.1).

Transection of the grafts can sometimes occur during graft preparation with FUT and FUE. These transected follicles should also be placed superficially compared to the intact hair follicles to avoid deeper location in the recipient site.

In order to prevent complications such as pitting, tenting, poor survival, folliculitis, and cysts, we need to classify grafts within the same individual into same length groupings and make proper incision depths according to each group. With this depth-controlled graft placement method, the author reduced or prevented these complications in most of his patients for the past 4 years [7] (Fig. 49.2) (see Chap. 19).

49.2 Hair as Foreign Body in the Recipient Skin

The transplanted hairs usually fall out between 2 weeks and 4 weeks after surgery. But some of the transplanted hairs keep on growing without falling out [8]. A small portion of hairs neither fall out nor keep on growing: they just remain in the recipient skin. These hairs act like a foreign body and can cause folliculitis (Fig. 49.3). These hairs can be pulled out by vigorous shampooing or by forceps at 4 weeks post-op, and folliculitis can be reduced with this method.

49.3 Pearls

1. There are significant intra-patient graft length differences.
2. Making the same depth of slit every time may result in improper graft level in the slit according to the length of graft: shallow or proper, or deep graft placement.

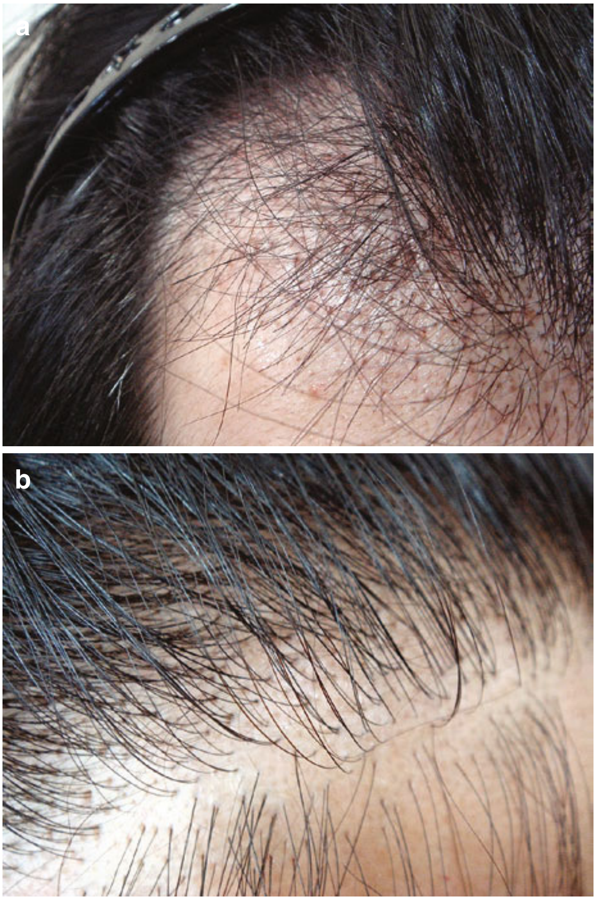

Fig. 49.2 Folliculitis and pitting are rare after the method of depth-controlled transplantation: (**a**) no folliculitis at 5 weeks post-op. (**b**) No pitting at 1-year post-op

Fig. 49.3 Remaining hair which shows no growth plays as a foreign body, and it induces folliculitis

3. Matching the graft length and incision length allows the proper graft placement in the slit: making 3 mm slits or 3 mm grafts, and 6 mm slit for 6 mm length of grafts.
4. Measuring the length of all grafts and grouping them according to the length are necessary for the depth-controlled graft placement.
5. These depth-controlled graft placements can prevent folliculitis, pitting, and even poor survival.

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Chapter 50
Prevention and Treatment of Postoperative Folliculitis

Ng Bertram

50.1 Background

Scalp skin in the recipient area can develop an inflammatory response to a wide range of stimuli such as infection, physical injury, or chemical exposure during a hair transplant procedure. Incidence of postoperative folliculitis was reported to vary from 1.1% to 20% [1]. Severity of folliculitis ranges from a mild, superficial inflammation with mild erythema and scattered pustules, to a severe, deep inflammation with widespread erythema and numerous cysts, pustules, and papules. Recommended treatment includes warm compresses, topical antibiotic ointment, topical mid-potency corticosteroid, incision and drainage, and systemic antibiotics.

50.2 Our Approaches

Seventy-five percent of all patients undergoing scalp hair transplant in our office are East Asians; 15% are Southeast Asians. Over 80% of all patients return for regular follow-ups 1 day, 1 week, 1 month, 4 months, 8 months, and 12 months afterward. Here we present another perspective regarding the nature, prevention, and treatment of recipient site postoperative folliculitis. According to the onset and probable etiology, we classify the folliculitis into three categories: traumatic folliculitis, foreign body folliculitis, and infective folliculitis.

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50.3 Traumatic Folliculitis

Pustules appear as early as the next day after the procedure. This is most likely inflammation rather than infection. Wound swabs usually yield no growth or just scanty growth of *Staphylococcus aureus*. Burying epidermis during site creation, transection of hair during site creation, and planting hair spicules with the graft may initiate an inflammatory response [2]. Release of sebum from the ruptured sebaceous glands during incision may also play a key role.

50.3.1 At-Risk Groups

Pre-existing folliculitis, furunculosis, and moderate to severe acne vulgaris, oily skin or pre-existing seborrheic dermatitis [3], sebaceous gland hypertrophy, or sebaceous cysts noted during strip harvesting.

50.3.2 Treatment

The most effective treatment is to puncture the pustule with a sharp needle, followed by compression with a cotton bud to squeeze out any pus. The inflamed area should be washed with cold water and povidone-iodine shampoo. Topical steroid-antibiotic preparations can be applied [4]. We prescribe systemic antibiotic such as 100 mg doxycycline daily or ciprofloxacin 500 mg bid for 5–10 days on selected cases. Frankly speaking, this is more for our peace of mind. Patients should be monitored frequently as new pustules may keep on popping up. It may take up to 3 weeks for the inflammation to subside (Fig. 50.1).

Fig. 50.1 Traumatic folliculitis at day 18

50.3.3 Prevention

There is no clear evidence that using sterile gloves during incision and insertion would reduce post-op folliculitis [5]. Administration of prophylactic antibiotics before a hair transplant surgery, such as a cephalosporin, remains controversial [6, 7]. We do not use antibiotics routinely as drug allergy is more dangerous than folliculitis. Patients at risk are asked to take a daily dose of doxycycline 100 mg and to shampoo with 2% ketoconazole for a week before surgery. The most effective preventive measure, however, is systemic steroid immediately after surgery. Our protocol of prednisolone 10 mg taken in a daily dose for 4 days has significantly reduced the incidence of folliculitis as well as facial edema.

50.4 Foreign Body Folliculitis

Inflammation can also be a result of either a foreign body reaction of recipient dermis or obstruction of the orifice by a hair fragment [1]. After 3 weeks, the transplanted follicle would enter the catagen-telogen phase. The detached hair stump would then be perceived by the immune system as a foreign body (Fig. 50.2). If this hair fragment is dislodged or removed, the folliculitis would subside spontaneously. If left behind, it may block the skin orifice. Another peak of inflammation can be triggered 3–4 months later when the new growing hair cannot penetrate the intact epidermis. It may eventually lead to ingrown hair or a chronic recurrent form of folliculitis [1] [4].

Fig. 50.2 Foreign body folliculitis at 4 weeks

Fig. 50.3 The J hair

50.4.1 At-Risk Groups

Asians with very coarse hair, dense packing, insertion without shaving, and implanting transected or damaged follicles.

50.4.2 Prevention

Gentle fingertip massage in a circular motion should safely be included in the post-surgical shampooing protocol in order to remove any loosened hair, starting a week after surgery [8].

50.4.3 Treatment

At the center of each pustule is always a hair spicule, the remnant of the hair shaft detached from the resting dermal papilla. This has the typical appearance of the letter "J." This so-called J hair can easily be removed using a pair of tweezers (Fig. 50.3). Pus should be drained by compressing with cotton buds. In the presence of widespread folliculitis, topical steroid-antibiotic ointment and Betadine shampoo can be used at home for the next 5 days. Systemic antibiotic is seldom required unless secondary infection is suspected.

50.5 Infective Folliculitis

Infection can appear anytime when the skin barrier is disrupted. It should be suspected in any case of severe or persistent folliculitis not helped by the above measures [1]. Immediate pre-op razor shaving and clipping of hair was shown to have a 3% increase in surgical infection [5].

50.5.1 At-Risk Groups

Dusty work environments, infrequent scalp washing, scratching of itchy scalp, cross infection in a hospital setting [6], or immunosuppressive medical conditions such as diabetes mellitus increase the risk. *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *enterobacter*, *klebsiella*, and *proteus* have been listed as pathogens [7].

50.5.2 Treatment and Prevention

Prior to the use of antibiotic therapy, purulent material should be cultured [1]. The management is the same as any postoperative wound infection and will not be discussed here.

50.6 Final Outcome

Though not a life-threatening condition, the scattered pustules are not welcomed by patients due its unsightly and alarming appearance. Most patients want to keep their transplant a secret without drawing any attention [6]. Chronic low-grade inflammation, if allowed to continue over months or years, may lead to scarring alopecia with follicular damage and hair loss [9]. There is always a concern that folliculitis may affect graft survival. Fortunately, with proper preventive measures and treatment, most folliculitis subsides uneventfully rarely affecting the final outcome [2].

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Chapter 51
Does Epinephrine Influence Post-surgical Effluvium?

Ratchathorn Panchaprateep

51.1 What Is Post-surgical Effluvium?

Post-surgical effluvium or shock loss is a shedding of the existing hair in and around the transplant area following hair restoration procedure. This condition causes temporary or permanent loss of hair in the anagen or rapid growing phase of the hair cycle following a hair restoration procedure. Shock loss happens even in experienced hands. Unger reported 15–20% of men and 40–50% of women in his practice [1, 2]. It certainly affects the weaker (miniaturized) rather than the residual terminal hair. If this hair is near the end of its lifespan, it may grow back finer and lighter in color or may not return [3]. However, the majority of the affected hair grows back after 3–4 months [4]. The degree of shock loss is unpredictable; it can be as minimal as thinning, as moderate as a small bald patch, or as severe as complete baldness. Less common is effluvium of the donor area. Shedding is more common and severe if the patient has extremely fine and minimally pigmented hairs [5], more preexisting hairs in the transplant area, and densely packed grafts [6]. Most physicians use the term telogen effluvium; however, we believe it is more likely an anagen effluvium in response to injury.

An anagen effluvium occurs if there is sufficient injury to the rapidly dividing keratinocytes in the hair matrix. The stoppage of cell division results in thinning and weakening of the hair shaft that is susceptible to fracture with minimal trauma when it reaches the surface of the scalp. Hair breakage in an anagen effluvium occurs within days to weeks (typically 1–3 weeks) following the injury. Post-surgical effluvium is somewhat different from the classic chemotherapy- or radiation-induced anagen effluvium. In classic form, hair loss occurs from broken hair shafts rather

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than from shedding; however, in some episodes of anagen hair loss, shedding of the entire hair shaft including the root sheath occurs [7, 8]. Microscopic examination of shedding hair is required to confirm the type of hair loss.

51.2 Factors Contributing to Post-surgical Effluvium

The exact etiology of post-surgical anagen effluvium is poorly understood. A proposed theory includes direct mechanical and chemical injury that interrupts blood supply and induces an inflammatory tissue response [9]. Some hair restoration surgeons believe that the vasoconstrictor epinephrine is one of the causes of post-surgical effluvium since it induces reduced circulation [10]. To validate this concept, we performed a control study evaluating the incidence of post-surgical effluvium with and without epinephrine in the tumescent anesthesia at the recipient area.

51.3 The Pilot Study "Does Epinephrine Influence Post-surgical Effluvium?"

To test the hypothesis, eight healthy patients (6 male and 2 female; mean age 38.8; range 27–60) with the clinical diagnosis of androgenetic alopecia were recruited into the trial. Patients with a history of previous hair transplantation or any scalp surgery were excluded. Four out of eight patients were assigned to the study group, in which no epinephrine was added to the tumescent solution injected into the recipient area. Another four control patients were matched to the study cases by sex, age, Norwood classification, and overall hair characteristics. In the control group, epinephrine was added to the tumescent solution in a concentration of 1:300,000.

The ultrarefined follicular unit graft procedure was performed using open strip harvesting and trichophytic closure. At the recipient area, we used a supraorbital nerve block and ring block with 1% Xylocaine with 1:100,000 adrenaline. In the four study patients, tumescent fluid with a mixture of normal saline 50 cm^3 and kenacort (40 mg/mL) 0.5 cm^3 without epinephrine was injected biplanar into both dermis and superficial subcutaneous fat. On average 30–50 mL was injected. For the four control group patients, epinephrine was added to the tumescent solution in a concentration of 1:300,000. We used coronal slit incisions, cutting carefully to avoid damage to the existing hairs. The sites for one, two, three, and four hair grafts were made using depth-controlled handle for 21, 19, 19, and 18G needle, respectively. The density of the recipient site varied from site to site according to density of native hairs. Dense packing was performed within the nearly bald area. Photographs were taken before and 1 month after surgery. Post-surgical anagen effluvium was observed and graded using a severity score.

The effluvium severity score (ESS) was used to evaluate severity of the post-surgical shedding at recipient site by three blinded dermatologists. The assessment of ESS was documented as follows: mild (1 = 0–25%), moderate (2 = 26–50%), marked (3 = 51–75%), and severe (4 = 76–100%).

51.4 Results

The four pairs of matched case-control patients completed the study. All patients had thinning hairs at the recipient area and no one experienced rapid hair loss. Men already taking finasteride were advised to continue to do so during surgery. The clinical features and effluvium severity score (ESS) of our patients are shown in Table 51.1.

The loss of transplanted and preexisting hairs occurred in the recipient area 2–4 weeks after surgery. The donor shedding was observed in the same period. No

Table 51.1 Clinical characteristics and effluvium severity score (recipient area) of patients

ID	Epi use	Sex/age/race	NW	No of grafts/hairs	Transplanted area	ESS[a] (1–4)	Remarks
1	No	M/32/ Caucasian	IV	3140 FUG/ 6746 hairs	Thinning hairs from front to crown	2	Finasteride 1 mg 3 mos before HT
2 (#1)	Yes	M/36/ Caucasian	V	4285 FUG/ 9053 hairs	Thinning hairs from front to crown	2	Finasteride 1 mg 2 yrs. before HT
3	No	F/27/Asian	LWII	2299 FUG/ 4309 hairs	Thinning hairs at front and top	1	
4 (#3)	Yes	F/30/Asian	LWII	2052 FUG/ 4145 hairs	Thinning hairs at front and top	1	
5	No	M/34/Asian	III	3049 FUG/ 5732hairs	Frontal hairline and top	2	
6 (#5)	Yes	M/40/Asian	III	3141 FUG/ 6109hairs	Frontal hairline and top	2	
7	No	M/60/Asian	V	3242 FUG/ 6696 hairs	Thinning hairs from front to crown	3	
8 (#7)	Yes	M/60/Asian	VI	2977FUG/ 5683hairs	Thinning hairs from front to crown	3	

[a]The effluvium severity score (ESS) was documented as follows (1–4): mild (1 = 0–25%), moderate (2 = 26–50%), severe (3 = 51–75%), and very severe (4 = 76–100%)

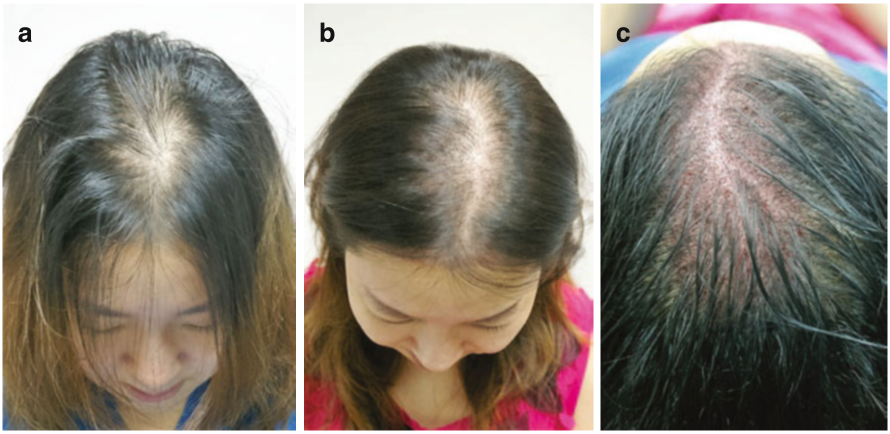

Fig. 51.1 Case 3: A 27-year-old female patient (**a**) before, (**b**) 1 month after transplantation without adrenaline in the tumescent fluid, (**c**) the area of transplant with 2299 FUG/4309 hairs

Fig. 51.2 Case 7: A 60-year-old male patient (**a**) before, (**b**) 1 month after transplantation without adrenaline in the tumescent fluid, (**c**) the area of transplant with 3242 FUG/6696 hairs

subject in either group experienced very severe or extensive loss (76–100%). In the study group one subject experienced severe loss (51–75%), two moderate (26–50%), and one mild (0–25%). There was no difference in the severity of effluvium in the two groups. Photographs of patients with post-surgical effluvium in the study group (without epinephrine) are shown in Figs. 51.1 and 51.2 and the control group (with epinephrine) are shown in Figs. 51.3 and 51.4.

We observed that shock loss or shedding in the temple area was less pronounced and most of the transplanted hairs continued to grow (as shown in Fig. 51.5).

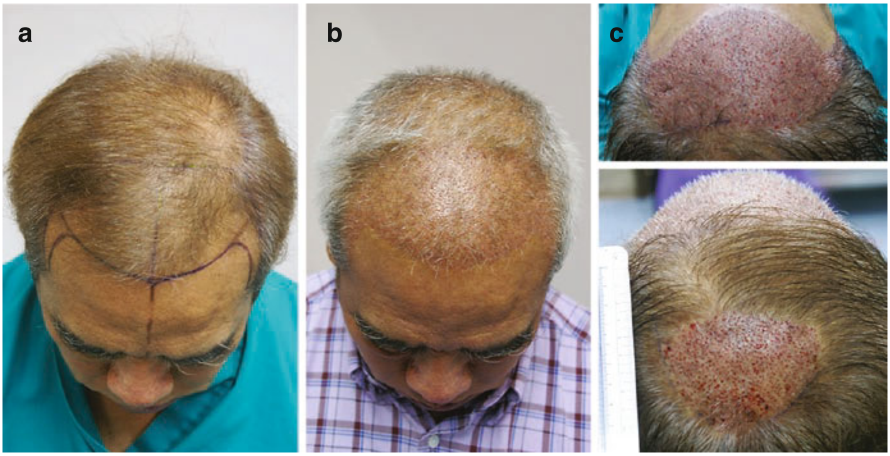

Fig. 51.3 Case 4 (matched with case 3): A 30-year-old female patient (**a**) before, (**b**) 1 month after transplantation with adrenaline in the tumescent fluid, (**c**) the area of transplant with 2052 FUG/4145 hairs

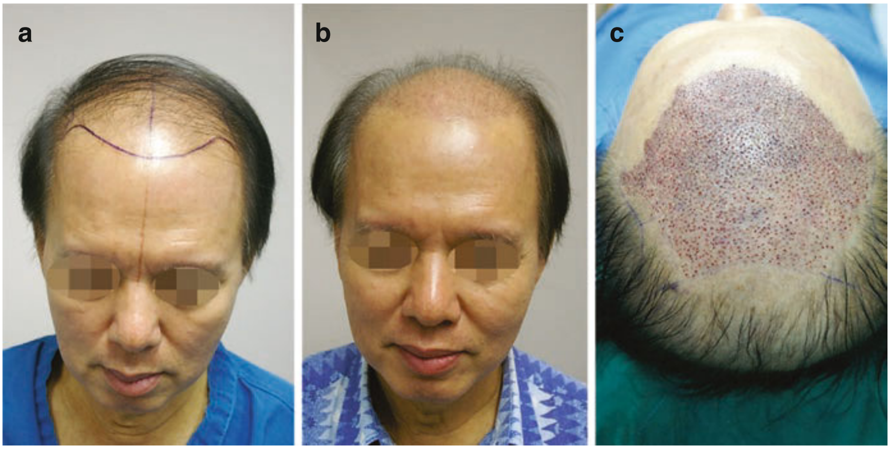

Fig. 51.4 Case 8: (matched with case 7): A 60-year-old male patient (**a**) before, (**b**) 1 month after transplantation with adrenaline in the tumescent fluid, (**c**) the area of transplant with 2977FUG/5683hairs

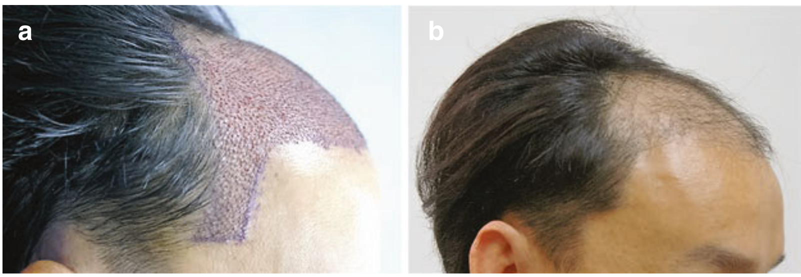

Fig. 51.5 (**a**) Before, (**b**) 1 month after, the transplanted hairs in the temple continue to grow without shedding

51.5 Discussion

Many surgeons attempt to reduce the incidence of effluvium by avoiding transection of native hairs while making incisions, using tumescence fluid, making parallel and depth-controlled incisions to avoid disruption of deep vasculature, minimizing doses of anesthetic and vasoconstrictive agents, and avoiding dense packing in areas not completely bald. Some add steroids to the tumescence fluid to decrease post-surgical edema and continue hair loss medications prior to and immediately after surgery [11].

True RH and Dorin RJ [10] established a protocol to prevent shock loss including identifying patients at high risk, lowering the risk presurgically (placing high-risk males on finasteride 6–12 months prior to surgery, continuing topical minoxidil during surgery); avoiding injection of local anesthetic or epinephrine-containing solutions into the recipient area; and creating low-impact recipient sites. In their study, 40 high-risk women were treated with this protocol and none reported extensive loss, one reported moderate shedding, and the remainder had minimal to no shedding. Jerry Cooley used de-epithelized grafts to make them shorter and inserted grafts into shallow slit incisions and reported minimal shedding [12].

Recipient site tumescence with normal saline is hypothesized to improve graft survival and prevent post-surgical effluvium by protecting deeper vessels from transection [13, 14]. The addition of corticosteroid or epinephrine to such solutions may have additional effects. Triamcinolone acetate is used to help reduce post-surgical edema and inhibit the inflammatory response from tissue injury [12]. It is speculated that this also may reduce the risk of effluvium. Epinephrine is added to local and tumescent anesthetics in order to constrict blood vessels through the activation of alpha-1 adrenergic receptors in the vascular wall. In addition to reduced intrasurgical bleeding, epinephrine also prolongs the duration of anesthesia by slowing removal of the anesthesia from the surgical field and increasing the intensity of anesthetic blockage [15].

The impact of tumescent fluids containing epinephrine on post-surgical effluvium has been debated [16]. Some hair restoration surgeons postulate that by interrupting blood circulation, epinephrine might cause ischemic injury to rapidly dividing hair follicle cells. Rassman and Bernstein [17] speculated that high epinephrine concentrations precipitate post-surgical effluvium, frontal recipient area necrosis, and poor graft growth. Beehner [13] has given anecdotal reports that post-surgical effluvium occurs with higher epinephrine concentrations. He described five cases with severe post-surgical effluvium after using 1:60,000 epinephrine tumescent solution.

In our study, we compared the severity of post-surgical effluvium in the study group where no epinephrine was added to the tumescent fluid to the matched control group in which 1:300,000 epinephrine was added. Our results showed no difference in the severity of post-surgical effluvium between the two groups. Shock loss was observed even though epinephrine was not added to the tumescent fluid. However, no subjects experienced very severe or extensive loss (76–100%). Moreover, the absence of epinephrine in tumescent fluid creates more bleeding at the time of surgery. This interferes with visibility, making it harder to place the sites precisely between the existing hairs and thus increases the duration of surgery.

Table 51.2 Protocol to prevent post-surgical effluvium [12, 18–25]

Identifying and reducing the risk presurgical
1. Thinning or miniaturizing hair at recipient area
2. Women/young man with rapid shedding
3. Cigarette smoking (stop 2 weeks before surgery)
4. Severe sunburn at recipient area
5. Scalp scarring from previous hair transplanting or scalp surgery
6. Continue using hair loss medication during surgery
Avoid intrasurgical pitfalls
1. Using tumescent fluid with low-concentration adrenaline injected biplanar
2. Adding corticosteroid to tumescent solution or prescribing oral prednisolone to reduce post-surgical edema and inflammatory response
3. Needle or blade should be sharp and matched with the graft size
4. Making depth control incision or accomplish by de-epithelization of grafts
5. Placing incisions carefully between the existing hairs
6. Prefer sagittal sites if more existing hair in the recipient area
7. Avoid dense packing into areas not completely bald
Proper post-surgical care
1. Post-surgical minoxidil may reduce incidence and hasten hair regrowth (from 6 to 1–2 months)
2. If effluvium occurs, topical camouflage can be used to conceal the thinning area (hair fibers or powder cakes with sprays)

Base on the limited number of patients in this pilot study, we believe that epinephrine is not the main factor that contributes to development of post-surgical effluvium. There are many factors involved during the pre-, intra-, and post-surgical period, and risks and recommendations are summarized in Table 51.2.

Furthermore, we observed that the shock loss was less common in the temple area and most of the transplanted hairs there continue to grow. In this area, we create recipient sites in a perpendicular fashion using the stick and place technique with one- and two-hair FUGs using 21 and 20 G needle, respectively. Typically, the grafts are inserted at a density of 25–30/cm^2 with 200–300 grafts placed per side. Possible reasons for better growth include a better blood supply due to the peripheral location, lower planted density in this area, and slits made as flat as possible following the native hair, in order to avoid injury to the underlying vessels [26]. The stick and place technique permits smaller incisions to be used, followed by immediate graft placement. This results in less vascular trauma and bleeding and may be important to minimal hair loss [27].

51.6 Conclusion

Our study suggests that epinephrine is not the main factor that influences post-surgical effluvium at the recipient area. All known risks should be carefully avoided during the pre-, intra-, and post-surgical period. This complication must be carefully discussed with the patient prior to surgery to avoid dissatisfaction. More studies are needed regarding this subject.

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Part IX
Hair Restoration of Special Consideration

Chapter 52
Hair Transplantation for Female Hairline in Asian Women

Kyle K. Seo

52.1 Introduction

The overall shape of the hairline and the proper ratio of the forehead to the entire face are important factors for defining a balanced and attractive face [1, 2]. An M-shaped hairline with a prominent frontotemporal recession is associated with a masculine facial appearance, whereas a round hairline is associated with a feminine face. Therefore, women with M-shaped hairline look more masculine. Meanwhile women with high hairlines also look more masculine and older than their years and lack facial harmony because of their unbalanced vertical facial proportions [3].

The surgical procedure initially introduced for hairline correction such as hairline lowering and correcting an M-shaped forehead was the scalp reduction surgery [2]. While allowing a high density of hairs, scalp reduction often leaves a permanent linear scar along the hairline, results in an artificial-looking straight hairline, and causes numbness in the scalp [1–3]. On the other hand, hair transplantation for female hairline correction is capable of creating a more natural-looking hairline in the absence of scars in the hairline. Accordingly, hair transplantation has become the technique currently in favor for female hairline correction. Although hair transplantation for female hairline correction is gaining more and more popularity in women, there is a general lack of detailed information describing such key aspects as natural hairline patterns in women, preoperative evaluation, and operative procedures. This chapter specifically covers such aspects, the knowledge of which is required to effectively perform hair transplantation for female hairline correction.

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52.2 Purposes of Hair Transplantation for Female Hairline Correction

Hair transplantation for female hairline correction can be classified by purpose into four types: the correction of an M-shaped hairline, hairline lowering, forehead width reduction, and sideburn augmentation. Since women with an M-shaped hairline are perceived to impart a masculine image especially in Asia, the correction of an M-shaped hairline is the most popular indication among Asian women seeking hair transplantation for hairline correction (unpublished personal data). Lowering the hairline and reducing the forehead width in order to improve the overall facial balance are the next popular indications. Creation or augmentation of sideburns is sometimes concomitantly recommended for women with congenitally narrow sideburns and a wide face, as well as for women who have undergone a previous facelift surgery during which their sideburns have receded or stretched backward. Sideburn augmentation serves to improve the facial balance from the profile view and also to camouflage the relatively wide facial width in Asians.

52.3 Characteristics of the Natural Female Hairline

Identifying the characteristics of the natural hairline pattern in women is prerequisite to establishing the guidelines for female hairline design since male hairline patterns are not applicable for achieving the appropriate "feminine" look. Moreover, although progression of baldness is an important consideration for employing receding hairline patterns in men, non-receding patterns are appropriate for the purpose of female hairline restoration.

52.3.1 Classification of Female Hairline

Broadly speaking, female hairline patterns can be classified into four different types: M shaped, rectangular, oval, and triangular (Fig. 52.1a). The M-shaped hairline represents a distinctly male hairline, with deep temporal recessions forming the shape of the letter M in the hairline, in which the apex of the temporal recession is located above the line parallel with the midfrontal point (Fig. 52.1b). The rectangular type represents a square-shaped hairline in which the frontotemporal apex resides slightly below the line parallel with the midfrontal point but above the arc formed by the oval hairline (Fig. 52.1b). The oval type represents an overall ovoid hairline without the presence of temporal recessions where the hairline resides above the straight line from the midfrontal point to the temporal point and slightly lower than the midpoint between this straight line and an imaginary 90° angle formed at the intersection of the vertical line from the temporal point and the line

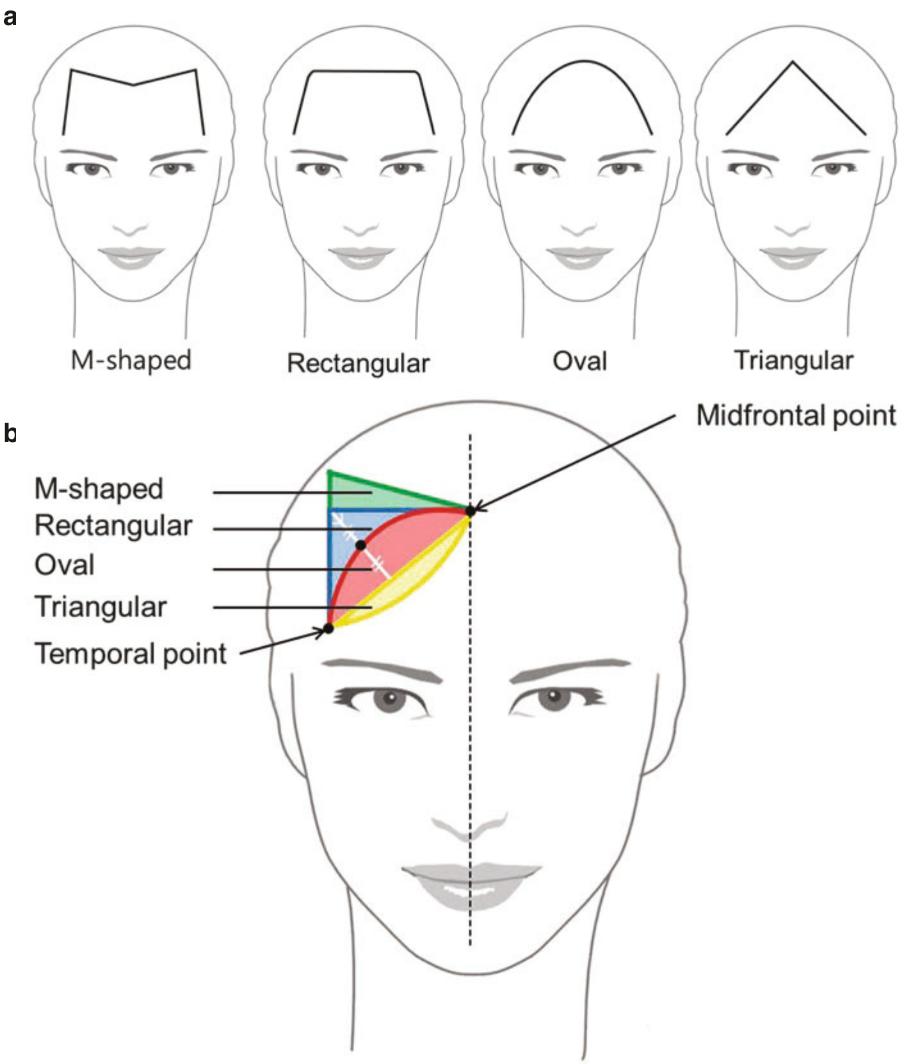

Fig. 52.1 (**a**) Classification of female hairline types: M shaped, rectangular, oval, and triangular. (**b**) Guideline for classifying female hairline types. The M-shaped hairline is one where the apex of the temporal recession is located above the line parallel with the midfrontal point, while in the rectangular type, the apex resides slightly below the said line but above the arc formed by the oval hairline. The oval hairline resides above the straight line drawn from the midfrontal point to the temporal point and slightly lower than the midpoint between the straight line and an imaginary 90° angle formed at the intersection of the vertical line from the temporal point and the line horizontal to the midfrontal point. The triangular type is defined as a hairline residing below the straight line from the midfrontal point to the temporal point

horizontal to the midfrontal point (Fig. 52.1b). The triangular type represents a triangular or convex hairline without the presence of temporal recession in which the hairline resides below the straight line from the midfrontal point to the temporal point (Fig. 52.1b).

According to Jung's paper on the classification of Korean female hairlines [4] evaluating 234 female volunteers, the incidence of the M-shaped hairline was 28.2%, oval type (round and bell type) 37.8%, rectangular type 27.4%, and triangular type 3.0%. The bell-type hairline in this paper can also be considered an oval hairline in the sense that it envisages a tall round forehead of which the height is 2 cm or higher than normal (6.38 cm).

In addition, the results from a study of 360 Caucasian female volunteers by Nusbaum showed a 61% incidence of the M-shaped hairline (concave triangular temporal recession), 26% rectangular (concave oval temporal recession), 9% triangular (convex type), and 3% oval (straight) [5]. Due to the different methods employed in classifying female hairline patterns in these two papers, a direct comparison of the results between Caucasian and Asian hairlines is hard to make. Nonetheless, one common conclusion that can be drawn from both these papers is that the M-shaped hairline is found much more commonly in Caucasians than in Asians, such that Nusbaum even defined the presence of temporal recessions as one of the key attributes of the female hairline. To be clear however, ethnic differences exist, whereby the oval hairline (without the presence of temporal recession) is much more common and generally more preferred among Asian women relative to Caucasian women.

52.3.2 Characteristics of Female Hairline

While the M-shaped hairline is characteristic of a male hairline pattern, the oval hairline is perceived as the ideal female hairline (Fig. 52.2a). This is especially the case in Asia, where the M-shaped female hairline tends to be associated with strong

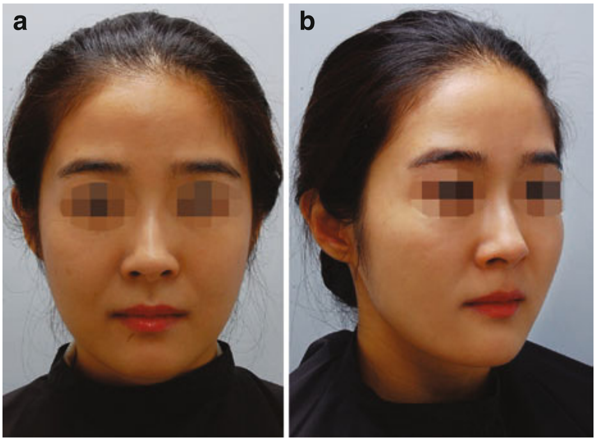

Fig. 52.2 (**a**) An aesthetically ideal female forehead features an oval hairline, balanced height and width, and the presence of fine hairs at the anterior most hairline (*frontal view*). (**b**) An aesthetically ideal female hairline should also have temporal peaks and sideburns of appropriate width (*side view*)

personality and masculinity. Also note that irregular undulation and density gradients are just as important in designing the female hairline as with the male hairline. In Caucasian women, on the other hand, the presence of lateral mounds, temporal recessions, and a widow's peak are common traits observed as frequently as 98%, 87%, and 81% cases, respectively. The prevalence is such that Nusbaum was led to conclude that these structures should be incorporated into female hairline design to give a "feminine" look to the transplanted hairline [5]. However, while such attributes can be regarded as individual factors contributing to hairline undulation, it would indeed be a generalization to assume these structures should also be present in the hairline design of Asian women. This is because these structures are neither observed as frequently in Asian women as with Caucasians (unpublished personal data) nor preferred by Asian women, particularly regarding the temporal recession [4].

Apart from the preferred shape of the hairline, the presence of fine hairs including vellus hair or miniaturized hair at the foremost area of the hairline is one of the essential factors that render the feminine look in the female hairline in relation to the male hairline (Fig. 52.2). Fine hairs were reported to be observed at the temporal recession in 87% of Caucasian women [5].

In terms of the overall facial balance, the position of the anterior hairline is an important factor in assessing vertical facial proportion. The ideal height of the forehead is considered to be one third of the vertical facial length from trichion to menton [1, 2]. The average height of the forehead from the midpoint between the eyebrows to the midfrontal point is reported to be 5.5–5.6 cm for both Caucasians and Asians regardless of ethnicity [4–6]. The appropriate forehead width also plays an important role in determining facial balance. In such context, an adequate distance between temporal peaks is one of the most crucial components of an aesthetically ideal forehead. The mean distance from the temporal point to a line projected vertically from the lateral canthus is 1 cm in Caucasian women [5]. The average width of the forehead (i.e., the distance between both temporal points) was reported to be 14.30 cm in Asian women [4]. Meanwhile, a balanced face from the profile view requires adequate sideburns of appropriate width located under the temporal peak (Fig. 52.2). Even though no report is currently available on the adequate size of sideburns in women, the average maximal depth of the infratemporal portion from the lateral canthus was reported to be 4.3 cm in Asian women [4].

52.4 Ethnic Differences Between Asians and Caucasians

Besides the dark and thick hair characteristic in Asian women, hairline patterns differ notably among different ethnic groups. As described above, the oval hairline is more common in Asians than in Caucasians, while the M-shaped hairline is found more prevalently in Caucasians than in Asians (see Sect. 52.3.1) [4, 5].

Also the concept of beauty is remarkably different between these ethnic groups. Since Asians have a wider face (brachycephalic type) compared with the narrow Caucasian face (dolichocephalic type) [7], Asian women show a keen interest in reducing their facial width, opting for procedures such as botulinum toxin injection for masseter reduction or even mandibular angle resection surgery [8]. In such context, hair transplantation for female hairline correction has also gained popularity among Asian women with a wide forehead who aspire to having a more oval and slimmer face. Meanwhile, whereas the M-shaped female hairline has negative associations in Asian countries with strong personality and masculine appearance, no such stereotypes exist in the West. As previously mentioned, such is the prevalence of temporal recessions in the Caucasian female hairline that Nusbaum was compelled to argue that it constituted the hallmark of the female hairline [5]. This illustrates why the M-shaped female hairline is the most frequent indication of hair transplantation for female hairline correction in Asian women (unpublished personal data).

52.5 Preoperative Evaluation

Preoperative consultation with the patient is a prerequisite procedure for determining the area to be transplanted. The hairline design should vary depending on the specific objective of the hair transplant, whether it is intended for camouflaging only the triangular temporal recession in an M-shaped female hairline or for lowering the hairline or reducing the forehead width. In confirming the patient's needs and desires, a helpful approach is to mark out different preliminary hairlines side by side so that the patient may visualize and identify the hairline that best meets her needs (Fig. 52.3).

The next step is to roughly calculate the size of the area that needs to be transplanted by applying Dr. Farjo's triangular concept [9] (Fig. 52.4). Assuming a transplantation in the temporal recession, Line A connecting the upper starting point of the new frontal hairline and the temporal point represents the base of triangle, while Line B perpendicularly connecting the apex of the temporal recession and Line A is the height. Accordingly, the approximate area of this triangle can be calculated as $A \times B/2\text{cm}^2$. Considering that correction is required on the temporal recession on both sides, the total area to be transplanted works out to $A \times B\text{cm}^2$. Where sideburn augmentation is concomitantly required, the rectangular area of the sideburn should be separately calculated (Fig. 52.4). Based on the area obtained in such manner, the approximate number of hairs required can be calculated.

52.6 Operative Technique

52.6.1 Hairline Design

With respect to the shape of the hairline, the oval type is preferred as the ideal female hairline especially in Asia (Fig. 52.5a). Meanwhile, the presence of irregular undulations in the hairline, including microspikes, is critically important to reconstructing a natural-looking female hairline as with hair transplantation for the male hairline (Fig. 52.5b). With respect to hairline height, the vertical one third of the face or 5.5–6 cm from the

Fig. 52.3 Different preliminary hairlines marked side by side. The preliminary hairline suggested on the right side of the patient is designed only to camouflage the triangular temporal recession in an M-shaped female hairline, while the marking on the left is for lowering the hairline and reducing the forehead width in addition to concealing the triangular temporal recession

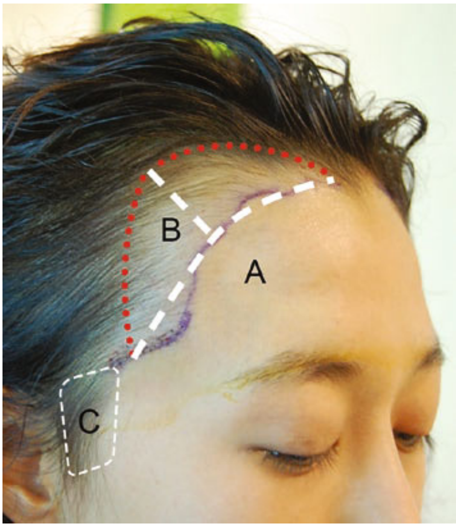

Fig. 52.4 Calculating the recipient area in transplanting the temporal recession/sideburn. Regarding the Line A connecting the upper starting point of the new frontal hairline and the temporal point as the base of triangle and the Line B perpendicularly connecting the apex of the temporal recession and Line A as the height, the area of this triangle is calculated as A × B/2cm^2. The area (C) of the sideburn represented as a rectangle is separately calculated

midpoint between the eyebrows is generally considered as the appropriate height for the new frontal hairline [2] (Fig. 52.3). However, the overall facial balance and the intersection between the vertical forehead and horizontal scalp plane must also be considered in determining the hairline height suitable for each individual. For example, in the case of a female patient with a long face, the frontal hairline would be better set slightly lower than the vertical one third of the face. It also bears noting the limitations in lowering the hairline through hair transplantation due to hair density issues. The maximum amount of hairline advancement that can be achieved in one session is approximately 2 cm. Patients who express their wish to lower their hairline by more than 2 cm should be informed in advance of the need for two sessions at an interval of at least 6 months.

The appropriate width of the forehead also plays an important role in determining the facial balance. In particular, Asian women with wide or round face generally aspire to having a more oval and slimmer face. In this regard, temporal peak restoration with hair transplantation can be beneficial to women with a wide forehead (Fig. 52.6). While the mean distance from the temporal point to a line projected vertically from the lateral canthus is reported to be 1 cm in Caucasian women, the relevant temporal point in Asian women should preferably be positioned farther than 1 cm from the lateral canthal line. Likewise, reconstruction of sideburns of appropriate width may also be considered if required (Fig. 52.6).

52.6.2 Single-Hair Graft Zone

The single-hair graft zone consisting of only 1-hair follicular units (FUs) comprises the first 0.5–1 cm of the female hairline, which is comparable to the transition zone in the male pattern hairline (Fig. 52.5). It should initially appear irregular and ill-defined but should gradually take on more definition and substance as it reaches the

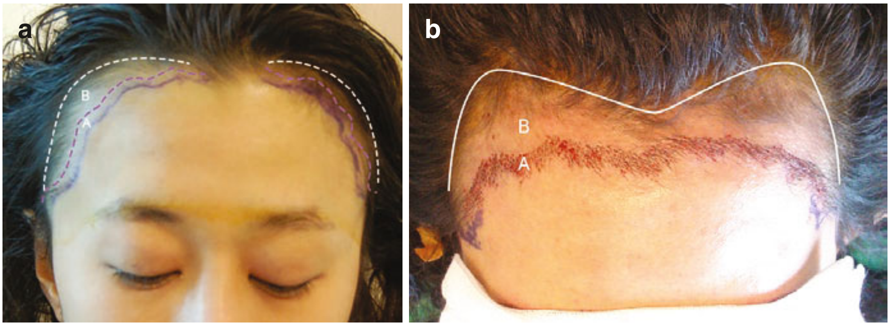

Fig. 52.5 Hairline design: single-hair graft zone (*A*) and multihair graft zone (*B*). (**a**) Hairline design. The oval type is preferred as the ideal female hairline, with the presence of irregular undulation. (**b**) Irregular undulation of the hairline with macroirregularity and microirregularity works together in the single-hair zone (*A*) to create a natural-looking hairline. Irregular undulation of hairline with macroirregularity and microirregularity works together in single-hair zone to create a natural-looking hairline. Multihair graft zone (*B*) composed of 1-, 2-, and 3-hair FUs sits directly posterior to the single-hair graft zone

Fig. 52.6 Restoring the temporal peak has resulted in an enhanced facial balance upon profile view. (**a**) A 27-year-old female before (*left*) and 12 months after (*right*) hair transplantation of 1987 hairs at temporal recession and temporal peak. (**b**) A 32-year-old female before (*left*) and 10 months after (*right*) hair transplantation of 2219 hairs at temporal recession and temporal peak

multihair graft zone. As is the case with the male pattern hairline, the combination of macroirregularity (mounds or recessions or snail-tracking appearance) and microirregularity (microspikes or intermittent areas of increased density) works together in the single-hair zone to create a natural-looking hairline (Fig. 52.5b).

Since Asians have thick black hair with an average diameter of 100 μm, which is substantially larger than the 70 μm usually found in Caucasian hair, placing multihair FUs and even thick single hairs at the leading edge of the hairline will result in an unnatural appearance [7]. Therefore, only thin single-hair FUs less than 70–80 μm in diameter should be placed in the first two to three rows of the single-hair graft zone, with a transition to thick 1-hair FUs toward the posterior portion of the single-hair graft zone. Occasionally, very fine single hairs can be transplanted to replicate the so-called “sentinel” hairs in the in front of the single-hair graft zone. While the recommended density of the single-hair zone is reported to be 36–49 FU/cm^2 by Jung, my recommendation is for 50 single-hair FUs/cm^2. Depending on the length of the new hairline, a total of 400–1000 single-hair FUs are required for transplanting the single-hair graft zone.

52.6.3 Multihair Graft Zone

The multihair graft zone consisting of 1-, 2-, and 3-hair FUs sits directly posterior to the single-hair graft zone, which is comparable to the defined zone in the male pattern hairline (Fig. 52.5b). In this zone, the hairline should develop a higher degree of definition and density. Concentrating 2- and 3-hair FUs in this area nicely accomplishes the fuller-looking hairline. Single-hair FUs can also be transplanted among the multihair FUs in this zone, particularly with Asian patients, considering that single-hair FUs are more abundant in Asians than in Caucasians [10]. The recommended density of the multihair graft zone is also 50–60 hairs or 15–30 FU/cm^2 with 2- and 3-hair FUs [4]. Depending on the area of the patient’s temporal recession, a total of 600–2000 hairs are required for the multihair graft zone.

52.6.4 Proper Direction and Angle

Hair direction changes along the hairline, with the change of direction varying for each individual. The hair along the frontal hairline is usually directed anteriorly, while the hair at the temporal hairline is pointed inferiorly and posteriorly [11]. In particular, hairs at the temporal peak are pointed posteriorly toward the ear (Fig. 52.7a).

There is a transition zone where hairs change direction near the frontotemporal recession (Fig. 52.7b). Here, the direction of existing hairs in the hairline can be used as a guide to identifying the direction of the transition. This is especially relevant for hairs diverging in the part line (Fig. 52.7b). However, for hairs on the side of the head opposite to the part line, the individual direction of existing hairs can largely be ignored, and instead hairs can be transplanted following the same general inferior and posterior direction for simplicity sake (Fig. 52.7a).

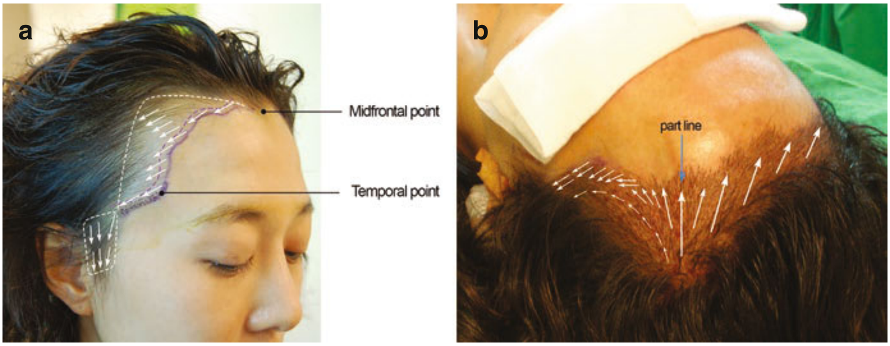

Fig. 52.7 Direction of implanted hairs. (**a**) The direction of hairs implanted on the side of the head opposite to the part line should consistently point inferiorly and/or posteriorly toward the ear. (**b**) The direction of hairs implanted on the side of the head where the part line is located should change near the frontotemporal recession, following the direction of existing hairs

With respect to angle, hairs at the temporal hairline are reported to form a more acute angle with the scalp (almost lying flat) than hairs at the frontal hairline (10°–15°) [11]. That notwithstanding, the angle of the implanter should preferably be inclined as acutely as possible toward the scalp along the entire hairline. This is because thick hairs particularly common in Asians have a natural tendency to stick upward and therefore may look unnatural unless they are angled acutely. It is precisely for this reason that reproducing a cowlick is unnecessary in an Asian women.

52.6.5 Tips for Density Issues

Hair transplantation for female hairline correction also has its drawbacks including sparse hair density. According to a study reported by Bernstein and colleagues, the aesthetic goal could be sufficiently achieved with half of the normal hair follicle density [12]. Logically therefore, an average of 50 hairs/cm^2 is sufficient for correcting the hairline of an Asian female patient since the density of Korean men is 100 hairs/cm^2 in the temple area [10].

In order to maximize the cosmetic density based on a limited number of grafts, the "selection and concentration" strategy should be deployed, whereby a greater portion of grafts are to be transplanted toward the hairline and the part-line areas. Fewer grafts are required for the opposite side due to the "shingling effect" [7]. Sometimes a well-constructed "widow's peak" can be used to create the illusion of a slightly lower hairline without using up too many grafts.

Where sideburn augmentation is concomitantly required with hairline reconstruction, 200–300 single-hair FUs should be transplanted into a sideburn that is 1.5 cm in width per side. Only thin single-hair FUs with less than 70 μm in diameter should be used in the first two to three rows of the sideburn with a shift toward thick single-hair FUs in subsequent rows the inner section of the sideburn.

52.7 Hair Removal Laser for Creating Fine Hairs at Hairline

Fine hairs are most prominent in younger patients, along temporal hairlines, and in female patients [5]. Therefore, the presence of fine single hairs at the foremost zone of the hairline is critical for designing a natural female hairline. However, the conventional technique currently is to use hairs harvested from the occipital scalp, where hair diameter is the thickest [13]. Moreover, most Asian patients have thicker hair compared to Caucasians [7]. Therefore, special care must be taken when correcting an Asian female hairline to reserve the use of the finest hairs for the most anterior rows of the hairline. A number of methods have been suggested to overcome this challenge, including the sorting of single-hair follicular units with small diameter (60–70 μm thick) [4], the grafting of bisected hair follicles [14, 15], and the follicular unit transplantation of body hair [16] or leg hairs [17]. Naturally thinner hairs from the postauricular zone or the nape of the neck can also be harvested and transplanted in the anterior hairline. However, it is true that their use is often limited due to numerous practical problems such as the limited abundance of fine hairs in Asians, poor yield of damaged hair follicles, longer operation time, the need for a highly skilled specialist, variations in hair angulation or quality, and insufficiency of body hair.

Meanwhile, on the basis of the finding that hairs surviving a hair removal laser (HRL) procedure become thinner, the author has investigated the efficacy and safety of applying the HRL to create fine hairs in Asian women with thick donor hairs [18] (Fig. 52.8). The principle underpinning this novel theory is that the HRL delivers partial damage to the follicular epithelium, which results in the regrowth of thinner hairs 2–3 months later. The HRL which the author used for this novel technique is the long-pulse neodymium-doped:yttrium aluminum garnet (Nd:YAG) laser (CoolGlide; Cutera, San Francisco, CA, USA). The relevant parameters are as follows: energy 35–36 J/cm^2, pulse duration 6 ms, and spot size 10 mm. The author's data shows a significant decrease in the mean hair diameter from 80.0 ± 11.5 μm to 58.4 ± 13.2 μm after a mean of 2.6 sessions (range, 1–5) undertaken at intervals of at least 3 months [18] (Fig. 52.8). This represents an average reduction in hair diameter of 25.7% and an average reduction in hair volume of 46.7% [18].

Since it is possible to cause partial damage to the follicular epithelium of thick hairs by delivering HRL with parameters appropriate for complete removal of thin

Fig. 52.8 The novel technique using hair removal laser is a simple yet an effective way to create fine hairs at the hairline subsequent to the hair transplantation for female hairline correction in Asians. (**a**) A 29-year-old female before (*left*) and after (*right*) three sessions of hair removal laser (Nd:YAG). Hairline from a previous hair transplantation which looked artificial and unnatural due to the presence of thick hairs and a straight linear hairline became much more natural and softer following the hair removal laser. (**b**) A 32-year-old female before (*left*) and 10 months after (*middle*) hair transplantation of 2429 hairs at the temporal recession and 8 months after (*right*) two sessions of hair removal laser (Nd:YAG). (**c**) A 31-year-old female before (*left*) and 10 months after (*middle*) hair transplantation of 3477 hairs at the temporal recession, temporal peak, and sideburn and 10 months after (*right*) two sessions of hair removal laser (Nd:YAG)


a
b
c

hairs, any HRL can be used for creating fine hairs leveraging this principle. This novel technique using HRL is a simple yet effective way to create fine hairs at the hairline subsequent to hair transplantation for female hairline correction in Asians.

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Chapter 53
Hair Transplantation in Transsexual Patients

Bessam K. Farjo

53.1 Introduction

When we talk about the identity of one's gender, we are referring whether an individual identifies themselves as male or female regardless of their actual biological sex as demonstrated by their genotype or phenotype. One can have the physical attributes of male or female but have the behavioural character and certainly see themselves as the opposite.

A diagnosis of gender identity disorder (GID) is usually made when this uncertainty of how you see yourself causes dysphoria and lifestyle dysfunction [1, 2]. The individual can be referred to as transgender or transsexual. A transgender person wishing to take positive action for change will in the first instance take on the physical appearance and behavioural characteristic of the sex they wish to change to in their society. The next step is to undergo hormone therapy and ultimately surgical treatment both genital and general cosmetic including hair restoration surgery [3]. It may be straightforward creating a natural hairline from a male perspective, but there are clear differences when it comes to creating a female hairline in a previously bald male. Acquiring a woman's hair is a huge issue from both a physical and psychological point of view.

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53.2 Incidence

The available statistics on the incidence of transgender individuals show that they are relatively uncommon in the general population. In most Western European countries, the incidence of male-to-female transgender people is about 1:12,000, whilst female-to-male transgender is close to 1:30,000 with both figures reported to be significantly rising over the last 15 years [4–7]. There is a lack of corresponding figures representing Asia and the Middle East due to cultural and legal issues in many such countries. However, Iran as of 2008 was reported to have been performing the largest number of transgender surgeries in the world outside Thailand.

53.3 Criteria for Hair Transplant Surgery

My criteria when it comes to accepting a transgender patient for hair transplantation are as follows:

1. They have completed a thorough psychological assessment with regard to their suitability for such a change.
2. They are receiving ongoing transgender hormone therapy as well as hair loss-controlling medications or have undergone gender reassignment surgery.
3. They have been living as the opposite gender for the last 1–2 years (Table 53.1).

These are based on Standard of Care guidelines developed by the World Professional Association for Transgender Health (WPATH) as a result of the increasing incidence and demand for treatments that have definitive and lifelong lasting effects.

53.4 Male-to-Female (MTF) Hair Transplant Surgery

The technique in this category will be almost identical to that of restoring a natural-looking female hairline in women. This approach is described elsewhere in this book, with the major difference in MTF patients being the degree of male pattern baldness already reached and whether the available donor hair is sufficient to create the lower and rounded hairline associated with women. In this instance it may be necessary to settle for a more conservative and higher hairline in order to achieve a more balanced coverage throughout a larger area. The majority of MTF patients though will not be willing to settle for a thinner look in exchange for coverage of a larger area as this is not a desirable look for females. In addition to the

Table 53.1 Common criteria for hair transplant surgery in transsexual patients

• Living as opposite gender for at least 1–2 years
• Surgical or chemical castration
• Thorough psychological assessment

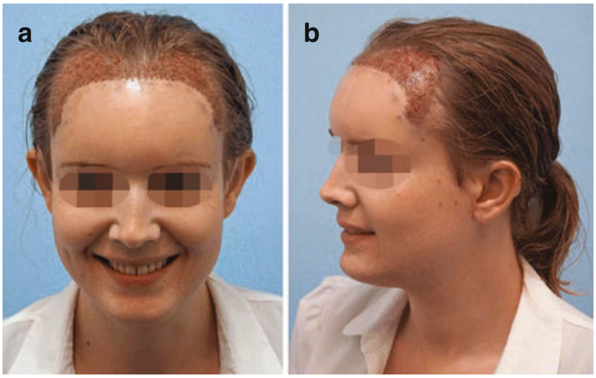

Fig. 53.1 (**a**) Frontal female hairline immediate post-op view. (**b**) Profile female hairline immediate post-op view

donor-to-recipient ratio mentioned here, you would also need to assess the stability of hair loss with regard to the future when it comes to determining the design and achievable density. The earlier the MTF patient has surgical or at least chemical castration in their hair loss phase, the more likely hair stability can contribute towards a cosmetically acceptable female look.

In our practice in the UK, the mean age at the time of gender reassignment is 34.4 years, and the majority of MTF patients have Norwood stage II–IV MPB. Therefore, 2000+ follicular unit grafts are usually available to harvest in one procedure to bring down the hairline and close the frontotemporal recessions (Figs. 53.1a–c and 53.2a–c).

An alternative but nowhere near as popular approach by surgeons is hairline advancement surgery. This involves making an incision on the hairline, mobilising hair-bearing tissue posteriorly perhaps as far back as the nuchal ridge and advancing the scalp forwards after excising bald tissue on the top of the forehead. This assumes that the hairline is the only concern, the hair loss is stable and the scalp is reasonably loose.

Fortunately, it appears that only a minority of MTF patients present with advanced male pattern baldness in the hair transplant practice. In these instances, I tend to draw a higher hairline. If a much lower hairline is strongly desired, the patient could wear a hair system or wig posterior to a densely transplanted hairline to benefit from the natural look yet achieve desired female density elsewhere.

MTF patients will desire the same hairstyles and options as most biological females. One common such hairstyle is the hair up in a bun where the hair is lifted from the neck up. For this purpose, and just like other women, if the hair transplant performed is the strip FUT type, then it is important to harvest and place the donor scar at a higher level than you would in males. Another issue is that these patients are likely to undergo other cosmetic surgery such as face and brow lifts. These procedures can potentially alter the position or even damage hairlines and, hence, should preferably be done prior to hair transplantation.

It has already been mentioned that being on medical therapy is one of the criteria for MTF patients to be suitable for hair transplant surgery. It is important to remember that unlike biological premenopausal women, such treatments can and usually do include finasteride or dutasteride even in surgically castrated patients.

Fig. 53.2 (**a**) Front 1-year result female hair transplant in transgender patient. (**b**) Profile 1-year result female hair transplant in transgender patient

53.5 Female-to-Male (FTM) Hair Transplant Surgery

It is far less common to see a FTM patient seeking hair transplant surgery. This is maybe due to the patient starting off with good hair as a female but also probably that hair loss is a feature that characterises males. I can only recall operating on one FTM patient, and if he had not disclosed the fact to me or his testosterone therapy, I would never have known. The hair transplant approach as well as donor and future considerations for FTM patients should be the same as for biological males (Fig. 53.3).

Fig. 53.3 Hairline advancement procedure 3-month result

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Chapter 54
When to Consider Scalp Advancement

Sheldon Kabaker, Mario Marzola, Sahar Nadimi, and Damkerng Pathomvanich

54.1 Background

The high hairline is more prevalent in certain ethnic and racial groups and may be a significant source of self-consciousness that cannot be overcome with camouflaging hairstyles. Patients perceive the problem as either a high hairline or a large forehead. Traditionally, the high hairline has been addressed by hair transplantation. Follicular unit grafts can look natural here but may require a number of procedures, depending on the density and the amount of lowering required. Perhaps 2 years would need to pass before the process is completed. Hairline lowering or advancement (also known as forehead reduction) is an efficient and effective method of reducing the forehead with immediately noticeable results. This surgery has its origins in maneuvers used for scalp reductions and flaps [1–5].

The ideal patient for the hairline advancement procedure is typically female with a congenitally high hairline and no personal or familial history of progressive hair loss. A congenitally high hairline causes the upper third of the face to be disproportionately greater than that of the middle and lower thirds. To achieve optimal results with a single procedure, potential candidates must meet specific preoperative criteria. Otherwise, a two-stage procedure is required with scalp expansion before hairline advancement in those with very high hairlines or minimal scalp laxity.

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Alternatively a second hairline advancement procedure can be done after 2–3 months when the scalp mobility has returned.

54.2 Preoperative Assessment and Planning

To select appropriate candidates for this procedure, the preoperative assessment should include a thorough examination of the scalp with a focus on scalp laxity, direction of hair exit, and frontotemporal points and recessions. Forward-growing hairs at the hairline allow for hair growth through the scar and the highest probability of scar camouflage. Patients with posteriorly exiting hairs at any point along the hairline, as seen in those with cowlicks, are informed that they might require future follicular unit transplantation to disguise the scar and achieve optimal results. Hair grafting is also preferred for individuals who desire coverage of deep temporal recessions or advancement of acutely, downward-facing temporal hairs.

During preoperative consultation, a measurement of the height of the hairline should be taken. A point should be chosen at the glabella at the level of the interbrow region. From this point, the average female hairline should measure approximately 5–6 cm, and hairlines greater than this are generally considered too high, especially if they cause imbalance with the lower two thirds of the face. Adequate scalp laxity can be determined by the relative ease of moving the hair-bearing scalp forward and backward and the pinching of the forehead skin. For patients with relatively tight scalps, massaging the scalp in a backward-forward movement for a month before the surgery can improve the forward advancement achieved.

Risks of the procedure as well as potential complications include bleeding, infection, telogen effluvium (“shock loss”), and scalp necrosis. In addition, specific problems relating to the postoperative scar include stretchback, widening, visibility with future hair loss, hypopigmentation or hyperpigmentation, and the possibility of needing a hair grafting session or scar revision to help camouflage the incision site. These scar problems rarely arise in the authors’ experience. All patients are also informed that diminished sensation over the frontal scalp should be anticipated for 6–12 months in the postoperative period.

54.3 Hairline Marking

Preoperatively, the existing hairline is marked in an irregular, undulating pattern just posterior to the fine vellus frontal hairs. As the markings approach laterally to the downward-directed hairs of the temporal tufts, they should be curved posteriorly into the temporoparietal hair for approximately 2–5 cm. It is preferable to create this marking in such a way as to avoid division of the posterior branch of the superficial temporal artery when performing the incision. Of note, women who have undergone prior scalp surgery (such as brow lifts, face lifts, and follicular unit transplantation) can undergo surgical hairline lowering if their key arteries can be identified by Doppler exam. The desired neo-hairline height is then chosen at a point over the forehead, and a marking is made replicating the natural hairline above.

54.4 Surgical Technique

After hairline marking, the patient is brought into the operating suite and placed in the supine position with the head slightly elevated. In the authors' experience, the procedure is well-tolerated with a combination of local anesthesia and intravenous sedation. The scalp and forehead are anesthetized in a ring block fashion along with 200 cc of tumescent solution. Once the scalp is well anesthetized, the incision is made at the hairline with a trichophytic approach, beveling forward at an angle that is approximately 60 degrees to the natural exit of surrounding hairs [6–9]. This incision should include only the first 2–3 hairs behind the point where fine hairs of the anterior hairline transition into more coarse and dense follicular units.

The incision is carried to the subgaleal plane and transitions at the temporal hairline to parallel the exiting hairs as it is extended into the posttemporal hair. Bleeding is minimal due to tumescence, especially if care is taken to avoid the posterior branch of the superficial temporal arteries. Dissection can then be performed rapidly in the subgaleal, bloodless plane taking care to avoid injury to the occipital arteries posteriorly. Undermining should go no further than the nuchal ridge and laterally to the limits of the galea. The operation is often done without the need to undermine anteriorly into the forehead. The non-undermined forehead scalp will help to secure the desired forward movement and avoid the need for Endotines mentioned later. If the patient desires a brow lift, however, dissection can be easily carried inferiorly to release the brows, and superior advancement of the forehead flap is performed in the usual manner described for brow elevation.

Once fully elevated, the scalp is advanced, and the use of a flap-marking device helps determine the amount of forehead overlap. If the planned hairline height is not reached, galeotomies can be performed to allow for additional advancement. These galeotomies are made with the use of a slightly bent, depth-controlled no. 15 blade to reach the more superficial subcutaneous plane while avoiding compromise to the blood supply of the flap. Each galeotomy provides a gain of up to 2 mm, and therefore, several parallel galeotomies may be required to achieve the desired hairline. A five-prong retractor is then used to stretch the scalp in the direction of advancement after the galeotomies have been performed. Firm pull over the course of 1–2 min to allow for tissue creep can add half a cm or more to the advancement.

After determining the level to which the scalp can be advanced, an incision is made in the forehead with the same beveled angle as that at the hairline while replicating the undulating pattern. Non-hair-bearing forehead tissue, including the skin, frontalis muscle, and galea, is then fully excised. One or two paramedian Endotines are then placed in the calvarium in a reverse direction to the usual placement during a brow lift at a 3–4 cm distance posterior to the neo-hairline. The scalp is then advanced with the use of a five-prong retractor securing the galea to the Endotines. The Endotines, in theory, help to relieve tension at the neo-hairline and work to allow the anterior 3–4 cm of scalp to be relatively compressed, thus distributing the subtle stretch of the scalp disproportionately and reducing the possibility of postoperative stretchback. The anterior compression is thought to minimize splaying of follicular units and help maintain, *and possibly increase*, the preoperative density at the hairline. The operation is often done without any scalp-anchoring device as previously mentioned.

The galea is reapproximated using 3–0 interrupted polydioxanone sutures, often with moderate tension, allowing for a tension-free closure at the skin edge. The skin is then closed with both interrupted 4-0 polypropylene sutures interspersed with surgical clips within the temporal scalp and 5-0 polypropylene sutures over the anterior hairline. Meticulous attention is given to the beveled skin closure at the hairline using loupe magnification to ensure appropriate overlap of the de-epithelialized hair follicles.

Occasionally, follicular unit grafts can be performed in the same sitting with donor material harvested adjacent to the intratemporal closure line. These grafts are only used in front of the temple hairs to narrow a wide forehead.

An evacuation drain has not been found to be necessary due to the amount of tension on the scalp and the resultant lack of subgaleal dead space (Figs. 54.1, 54.2, 54.3, 54.4, 54.5, 54.6, 54.7, 54.8, 54.9, and 54.10).

Fig. 54.1 Patient 1—Front view

Fig. 54.2 Patient 1—Left view

Fig. 54.3 Patient 1—Right view

Fig. 54.4 Patient 1—Close-up of scar

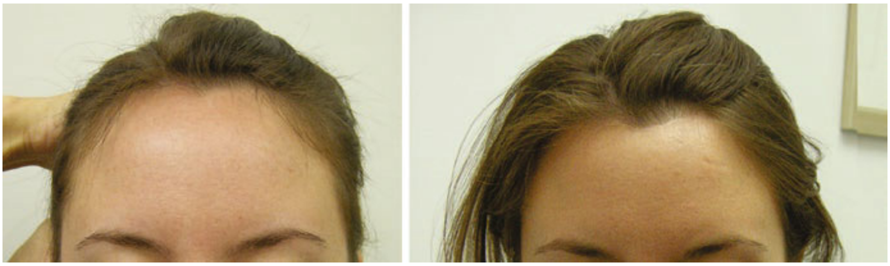

Fig. 54.5 Patient 2—Front view

Fig. 54.6 Patient 2—Left view

Fig. 54.7 Patient 2—Right view

Fig. 54.8 Patient 3—3–4 cm advancement in one procedure

Fig. 54.9 Patient 4—Close-up of scar left side

Fig. 54.10 Patient 4—Close-up of scar right side

54.5 Postoperative Care

Immediately postoperatively, a pressure dressing is applied. On the following day, the dressing is removed and patients can resume most non-strenuous activities within the first 24–72 h. Patients may shower after 48 h. Edema is minimal, and periocular and forehead ecchymosis is rare, which is attributed to the strong, layered closure. A concurrent brow lift, however, does increase the likelihood of periocular edema and bruising. Because tension is borne by the deep galeal closure, removal of skin sutures and clips is permitted within 7 days.

Due to the initial incision, there is minimal prolonged discomfort from the operation as the scalp is insensate for 6–9 months postoperatively, also allowing the Endotines to be very tolerable. They should be long dissolved by the time sensation returns; hypoesthesia has resolved in all cases to date.

54.6 Tissue Expansion

Preoperatively, if the scalp is noted to have minimal scalp laxity or the amount of advancement required to achieve a desirable hairline height is beyond the average 2.5 cm, a two-stage procedure is recommended. The two-stage procedure involves the initial insertion of a tissue expander with expansion of the scalp performed gradually over the following few weeks using similar methods as those described in the literature [10]. A second procedure, which, with the exception of removal of the expander, is exactly as that described earlier, takes place when the desired expansion is achieved. In the senior author's experience, this method has allowed for up to 10 cm of hairline advancement.

54.7 Case Study 1

A 25-year-old female with congenitally high hairline. Hairline measured 8 cm from the glabella. Patient underwent a single-stage hairline lowering surgery. Figure 54.11 shows preoperative markings (left) and immediate postoperative results following 2.5 cm of hairline lowering (right). Preoperative and postoperative day 1 views (Figs. 54.12, 54.13, 54.14, and 54.15).

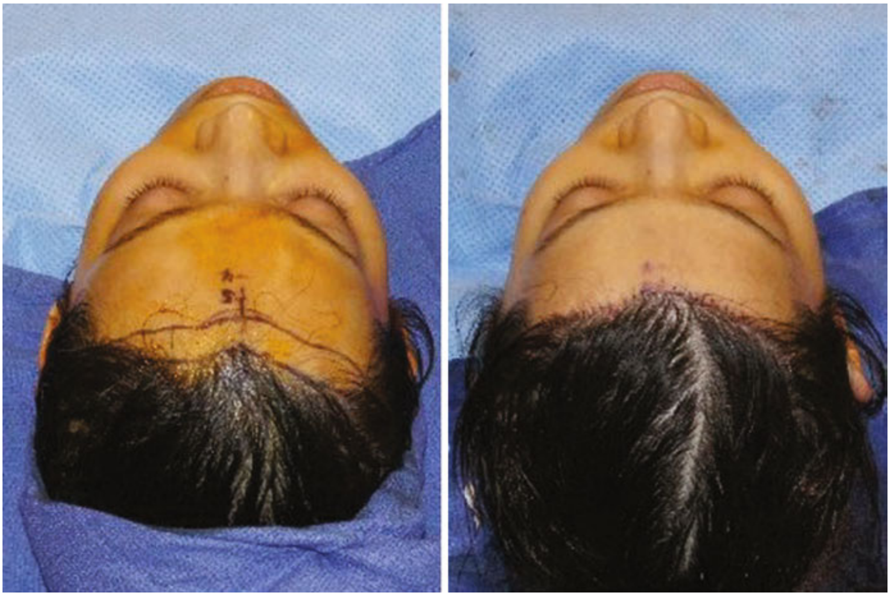

Fig. 54.11 Patient 5—Preoperative markings (*left*) and immediate postoperative results following 2.5 cm of hairline lowering (*right*)

Fig. 54.12 Patient 5—Left view

Fig. 54.13 Patient 5—Right view

Fig. 54.14 Patient 5—Right view

Fig. 54.15 Patient 5—Front view

54.8 Case Study 2

A 24-year-old female with congenitally high hairline. Hairline measured 8.5 cm from the glabella. Patient underwent a single-stage hairline lowering surgery. Figure 54.16 shows preoperative markings (left) and immediate postoperative results following 3 cm of hairline lowering (right). Preoperative and postoperative day 1 views (Figs. 54.17, 54.18, and 54.19).

Fig. 54.16 Patient 6—Preoperative markings (*left*) and immediate postoperative results following 3 cm of hairline lowering (*right*)

Fig. 54.17 Patient 6—Right view

Fig. 54.18 Patient 6—Front view

Fig. 54.19 Patient 6—Looking down view

54.9 Conclusion

The single-stage hairline lowering procedure performed on a scalp with average laxity will allow for up to 2.5 cm of advancement with excellent long-term results. Very lax scalps may allow for up to 3.5 cm advancement with this one-stage approach. This brief (1.5 h) operation moves an average of 3000 follicular units at one time. In those with very high hairlines or minimal scalp laxity, another advancement procedure can be performed after 2–3 months when the initial laxity has returned, or a two-stage procedure with scalp expansion before the hairline advancement can be done. This situation occurs in less than 10% of patients.

Surgical hairline lowering is generally well tolerated with minimal morbidity, and the end result, whether achieved through a one-staged or two-staged approach, has been met with excellent overall patient satisfaction (Figs. 54.20, 54.21, 54.22, 54.23, 54.24, and 54.25).

Fig. 54.20 Patient 7—Front view before and immediate after surgery

Fig. 54.21 Patient 7—Left oblique view before and immediate after surgery

Before 1 day Post-op

Fig. 54.22 Patient 7—Right oblique view before and immediate after surgery

Before 1 Year 5 Months post-op

Fig. 54.23 Patient 7—Front view before and 1 year and 5 months after surgery

Before 1 Year 5 Months post-op

Fig. 54.24 Patient 7—Left oblique view before and 1 year and 5 months after surgery

Before

1 Year 5 Months post-op

Fig. 54.25 Patient 7—Right oblique view before and 1 year and 5 months after surgery

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Chapter 55
When and How to Restore Temporal Point Recession

Mohammad Humayun Mohmand, Muhammad Ahmad, and Shahid Jamil

55.1 Introduction

Throughout history mankind has tried to define beauty. As surgeons, we are required to have the scientific approach to formulate operative plans with successful surgical outcomes [1]. The ancient Egyptians are thought to be the first to divide the human body into equal parts [2]. Later the Renaissance artists especially Leonardo de Vinci divided the face into symmetric ideal proportions and divided the profile into equal thirds (Fig. 55.1). The neoclassical canon of facial proportions divides the face vertically into fifths (Fig. 55.2), with the width of each eye, the intercanthal distance, and the nasal width all measuring one-fifth [3]. However direct anthropometry and photogrammetric analyses in Caucasian and Asian subjects demonstrate variations in these proportions, with the width of the eyes and nasal widths often being either less than or greater than the intercanthal distance [3–5]. Another Renaissance artist, Albrecht Durer, used his own finger as a unit of measurement and divided facial profile into four equal parts [2]. The golden ratio, denoted by the symbol (phi), is an irrational number of the order of 1.618033988, and though studied by Indian mathematicians over 2000 years ago, it first appeared in written documentation in Euclid's elements about 300 BC [6]. Ricketts showed that the proportions in a face generally perceived as being beautiful are intimately related to the golden ratio [7–9].

The true objective of hair restoration is more than just making a patient who has had hair restoration not look like he has had any procedure done at all [2]. Successful hair restoration requires a sense of aesthetics. Whichever frontal hair line pattern (triangular, oval, flat, or crescent) is selected according to the shape of the face, almost 2/3 of men and 1/3 of women will require special attention to the temporal

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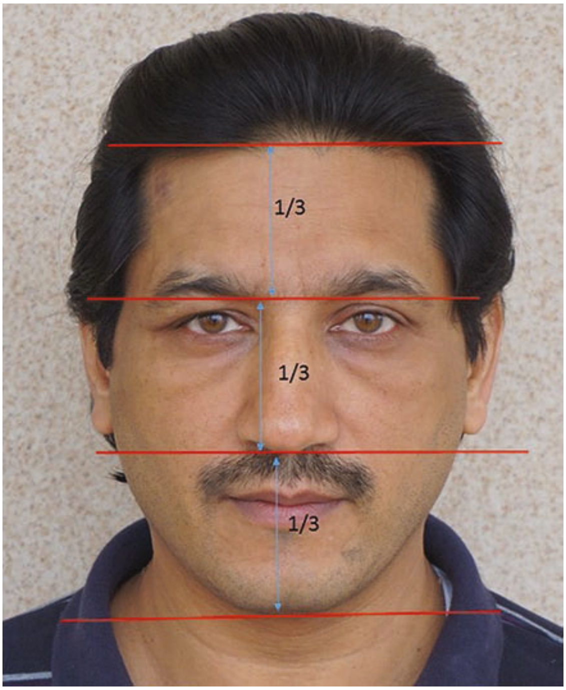

Fig. 55.1 Rule of thirds

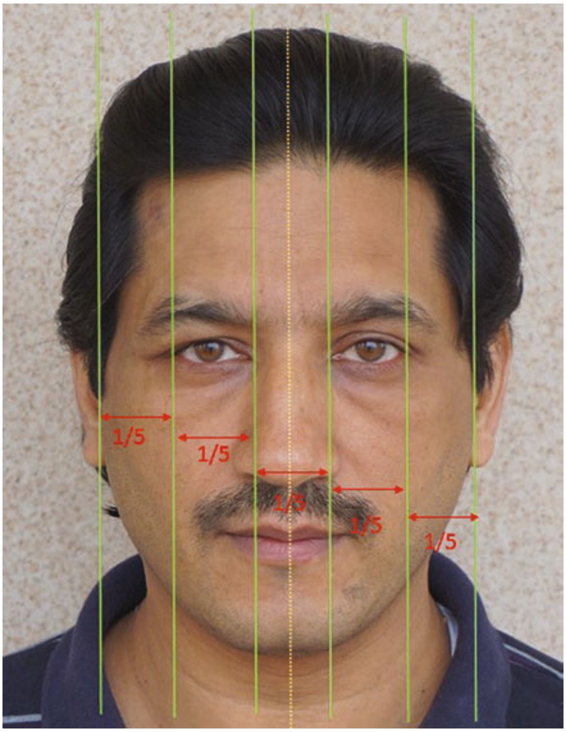

Fig. 55.2 Rule of fifths

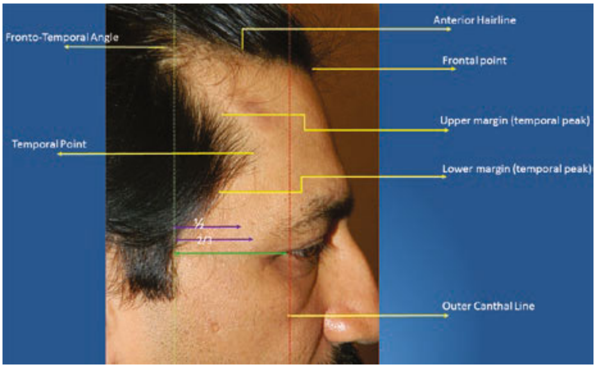

Fig. 55.3 Normal anatomy of temples

regions. An aesthetically designed hairline and balanced temporal points with special attention to frontotemporal angle address the physical as well as psychological needs of the patient.

The temple normally consists of upper and lower borders. The area where these two join each other is the temporal point (Fig. 55.3). The upper border is connected to the anterior hairline and forms the "frontotemporal angle." The temporal point is normally between 1/2 and 2/3 of the distance between outer canthal margin and pretragal vertical line. The lower border is concave whereas the upper border can be straight, concave, or convex [10]. Hair direction along the upper temporal border can vary from a slightly anterior direction to a posterior direction. In addition, the right and left temporal regions may have different hair angles as well as different degrees of hair loss.

Asians, especially with Norwood VI or VII patterns, do not have sufficient donor hair to provide cosmetic density for a low anterior hairline and require temporal point augmentation when the anterior hairline is brought down [11].

55.2 Classification of Temporal Points

Brandy classified temporal point baldness into four categories: (A) no loss, (B) slight recession of the point with early diffuse thinning, (C) significant posterior recession of the point with the remaining area being overtly thin, and (D) points and remaining area being lost except for remaining vellus hairs [12].

Mayer et al. also proposed a system to classify temporal point status, i.e., *N* = normal (no thinning or recession of hair), *T* = thinning and mild recession, *P* = recession parallel to anterior sideburn line, and *R* = recession progressed to a reversed angle which is now concave instead of convex [13]. This classification using capital letters (N, T, P, or R) is added after Norwood classification in bracket, e.g., VI (T) or VI (P). Patients in class N or T usually require no augmentation. Class P and R can be considered for restoration of temporal points.

In a recent classification by Ahmad et al., the temporal points are classified into four categories, i.e., “P0” to “P3.” “P0” indicates “no hair loss at the temporal area,” “P1” indicates the temporal point is located not less than the junction of one-third and two-third of the distance between the outer canthus to tragus, “P2” shows the temporal point is located not less than the half of the distance between the outer canthus to tragus, and “P3” denotes the reverse of “P1” [14].

55.3 Pros and Cons

There is reluctance regarding restoring temporal points among some hair restoration surgeons due to the fear of producing unnatural results; however a well-reconstructed temporal area is very rewarding [10]. A younger patient would not be encouraged to undergo temporal point recreation due to the potential for developing aggressive hair loss in later years. Lack of emphasis on reconstructing temporal points is also reflected by the fact that the problems of hair loss and recession of the temporal points are not addressed in either Hamilton’s or Norwood’s classifications. The lack of color match should NOT stop the surgeon from restoring these points.

The other school of thought is in favor of recreating the temporal points as this will restore the “golden ratio” and facial profile [15, 16]. Restoring only the frontal hairline can leave a “lid appearance” [10]. As the borders of temporal area are relatively short, the total area to be recreated is small; therefore about 100–150 hair follicular units can fulfill the requirement. Temporal point recreation will also reduce the appearance that the individual is wearing a hairpiece [10]. Hair restoration performed with and without the temporal point recreation produces a subtle but significant difference (Fig. 55.4).

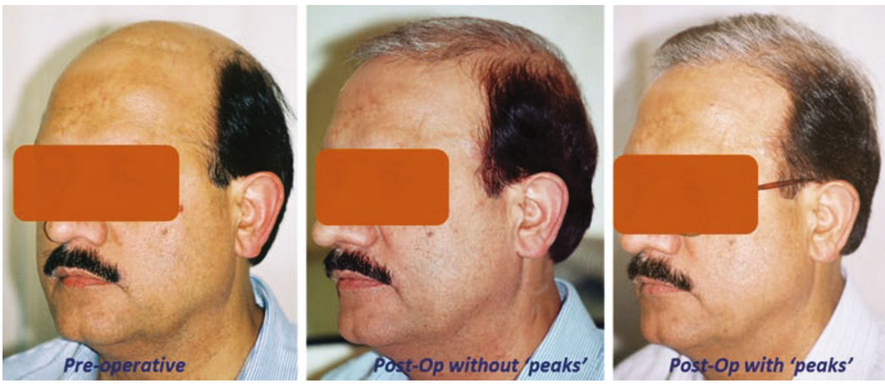

Fig. 55.4 Result of a patient with and without temporal point recreation

55.4 How to Design?

55.4.1 General Principles

There should be a pleasing proportion between the temporal hair and frontal transplant zone hair. The temporal hair aesthetically serves the purpose of holding up the frontal hair. The patient's age is essential in evaluating this hair because the anterior temporal border is likely to migrate posteriorly with age. If the temporal hair have receded fairly far posteriorly, closer to the ears, a more superior frontal hairline height produces a more balanced and aesthetic appearance.

Another option is to strengthen the temporal area with follicular units if the density is sparse or to transplant anteriorly to the existing temporal hair. During the consultation or on the day of the procedure, the patient should be asked his preference as to whether he prefers to restore the temporal points or not. If not, then the frontal hairline height (described above) is adjusted accordingly. The newly created temporal points should NOT extend beyond the line perpendicular to the angle of eye.

55.4.2 Methods Available

There are various methods mentioned in the literature to restore/recreate the temporal points. The surgeon can opt for any method depending upon his experience, preferences, and patient's factors.

A. Draw one line starting from the nose tip through mid-pupil and the second line starting from the earlobe to the proposed central hair point, and determine where the two intersect (Fig. 55.5) [17]. The point where the two lines intersect is an excellent reference for placement of the anterior tip of the temporal points.
B. It is fairly simple and relatively subjective. To obtain a fair estimate of future baldness in the majority of patients, thoroughly wet the temporal region and entire head. The surgeon may then scribe the extent of future baldness that is likely to occur posterior to the temporal point and of the whole head in general. The front hairline is first scribed with surgical marker, followed by the temporal points. This is performed by using high magnification loupes and studying the original vellus hair pattern existing within the region. In many patients the surgeon may want to move the temporal points posteriorly from where it was originally, to coordinate with the placement of frontal hairline. The more conservative the hairline design, the more conservative the temporal point placement.
C. Another method of designing the temporal points is by drawing two vertical and horizontal lines:

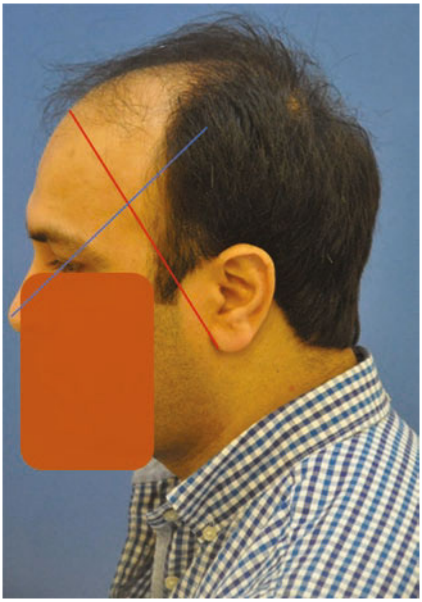

Fig. 55.5 Drawing of the temporal peaks

Line 1. Frankfurt horizontal line, by drawing a straight horizontal line from the top of the ear canal to bottom border of the eye

Line 2. Pretragal vertical line, by drawing a vertical line just in front of the ear, where this vertical line intersects the outer canthal plane

D. Another method was mentioned by Simmons, in which he used “three” new lines (Fig. 55.6) [18].

55.5 Author’s Personal Method

Mark another point, 2 cm in front of the point where canthal plane intersects the vertical line. Connect the receded hairline to this point. To restore the hairline, first find traces of temporal points, and restore it. If no traces of temporal point, mark the new temporal point. The average height of temporal point from the Frankfurt horizontal line is 4.5 cm or 1.5 cm above the eyebrow level. Mark lateral canthal line. Draw another vertical line parallel to the lateral canthal line 1.5 cm behind it. Draw a horizontal line parallel to Frankfurt line at above average 4.5 cm height. Where this line intersects the vertical line behind the outer canthal line marks the point; it is the apex of temporal point. Drop the temporal hairline down and forward from the apex of frontotemporal angle at 45° to join marked apex of temporal point. From apex of temporal point, drop the temporal hairline down and backward at 45° angle to join the sideburn.

After the design is drawn with a surgical marker, irregular dots that outline the proposed temporal point can be marked (Fig. 55.7). These don’t rub off when the anesthesia is introduced or when the area is cleansed with an antiseptic agent.

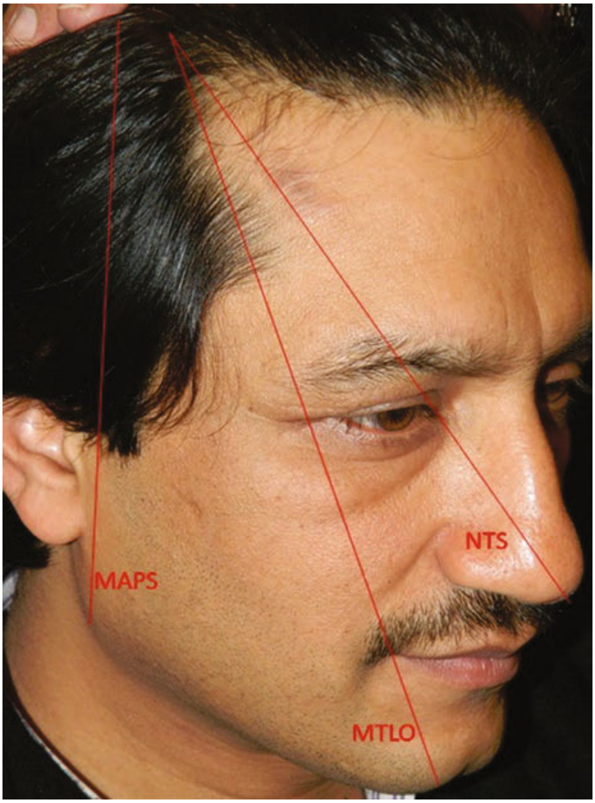

Fig. 55.6 Line describes by Simmons et al. [18]

The best match is of hair color and caliber is usually found in the supra-auricular or the supra-postauricular area. To avoid creating a very unnatural appearance, it is imperative to match the color of the transplanted hair to that of the hair in the receding temporal point. It is better not to build out the point if no matching hair color is available. Because the best match of hair color and caliber is found in the supra-auricular area, the planned incision should be extended to include hair from this area when the donor strip is taken. The hair should always be left at least 1 cm long. This ensures an easier determination of curl and hair direction when the grafts are placed into the recipient area. There are a few reports of using nape of the neck hair to reconstruct the temporal region [19].

While making the recipient slits, the blade should always be placed almost flat along the skin surface (Fig. 55.8). The recipient sites along the edge are best made with an 18–20-gauge needle or 15° sharp point beveled up blade. Single-hair grafts fit well into these sites. More posterior to the point and single-hair grafts, the 18 g needle/spear point 88/89 blade placed almost flat to the skin surface creates an excellent site for two-haired grafts. A more natural result is obtained by avoiding three-hair grafts in the temporal points, unless the patient has extremely fine, blonde, or gray hair or is of the black race.

Fig. 55.7 Marking of the tmporal points in relation to the anterior hairline design

Fig. 55.8 Recreation of the recipient area

The decision about the amount of donor hair to be used for the points is made based on the calculations in square centimeters of the area to be restored. A density of 20 FUs/cm is a reasonable goal (Fig. 55.9). Usually, about 100–150 grafts are required per side. Only the one-hair and two-hair grafts should be used, and of course only the naturally occurring single FUs should be placed at the edge.

To reproduce nature, observe that the hair in the points not only grows at a very acute angle but also inferiorly and posteriorly. There are usually a few residual miniaturized or vellus hairs that can be used as a template to duplicate a correct angle and direction. As already noted, the needle or blade should be kept as flat as possible to create these acute angles. The skin must also be kept tight using the surgeon's index finger and thumb as the sites are made, with the other hand making the slits as acute as possible.

In order to mimic nature, the author first notes the curl of the hair shaft as grafts rest in the Petri dish (Fig. 55.10) [20]. The author then meticulously places single-hair follicular units keeping the natural curl of the hair shaft toward the skin. Grafts are placed carefully while observing the changing angles of sites along the pattern of existing vellus hairs (Fig. 55.11).

Fig. 55.9 Density at the re-created temporal area

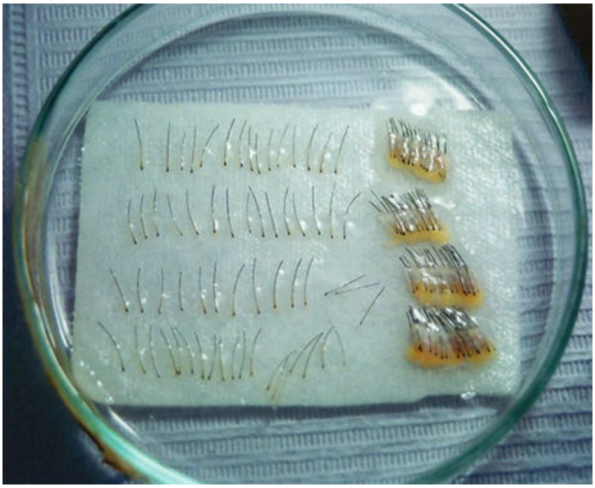

Fig. 55.10 Orientation of follicular units (only hair with curl are selected)

Fig. 55.11 Careful observation of the hair shaft

While placing the grafts in the slits, it is imperative to keep the curvature of hair shaft in the correct direction (Fig. 55.12). Orientation is rechecked regularly and if necessary the placement is corrected by rotating gently with fine forceps (Fig. 55.13). The direction of the shaft is checked for every graft placed in the temporal zone (Fig. 55.14). This extra step results in aesthetically pleasing postoperative result (Fig. 55.15). The correct orientation of the placed grafts results in the aesthetically pleasing temporal points. If this extra step is not taken, the result would be good but not perfect (Fig. 55.16).

To address the frontotemporal angle, one needs to understand different hair styling especially if side parting. For individuals planning on using side parting, assess the level of side parting, and when placing the grafts make sure to place the curl of hair in such a manner that it should go along the curvature (Fig. 55.17). An interesting technique is mentioned which is achieved by molding the straight blade into a curved blade for creating slits in the temporal area [21].

Fig. 55.12 Gentle rotation to correct the angle of hair shaft

Fig. 55.13 Correct orientation of the hair shaft

Fig. 55.14 Rechecking the angles of each graft

Fig. 55.15 Post-op temporal points restoration

Fig. 55.16 Post-op result without considering the curvature of the hair shaft

Postoperative care of these newly created temporal points is of utmost importance. A 5–10 cm square piece of nonstick gauze is cut diagonally from corner to corner, which creates two triangles that fit properly over the temporal points. A topical antibiotic ointment is placed over the grafted site, and this piece of gauze is placed over the grafted area. A nonadhesive bandage is used to stabilize the dressing, which is removed the next morning. The final outcome should be a result that appears as if no surgery had been performed (Fig. 55.18).

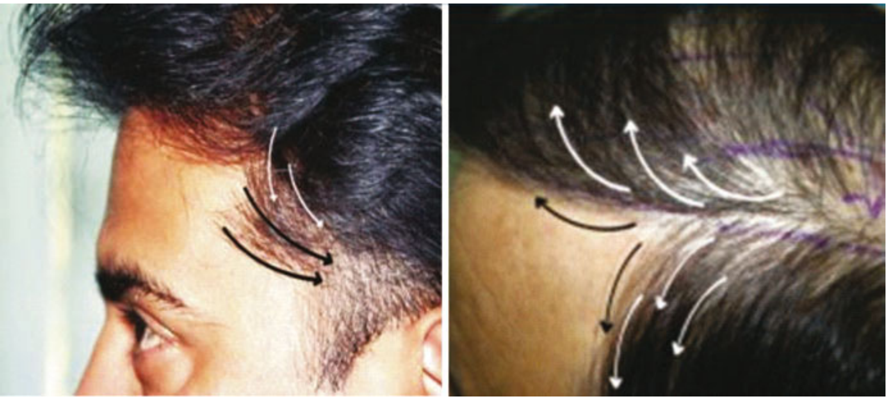

Fig. 55.17 Curl of the transplanted hair

Fig. 55.18 Aesthetic post-op final result with unnoticeable angles of hair

55.6 Conclusion

Although the temporal points are very difficult to recreate, the results are rewarding if the general principles are followed, and the important points in planning and execution are not omitted.

55.7 Practical Tips

Indications for restoration:

- Temporal recession should always be assessed with the Norwood scale.
- Restore points in patients younger than 35 years with only type II to IV with strong negative family history.
- Be careful in patients with type VI and VII.
- Do not restore temporal points in a patient younger than 25 years.

Practical tips about designing:

- Do not cross the temporal point beyond half the distance between the tragus and outer canthus.
- Keep it to 1/3 of the distance between the outer canthus and pretragal line in patients over 40 years.
- Be sure to keep the shapes equal on both sides.

Expert practical tips:

- Only select single-hair FUs for hairline.
- Maintain the transition zone.
- Be 100% sure to select the hair with curl.
- Make sure to keep the curvature of hair shaft or curl of the graft in correct direction.
- Make sure the slits are as acute as possible, almost flat.
- The direction of slits should be more vertical on upper side and more horizontal on lower side or along the existing vellus hair directions.

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Chapter 56
Crown Restoration: Indications, Technique and Design

Bessam K. Farjo

56.1 Introduction

Hair transplant surgery in the crown requires skill and experience and is perhaps an area for the beginner surgeon to avoid. The problem is that the crown baldness can expand in all directions, and if an early transplant is performed followed by continuing hair loss, it can give rise to the potential pattern of an unnatural looking island of hair surrounded by a moat or a ring of baldness. Of course, one can have more hair transplantation to chase the loss but what if the front starts to bald significantly later on with decreasing donor availability, or the patient changes their mind about continuing with further hair transplant surgery? [1]

In the younger person where there is family history and potential for significant loss at the frontal scalp, there is always the question of when it is safe to significantly transplant the crown. If you want to be really conservative, then perhaps wait until the patient is 40 years old, but the majority of experienced surgeons avoid anyone under the age 30 even with no apparent family history of frontal loss. Medical therapy can help slow down further loss in the meantime [2].

In general transplanting the crown should have a low-risk approach, avoiding doing surgery until the hair loss is reasonably stable or in patients who are destined to end up with Norwood class 6 or 7. This is especially true in cases of high colour contrast of hair and skin. If in doubt, then ideally aim to design a plan for a one-off hair transplant procedure. The patient should agree with the expectation of light coverage and a thinning look compared to slick bald. This allows the patient to limit further work and not commit to chasing the baldness in case of significant further loss [3, 4].

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56.2 Criteria

More often than not, patients want more hair and density and will put the surgeon under pressure to agree to provide that. My general rules and guidelines for who can have large sessions of dense packing in the crown are as follows:

- Patients aged 35 or older.
- Stable history of hair loss in the crown supported by similar family history.
- Limited current and future potential frontal hair loss.
- The patient does not want or need any more hair transplantation in the front.
- Beware of patients on hair stabilizing medications, as they are not necessarily safe to work on. They may stop their meds anytime.
- High-quality and high-density donor hair.

56.3 Design

The frontal forelock pattern and hair direction is generally more straightforward than the crown where you have a whorl or two to contend with. The hairs sprout out of the centre of the whorl in a concentric fashion in a clockwise (S-pattern) or anti-clockwise (Z-pattern) direction. In a survey type study conducted by Ziering et al., they noted that individuals who had two whorls exhibited either the SS or SZ patterns whilst none had the ZZ pattern. They also noted that Afro-Caribbean and women commonly exhibited no whorls in the crown and termed that 'diffusion' pattern [1].

When restoring hair in the crown and determining hair patterns and direction, it is best to follow existing hair. In the majority of patients, it will possible to detect miniaturized or vellus hairs under magnification and use those as a guide. However patients generally do not like a 'double crown', and if sufficiently bald, I avoid re-creating the second whorl. If there is no physical evidence remaining of hair direction and whorl pattern, then it is best to design a whorl just lateral to the midline on the same side as the one where the patient parts their frontal hair from. This way you allow the hairs from the whorl to sweep gradually upwards, and fan out to blend naturally with the hairs above and in front of them. In other words if the patient parts from left to right, then you create a clockwise whorl, whereas right to left parting requires an anticlockwise crown (Fig. 56.1) [3, 5].

The bald crown could be classically rounded like a circle or have other rounded shapes most commonly a convex kidney shape where the smaller arc is on the inferior side. Occasionally, you may find an almost separate and much smaller rounded thin crown below the main area, which has the potential to eventually blend into the main bald crown. Finally, in the circular bald pattern, you may often find a thinning patch of various severities shaped like an inverted triangle below the bald crown. Whatever the shape may be, it is important to make a judgement on the degree of irregular blending that needs to be made at the edges separating baldness and the

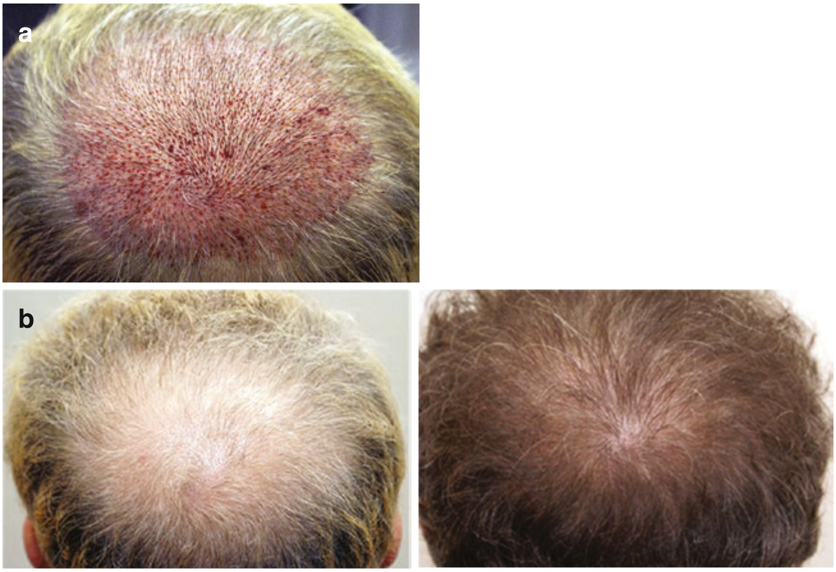

Fig. 56.1 (**a**) Whorl design immediate post-op view. (**b**) 1-year result

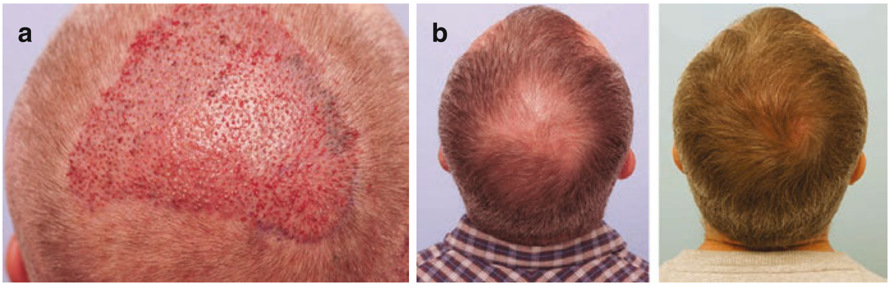

Fig. 56.2 (**a**) Crown design sticking to the upper part. (**b**) 1-year result

thinning areas in all directions. The aim should be to avoid sharp lines of separation if the patient advances in baldness into these transitional zones.

If donor hair supply is not in question but the crown has potential for further loss, then a compromise that reduces the risk of the development of an unnatural bald halo or a smiley face bald patch is to avoid transplanting significant hair below the whorl. In other words, stick to hairs that are fanning upwards, and limit the inferiorly pointing hairs just enough for a natural feathering/blending zone (Fig. 56.2). The length from the upper and laterally flowing hairs will naturally fall over the lower zone and at least temporarily offer a reasonable disguise of the thinning areas. The patient can always come back at a later date for the lower crown if it deteriorates significantly and once it shows relative stability hair loss wise.

56.4 Technique

If the crown is the only area being operated on the day of surgery, then I generally pair all 1-haired grafts whether obtained by FUE or FUT. These grafts are not required for refinement in the crown, and on their own they often disappoint as far as the look of density is concerned. The centre of the whorl is probably the most directly visible area of the transplanted crown, and the 2-haired grafts there offer an excellent compromise combining reasonable density with a natural appearance. Depending on the number of 2-haired grafts produced, an area of at least 2 cm in diameter around the whorl is dense packed with them in a spiral concentric direction as described above. The other area where the 2-haired grafts are mainly utilized is the lower crown where the hairs will be flowing in a downward direction. They can continue to be used densely as you move outwards and upwards away from the whorl and then gradually blended with 3–4-haired grafts. These latter grafts will be mainly placed in the zones where the hairs are flowing upwards blending into the area above the crown, as well the area continuing outwards from there where the hairs begin to flow laterally and downwards in the vertical half of the crown contralateral to the position of the whorl. At this stage the grafts do not have to be as densely packed because the downward direction, layering of the hairs and higher number of hairs per graft contribute to the illusion of density [6].

A final word must be said about the angles at which the grafts need to be placed in the crown. The 3–4-haired grafts need to blend with the hairs at the back of the forelock and as such need to be placed at an angle of 40–45°. The 2-haired grafts placed inferiorly with the hairs pointing downwards will blend with the more acute exiting hairs in the occipital area, and therefore an angle of approximately 30° is more appropriate. One of the tell-tale signs of hair loss in the crown is the flattening effect of the scalp particularly when viewed in profile. Placing the grafts in and around the whorl at a more obtuse angle of say 70–80° can counteract this. The added bonus of this last approach is easier dense packing and less popping of the grafts in the whorl (Fig. 56.3).

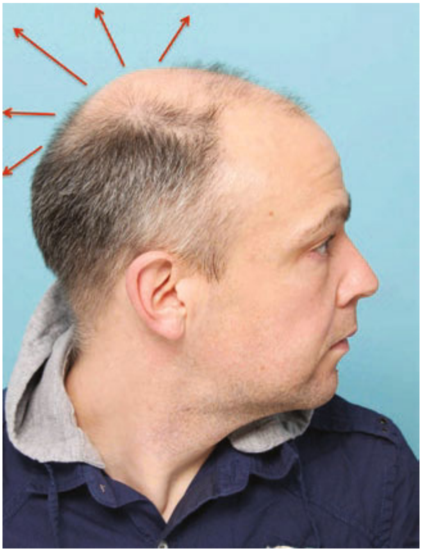

Fig. 56.3 Graft site angles in the crown

56.5 Conclusion

The crown is certainly a challenging area of hair loss for the surgeon. For the beginner it is vastly more difficult to assess with any certainty the future behaviour of the hair. It requires significant experience in terms of surgery as well as an eye and instinct for the potential of future hair loss. Even in the right candidate at the right time, skill and artistry are of paramount importance to maintain a completely natural appearance and behaviour of the grown transplanted hair.

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Part X
Body Hair Transplantation

Chapter 57
Eyebrow Transplantation in East and Southeast Asians

Julieta Peralta Arambulo

57.1 Introduction

The surgeon must pay attention to the details of the procedure, including keeping the ultrafine grafts viable, using an implanter to reduce trauma during graft placement, and planting at an acute angle, with hair curl correctly oriented toward the epidermis [1] as shown in Table 57.1. In the author's experience, even after just one session, patients are satisfied and happy with the results (Fig. 57.1. A documentation of strip FUT procedure. This 27-year-old female lacing the lateral third of eyebrows came for laser surgery of ugly eyebrow tattoo. The beige pigment was used in salon to conceal the tattoo and this made laser surgery ineffective. The tattoo was removed by elliptical excision under local anesthesia instead. B,C,D, E Results 1 year after 1st session of eyebrow transplant: right eyebrow, 98 grafts placed; left eyebrow, 160 grafts placed . Retouch with 40 single grafts by FUE technique to lengthen the eyebrows tails and fill in the remaining gaps was done on the day this photo was taken) (Fig. 57.2. A documentation of strip FUT procedure. This 35-year-old male patient has normal thin eyebrows. He is the same patient in Fig. 57.3. A total of 498 grafts is placed in both eyebrows. B. The result 4 years after 1 session.

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Table 57.1 Successful eyebrow transplantation depends on the following [2]

1.	Proper patient evaluation and education
2.	Innate passion, artistry, and experience of the surgeon
3.	Knowledge of eyebrow anatomy
4.	Attention to procedure details with the ability to reproduce the most acute angle and direction using single-hair grafts
5.	Proper instrumentation to avoid graft trauma

Fig. 57.1 (**a**) Documentation of strip FUT procedure: This 27-year-old female lacking the lateral third of eyebrows came for laser surgery of ugly eyebrow tattoo. The beige pigment was used in salon to conceal the tattoo, and this made laser surgery ineffective. The tattoo was removed by elliptical excision under local anesthesia instead (**b**, **c**, **d**, **e**). Results 1 year after first session of eyebrow transplant: right eyebrow, 98 grafts placed; left eyebrow, 160 grafts placed. Retouch with 40 single grafts by FUE technique to lengthen the eyebrows tails and fill in the remaining gaps was done on the day this photo was taken

On the day this photo was taken, second session is done by FUE technique to fill in the remaining gaps and thicken more the eyebrows: right eyebrow, 47 grafts placed; left eyebrow 42 grafts placed).

57.2 Surgical Approach

Patients present with a variety of concerns when seeking eyebrow restoration (Table 57.2), but the majority of Filipino patients who desire eyebrow augmentation have low density, normal thin hair caliber, and with uneven and or with incomplete eyebrows, especially lacking the lateral third.

Fig. 57.2 (Upper figure) Documentation of strip FUT procedure: This 35-year-old male patient has normal thin eyebrows. He is the same patient in Fig. 10. A total of 498 grafts is placed in both eyebrows. (Lower figure) The result 4 years after one session. On the day this photo was taken, the second session is done by FUE technique to fill in the remaining gaps and thicken more the eyebrows: right eyebrow, 47 grafts placed; left eyebrow, 42 grafts placed

Fig. 57.3 Strip FUT: 1 day after placing 249 grafts in male patient left eyebrow; the 1 cm hair length makes it easier to recognize the natural hair curl pointing into the epidermis. Note the bruising and swelling of upper eyelids

57.2.1 Eyebrow Length and Anatomy

The length of normal eyebrows in male and female Filipinos is almost identical to other Asian ethnic groups. My observation in 50 Filipinos (25 male and 25 female) revealed different shapes: straight, round, high arched or low arched, and with an average eyebrow length of 4.5–5.5 cm in females and 5–6 cm in males. Eyebrow thickness measurement was not performed because threading practices make this calculation inaccurate, particularly in females.

Table 57.2 Indications for eyebrow transplantation [3]

1.	Congenital absence of eyebrows
2.	Inactive autoimmune condition, i.e., alopecia areata of the eyebrow of more than 1 year duration
3.	Camouflage of eyebrow scar secondary to infection and inflammation
4.	Camouflage of eyebrow scar secondary to trauma from surgery including laser treatment, accident, thermal or chemical burn
5.	Augmentation of normal or low-density eyebrow with very thin hair caliber
6.	Uneven and incomplete eyebrows including loss of lateral eyebrow with or without associated hypothyroidism (Queen Anne's sign)
7.	Eyebrow contouring especially in patients with asymmetrical eyebrows
8.	Camouflage of ugly eyebrow tattoo

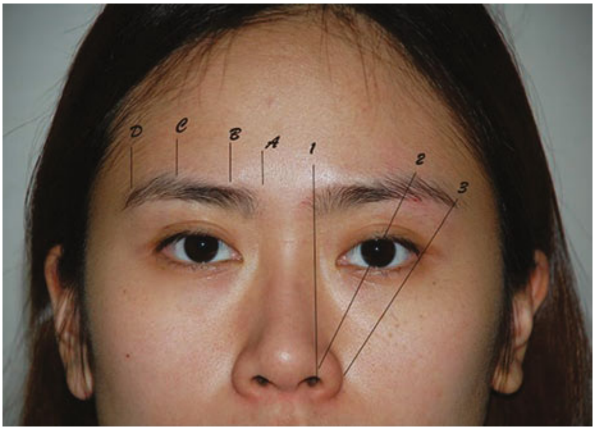

Fig. 57.4 (**a**) Anatomy. Eyebrow sections, right: distance between line. A–B, head; B–C, body; C–D, tail. (**b**) The eyebrow size and shape are depicted in the left eyebrow. A vertical line which is drawn from the center of the nostril that intersects with top brow line is the starting point; a vertical line from the center of the nostril to the middle iris crossing the top brow is the arch; and the vertical line from the edge of the nostril to the outer corner of the eye is the end (www.beautypointofview.com) (This is important in creating eyebrow symmetry)

The eyebrow is divided into three sections. The natural eyebrows contain only single hairs with a characteristic hair direction in each section that may serve as a guide during hair transplant surgery [2, 4] (Fig. 57.4. A Anatomy. Eyebrow sections, right: distance between line. A-B, head. B-C, body. C-D, tail)

- Head: is the most medial portion of the brow, has a square and rounded border and measures 1–1.5 cm length in female and 1.5–2 cm in male, and is located just medial to a vertical line drawn from the medial canthus [4]. It contains the thinnest hairs that are also shorter and lighter in color. The direction of these hairs points upward for about half a centimeter, after which the hairs increase in caliber and begin to point upward and laterally [2]. The distance between medial brows in Filipinos is 1.5–2 cm.

- Body: is the most prominent part of the brow and is approximately 1.5–2 cm with caudal (bottom) border initially continuing from the head in a flat/horizontal direction then slightly arching at the lateral canthus in a cephalic direction. A subtle narrowing of the lateral half of the body is seen in women but remains wider and thicker in men. It contains the thickest and densest hairs and in the majority of cases displays cross hatching beginning at the medial limbus, with cephalic hairs angling slightly down and the caudal hairs angling slightly up [4].
- Tail: is the narrowest portion and measures approximately 1.5–2 cm. It usually descends from the peak of the arch in a subtle downward direction [3]. The majority of Filipino women desire the tail to continue in a horizontal direction at the same height as the medial brow for more youthful appearance. It contains thinner hair and less density, and the hair direction is observed to be more downward than central convergence.

57.2.2 Eyebrow Shape and Marking

The challenge starts with the eyebrow aesthetic markings which are made to ensure symmetry with a contour that fits the shape of the face of the patient. Most of all, the eyebrow outline created must be according to the patient's goal.

In individuals with thinning eyebrows, shading the existing eyebrow will show its natural shape which is unique and complements the remainder of the facial features. However, in patients with almost absent eyebrows, the use of stencils will be of great help when shaping the brows, and following the steps in Fig. 57.4 B (The eyebrow size and shape are depicted in the left eyebrow. A vertical line, drawn from the center of the nostril that intersects with top brow line, is the starting point; a vertical line from the center of the nostril to middle iris crossing the top brow is the arch; and the vertical line from the edge of the nostril to the outer corner of the eye is the end (www.beautypointofview.com). This is important in creating eyebrow symmetry.) will help create symmetry. The patient's participation in the design planning process is encouraged so that her expectation and satisfaction become closely congruent. Preoperative photo documentation is important prior to marking.

57.3 Procedure

The choice of donor hair should match the caliber, color, and texture of the existing eyebrow [2]. Possible donor areas are the temporal, postauricular, and sideburn areas [5]. However, the usual site for taking donor hairs is from the mid-lower occipital area of the scalp, where the hairs are least likely to turn gray and have the best texture and curl [6].

The donor hairs can be obtained by strip follicular unit transplantation (FUT) or by follicular unit extraction (FUE). Local anesthesia, 1% Xylocaine with 1:100,000 epinephrine, is given one section at a time, and normal saline solution is used to tumesce both donor and recipient areas.

With the strip method (FUT), a donor strip of 1 cm in width by 5 cm in length can provide 400–500, 1–2-hair grafts. Production of ultra-skinny single grafts is performed by well-trained staff under the stereomicroscope with 10x magnification [2]. Two-hair grafts are usually longitudinally dissected to produce more single grafts. The hairs of eyebrow grafts are kept long (1 cm) because it shows the natural curl of the transplanted hair (Fig. 57.5. Donor strip dissected into ultra-skinny single-hair grafts with 1-cm-long hair shaft showing the natural curl) (Table 57.3). Avoidance of graft desiccation is crucial to keep them viable.

Starting at the tail section, the grafts are placed by stick and place technique using disposable 23 or 24 gauge shoehorn-shaped needles. Acute angled coronal slits are created on a stretched skin following the angle and direction of existing hairs per eyebrow sections described earlier (Fig. 57.6 A,B. Intraoperative slits creation: 23 or 24 gauge shoehorn-shaped disposable needles are used to create a more acute slits following the angle and direction of existing hair). The angle of the recipient sites should be as acute as possible to allow the hairs to grow in a flat position relative to the forehead [4]. Two implanters are used: one with 0.6 mm needle to place single grafts and one with 0.8 or 1 mm needle to place two-hair grafts. The use of implanters allows atraumatic placing of the grafts and makes the procedure less time consuming, but it still remains a difficult procedure.

For uniformity and symmetry, the number of grafts placed is recorded in each section. To create a natural result, coarser hairs or sometimes two-hair grafts are

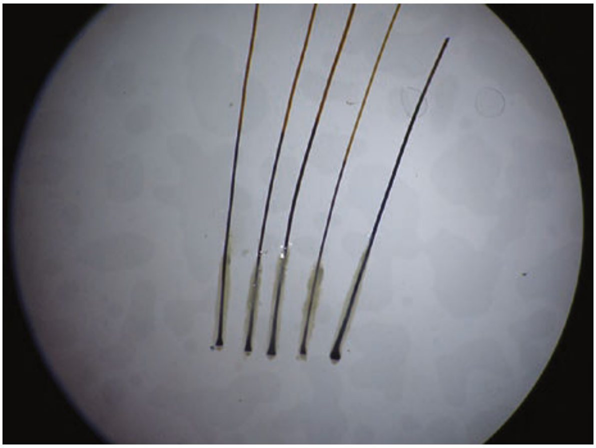

Fig. 57.5 Donor strip dissected into ultra-skinny single-hair grafts with 1-cm-long hair shaft

Table 57.3 The advantages of strip FUT eyebrow procedure

1. The 1 cm hair length shows the natural curl of the transplanted hair which provides easier guide for proper placement of grafts
2. Majority’s choice of technique in full eyebrow procedure

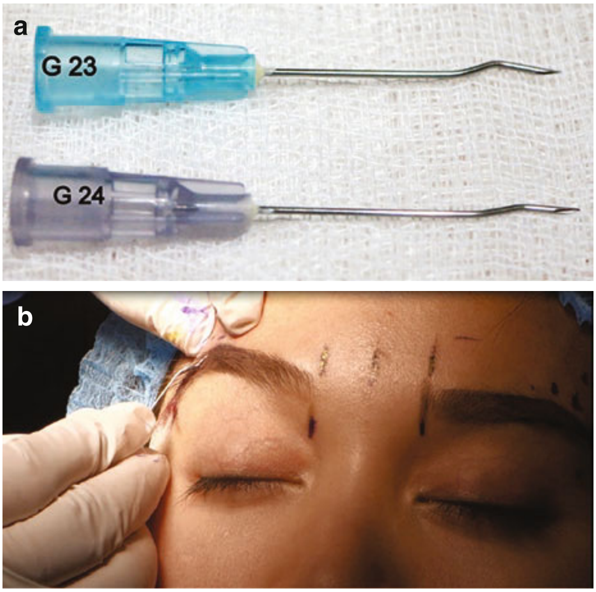

Fig. 57.6 (**a** and **b**) Intraoperative slit creation: 23 or 24 gauge shoehorn-shaped disposable needles are used to create a more acute slits following the angle and direction of existing hair

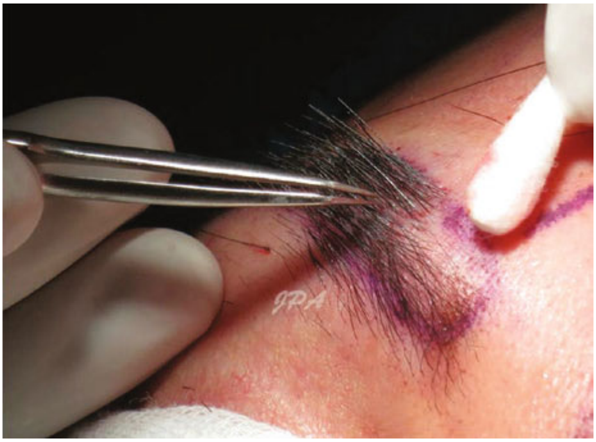

Fig. 57.7 Intraoperative: the use of fine forces in checking the direction of grafts placed 1 cm hair curl, which should be pointing into the skin

placed in the medial and central body, and all the finest hairs are irregularly distributed along the periphery similar to normal eyebrows.

After every graft insertion, checking the hair angle and direction becomes easier, and any hairs sticking out are simply rotated, so the direction of curl complements the direction of the recipient site with hair curl pointing toward the epidermis [2] (Fig. 57.7. Intraoperative: use of fine forces in checking the direction of grafts placed 1 cm hair curl, which should be pointing into the skin). (Fig. 57.3. Strip FUT: 1 day after placing of 249 grafts in male patient left eyebrow; the 1 cm hair length makes easier to recognize the natural hair curl pointing into the epidermis. Note the bruising and swelling of upper eyelids).

Fig. 57.8 (**a**) Documentation of eyebrow procedure by strip method. Before: left eyebrow with thin hair caliber lacking the lateral third in a 45-year-old female. (**b**) Right after placing the 364 grafts (349 1-hair grafts; 15 2-hair grafts scattered in the body section) harvested from lower occipital area. (**c**) 1 year after shows good result but with mild aberrant direction of few hairs. Though patient did not follow the instruction to train the growing hair to lie flat, the patient was so satisfied with the result

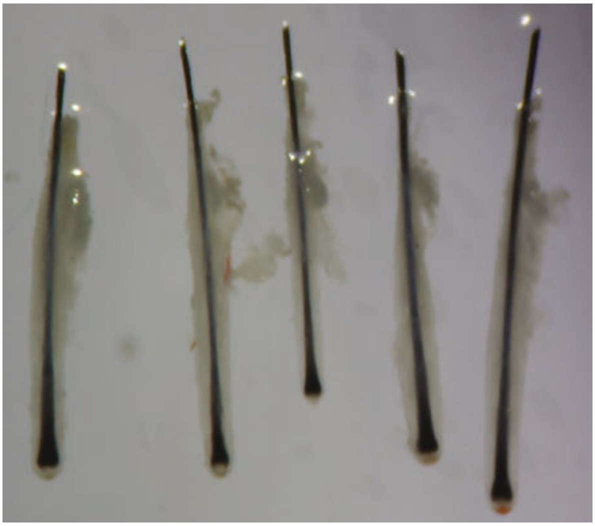

Fig. 57.9 Grafts harvested by FUE method are dissected into skinny single grafts; the 1 cm hair shaft hardly shows the hair curl

In Asian patients, the hair tends to grow very straight, which makes it somewhat more difficult to achieve the desired flatness of growth. 80% of transplanted hairs will grow, and of these 15% will grow in an aberrant direction, either too vertical or not flat enough to the skin due likely to contracture of the skin [4]. (Fig. 57.8 A. Documentation of eyebrow procedure by strip method. Before: left eyebrow with thin hair caliber lacking the lateral third in a 45-year-old female. B. Right after placing the 364 grafts (349 1-hair grafts; 15 2-hair grafts scattered in the body section) harvested from lower occipital area. C. 1 year after shows good result but with mild aberrant direction of few hairs. Though patient did not follow the instruction to train the growing hair to lie flat, the patient was so satisfied with the result.)

For the FUE method, the author uses a Safe Scribed motorized FUE machine with a 0.9 mm blunt punch to harvest the grafts and a 6x magnification loupe to increase visibility. To facilitate harvesting, the donor hair is cut to 1 mm in length. The short hair makes it difficult to recognize the natural hair curl used as a guide in proper placing of the grafts. (Fig. 57.9. Grafts harvested by FUE method are dissected into skinny single grafts; the 1 cm hair shaft hardly shows the hair curl.)

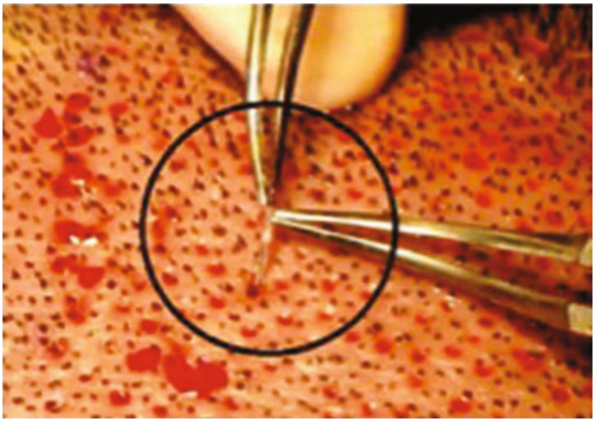

Fig. 57.10 Photo is taken from below the occipital area; removal of individual follicular graft after dissection by FUE method shows the location of the sebaceous gland that is directly anterior to the hair, where the direction of the hair curl is

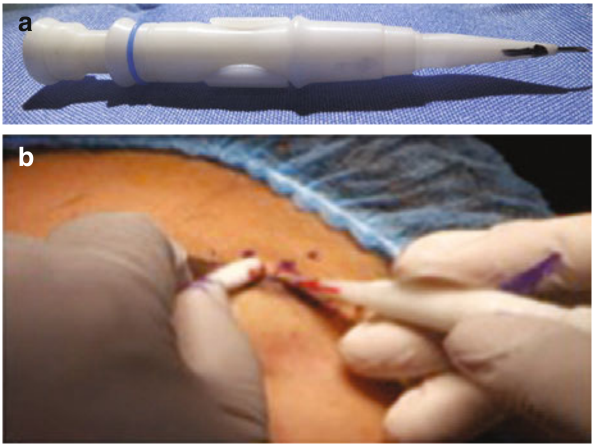

Fig. 57.11 (**a**) Implanter with 0.8 mm needle for 2-hair grafts (not shown is implanter with 0.6 mm needle for 1-hair graft); Pentel pen is used to mark one side of vertical opening black and the part opposite the vertical body opening red. The proper position of the loaded graft is in the sebaceous gland which is along the vertical needle opening and facing the loader. This method guides the author to the location of the sebaceous gland which is anterior to hair curl. (**b**) Intraoperative stick and place method for proper placement of grafts; during insertion, the black marking of the implanter needle should be facing the physician and is then rotated clockwise until the red marking is seen

However, understanding the location of the sebaceous gland helps in locating the hair curl. Hairs naturally curl in the direction of hair growth, and the sebaceous gland is directly anterior to the hair [4]. The location of sebaceous gland becomes even more difficult to recognize in two-hair grafts longitudinally dissected into ultrathin single grafts. (Fig. 57.10. Photo is taken from below the occipital area; removal of individual follicular graft after dissection by FUE method shows the location of sebaceous gland is directly anterior to the hair, where the direction of the hair curl is.) To ensure a natural result from FUE eyebrow transplant and to lessen the complication of hair growing out of alignment resulting in an unnatural look, it is important to pay attention to this detail during placing of grafts with the use of implanter. Each graft is placed with the sebaceous gland facing toward the loader and along the vertical body opening of the implanter needle. The vertical opening is marked with Pentel pen which serves to guide the author to the direction of the hair curl and sebaceous gland location. During insertion of grafts, the needle is rotated slightly clockwise to assure correct placing of grafts so that the natural hair curl faces the epidermis. Meticulous attention to loading of the grafts by a knowledgeable assistant, careful graft handling, and avoiding graft desiccation are other important details ensuring a good aesthetic result. (Fig. 57.11. A. Implanter with 0.1 mm needle for 2-hair grafts (not shown is implanter with 0.6mm needle for 1-hair grafts); Pentel pen is used to mark one side of vertical opening black , and the part opposite the vertical body opening red. The proper position of the loaded graft is in the sebaceous gland which is along the vertical needle opening and facing the loader. This method guides the author to the location of sebaceous gland which is anterior to hair curl. B. Intraoperative stick and place method for proper placement of grafts; during insertion the black marking of implanter needle should be facing the physician and is then rotated clockwise until the red marking is seen.) Though majority of hair transplant surgeons would prefer eyebrow transplant by strip method because the 1 cm hair length shows the natural curl of the transplanted hair, which provides easier guide for proper placement of grafts, the advantages of the FUE technique in the author's experience are the following (Table 57.4) (Fig. 57.12).

Fig. 57.12 Documentation of FUE technique: (**a**) This 57-year-old male patient had incomplete lateral eyebrows; (**b**) right after placing a total of 82 grafts; left, 42 grafts; right, 40 grafts; (**c**) right lateral eyebrow result 2 years after one session. This photo was sent by the patient

Table 57.4 The advantages of the FUE eyebrow transplant

1.	Elimination of linear donor scar
2.	Allows selection of single- and double-hair grafts that match the eyebrow hair caliber
3.	Easier and faster way to harvest more grafts if needed
4.	Avoids excess graft harvest
5.	Ideal technique for small procedures and touch-ups

57.4 Postoperative Care

The patient leaves with no bandages and is advised to avoid touching the eyebrows for at least 3 days. However, normal saline solution that is gently sprayed (6 inches away) every hour starting 24 hours after surgery can be used to help decrease or soften scab formation. Spray can be used also to relieve the occasional itchy sensation. After 3 days, gentle dabbing with antibiotic ointment is allowed for 7–14 days to further soften the crust and also to train the hair to lie flat.

When properly performed, eyebrow transplantation complications are rare. However, occasional temporary mild folliculitis as well as bruising and swelling of upper eyelid may develop, which usually lasts for 3–4 days. Most transplanted eyebrows do not fall out but rather continue to grow. If transplanted hairs are shed, hair regrowth is observed 2–4 months after surgery. Since occipital donor hairs are transplanted into the eyebrows, they will continue to grow longer than native eyebrow hairs, and therefore they need to be trimmed, typically once a week.

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Chapter 58
Eyebrow Transplantation in Western Asians

Ali Abbasi, Ramin Rabani, and Sheida Abbasi

58.1 Appearance and Function of the Eyebrows

The eyebrows are two arched eminences of skin situated above the orbital regions [1, 2]. Eyebrows are a natural frame for the eyes and should be kept in appropriate proportion to the face. Eyebrows may serve a number of functions such as preventing sweat and debris reaching the eye and protecting the eyes from light. The eyebrow is important to facial emotional, expression, nonverbal communication, sexual dimorphism, and body language. The hairs of the eyebrows are short, thick, and stiff and are set obliquely. The diameter of eyebrow hair is normally thinner than scalp hair in Asians, while scalp hair is thinner in Caucasians [3]. Eyebrow hair normally tends to be less dense laterally than medially; thus, hair loss from any cause is apt to be more obvious in the lateral portion [4]. Any change (by makeup or cosmetic surgery) in shape, size, density direction, angulation, or color can affect facial expression. Like skin and hair, the eyebrows undergo similar changes, such as aging, thinning, fading, and graying, and thus may make a person look older over time.

58.2 Eyebrow Hair Growth

The eyebrow hair growth cycle (anagen) is very short, lasting only for about 4 months, meaning that eyebrow hair will not grow very long before entering the resting (telogen) phase and falling out. In contrast, scalp hair anagen phase can last 3 years, enabling the scalp hair to grow much longer.

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58.3 Eyebrow Loss

The most common cause of hair loss is telogen effluvium [5]. Telogen effluvium is an increased shedding of otherwise normal telogen hairs. It usually occurs in response to systemic disease or altered physiologic states such as severe emotional stress and can result in diffuse loss of eyebrow hair [5]. Eyebrow loss can also occur due to many other factors, such as genetics, congenital, thyroid, autoimmune disease (lupus erythematosus, alopecia areata, follicular mucinosis), chemotherapy, infections (fungal infections and syphilis), continuous and severe scratching, over plucking and trichotillomania, cicatricial conditions (secondary to trauma, burn injuries, or frontal fibrosing alopecia), and medications (clonidine, valproic acid, Prozac, and propranolol). Unlike scalp hair loss, the loss of one's eyebrows is not natural and is not cosmetically acceptable.

58.4 Treatment

Treatment depends on the underlying etiology; thus medical therapy may be appropriate for eyebrow loss induced by skin diseases (alopecia areata, trichotillomania), drug side effects, endocrine disorders, metabolic abnormalities, inflammations, toxins, psychiatric disorders, age changes, and systemic disease, and surgery (restoration and reconstruction) may be appropriate for other causes.

Different techniques of eyebrow restoration and reconstruction:

All techniques should follow the natural Eyebrow shape, hair direction and angulation of eyebrow very closely.

58.5 Eyebrow Transplant Technique

Follicular unit grafting is the most widely used technique, but there are other techniques such as composite hair graft, punch graft, subcutaneous pedicle island flap, temporoparietal fascia flap (TPF), and finally the cosmetic tattoo.

58.5.1 Shape of Eyebrow

Men and women have differences in the shape of the eyebrow. Men typically have thicker brows with a more horizontal orientation, but women have a more delicate and elegant shape.

Eyebrow is divided in three parts, head, body, and tail.

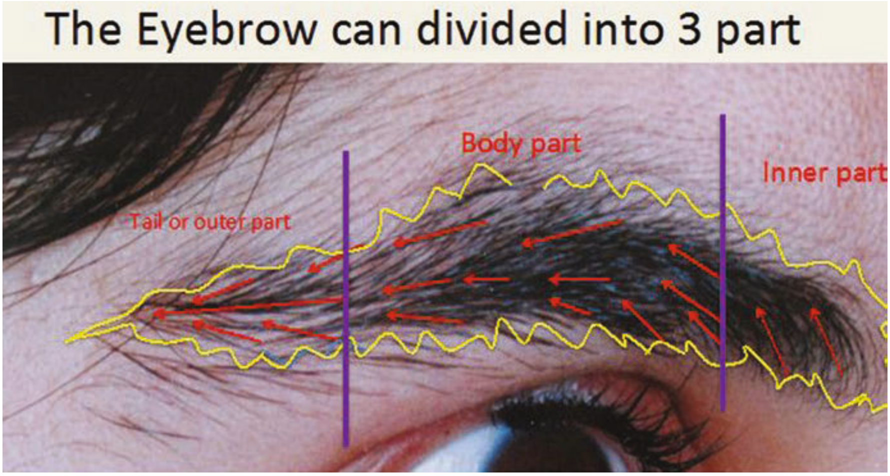

Fig. 58.1 The eyebrow can be divided into three parts

The direction of hair in the eyebrow head is vertical, and its shape is somewhat rounded, while the eyebrow body arches slightly with hairs that cross each other. The direction of hair in the tail is horizontal, and this is the narrowest part of eyebrow (Fig. 58.1). Where is the ideal position of the eyebrow on the face? How should the eyebrow be shaped to on the face? There are different methods to shape the eyebrow on the face.

To determine where the head of eyebrow should begin, draw a vertical line that starts from ala nasi passing through the medial angle of the eye. The inner edge of the eyebrow head starts at this line (line A). To determine where the arch of body of eyebrow should peak, draw a vertical line from lateral border of the iris (line B). To determine where the tail of eyebrow should be terminated, draw a line from ala nasi passing through the lateral angle of the eye. The tail should touch this line (Line C) (Fig. 58.2).

58.5.2 Procedure

Donor site selection for eyebrow:

The best donor site for eyebrows is in the mid-occipital area because this area usually does not turn gray or white in color. Single hairs are best for harvesting and implantation.

Method for implantation:

Sharp and fine point scalpel
Needle (Fig. 58.3a)
Pen-like implanter

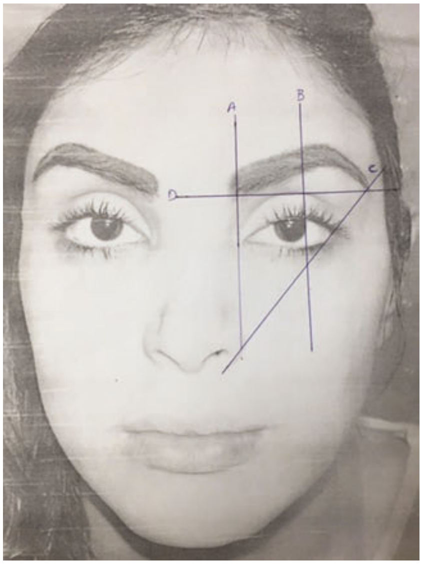

Fig. 58.2 Design shape of eyebrow

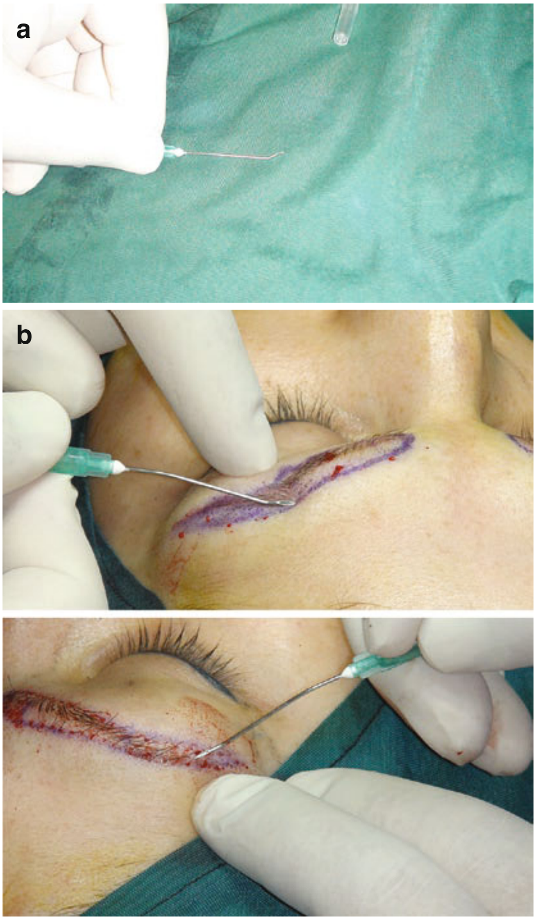

Fig. 58.3 (**a**) Making correct angulation and direction recipient site in the margin of the body of the eyebrow by needle gauge no. 21. (**b**) Making correct angulation and direction recipient site in the margin of the tail of the eyebrow by needle gauge no. 21

Local Anesthesia:

After drawing the shape of eyebrow, administer local anesthesia with lidocaine 2% with epinephrine 1/100,000.

Implantation:

Regardless of the method of implantation, we should keep in mind some important tips for eyebrow transplanting. Use only single hairs, not grafts containing multiple hairs. Hairs must be planted angled as flat to the skin surface as possible and should follow the natural direction and angulation of the eyebrow. In the medial third (head of eyebrow), the grafts should be oriented upward, while in the middle third (body), the grafts should converge toward each other, and in the tail, grafts

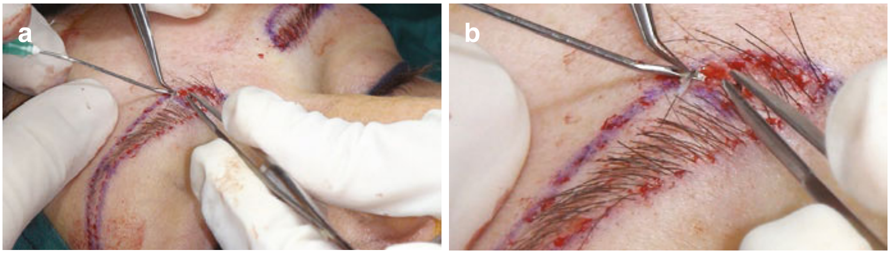

Fig. 58.4 (**a**) Graft placement. (**b**) Magnified graft placement

Fig. 58.5 It is better to make the eyebrow a little wider than the normal

Fig. 58.6 Before and after eyebrow transplantation

Fig. 58.7 Before and after hair transplantation

should be place in a horizontal orientation (Fig. 58.4). About 150–200 hairs are required for a full eyebrow.

58.6 Conclusion

Eyebrow loss is a clinical sign in many systemic and dermatological disorders. A proper diagnosis and appropriate management is necessary. Management of eyebrows loss may require medical or surgical management. The final appearance of implanted eyebrows should be natural and beautiful (Figs. 58.5, 58.6, and 58.7).

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Chapter 59
Eyelash Transplantation

Ali Abbasi, Ramin Rabani, and Sheida Abbasi

59.1 Introduction

Treatment of eyelash loss depends on the underlying etiology, so medical therapy is indicated for eyelash loss induced by skin diseases, drug side effects, endocrine disorders, metabolic abnormalities, inflammation, toxins, psychiatric disorders, aging, and systemic disease. Surgery (eyelash transplantation) is indicated for traumatic insults. In the author's experience, the indications for eyelashes transplant are limited to burns, trauma, congenital atrichia, and long-standing biopsy proven alopecia areata. When the source of eyelash hair is from the usual scalp donor area, the new eyelashes will continue to grow like scalp hair and will need to be trimmed regularly.

59.2 Eyelash Characteristics

Academic knowledge about the characteristics of the eyelash follicle is essential for eyelash transplantation, including growth, cycle, morphology, length, curl, pigmentation, and aging, as well as gender and ethnic differences. Eyelashes contribute to the beauty of the eye and face, and through its blinking reflex helps protect the eye from trauma and foreign body particles such as dust and grit. Compared with human scalp hair, very little has been reported about the histology and biology of eyelash follicles. Eyelash follicle morphology is very similar to the scalp hair follicle and structurally very close to curly hair, but some biological processes related to follicle cycle, texture, and pigmentation differ markedly.

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Fig. 59.1 Eyelashes tend to bend from the bulb to the tip of the shaft like as a French needle

A regular curved shape characterizes the terminal eyelash hair shaft [1]. Eyelashes tend to bend from the bulb to the tip of the shaft similar to a French needle (Fig. 59.1). The eyelash length is much shorter than scalp hair, due to a shorter anagen hair cycle.

The development of the upper eyelash occurs at about week 9 of gestation, prior to the lower lid [2]. The upper lashes grow in four to five imperfect rows and two to three rows in the lower lid. The mean number of eyelashes of the upper lid is 300–400, while the lower lid averages 100–150 (Fig. 59.2). The upper eyelashes are arranged in groups of 10–20 in the shape of triangles or pyramids. The lower lid lashes grow downward and look like a waterfall (Fig. 59.3) (refer to Sheida Abbasi, MD, ISHRS 21th annual meeting, Oct.2013, San Francisco).

The upper lid's lashes grow upward, have a curve shape, and are darker, longer, and denser than lower eyelashes. The upper lid's lashes arranged in four or five rows at the tarsal margin (Fig. 59.4). The lower eyelashes are thinner, lighter, and sparser than those of the upper lid. The upper and lower lashes are arranged such that they don't interlace while the eyelids are closed (Fig. 59.5).

The lash length varies from 8 to 12 mm on the upper lid and from 6 to 8 mm on the lower lid [2, 3]. The anagen phase of the eyelash is 34 ± 9 days, and the complete cycle of the eyelash is 90 ± 5 days. The average daily growth rate of the eyelash is 0.12 ± 0.05 mm. At any given time, 59–85% of eyelash follicles are in telogen phase [3]. Eyelashes take about 7 to 8 weeks to grow back if pulled out but constant plucking may lead to permanent damage.

Eyelash hair is not androgen dependent [4] and therefore is not affected by puberty. Some asymmetry occurs in eyelashes, similar to that observed in curly scalp hair. This is due to the asymmetric distribution of keratin K38 in the bulb, resulting in a curved fiber [5]. In addition, dopachrome tautomerase was found to be expressed in eyelash follicle melanocytes, while it was strikingly absent in scalp

Fig. 59.2 300–400 eyelashes in upper lid

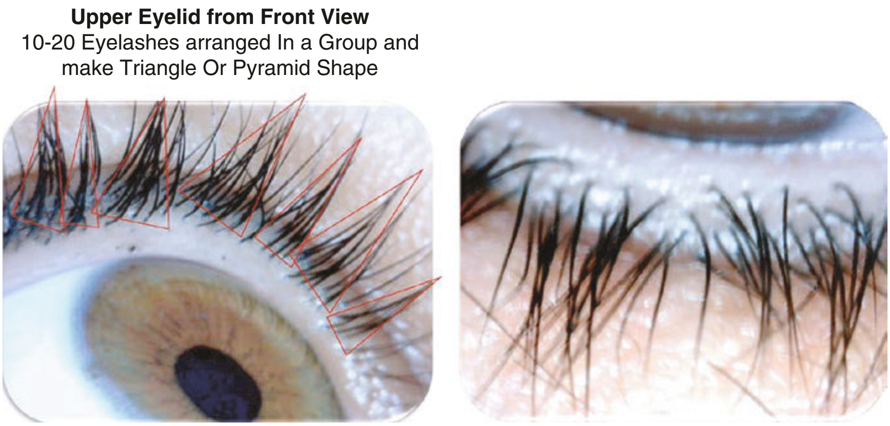

Fig. 59.3 10–20 eyelashes arranged in a group and make triangle or pyramid shape and lower lid's lashes grow downward

hair follicle melanocytes. This may explain why eyelashes do not turn gray—or only at a very late stage of ageing.

Eyelash follicles are free of arrector pili muscles [3] and are associated with a number of glands known as Zeis and Moll glands [2, 3]. Zeis glands are sebaceous

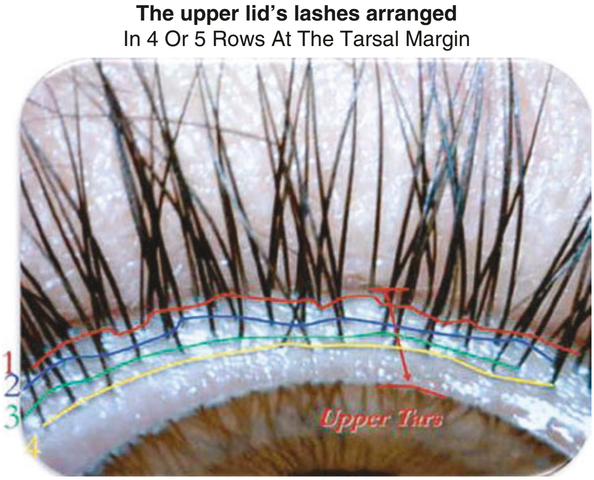

Fig. 59.4 The upper lid's lashes arranged in four or five rows at the tarsal margin

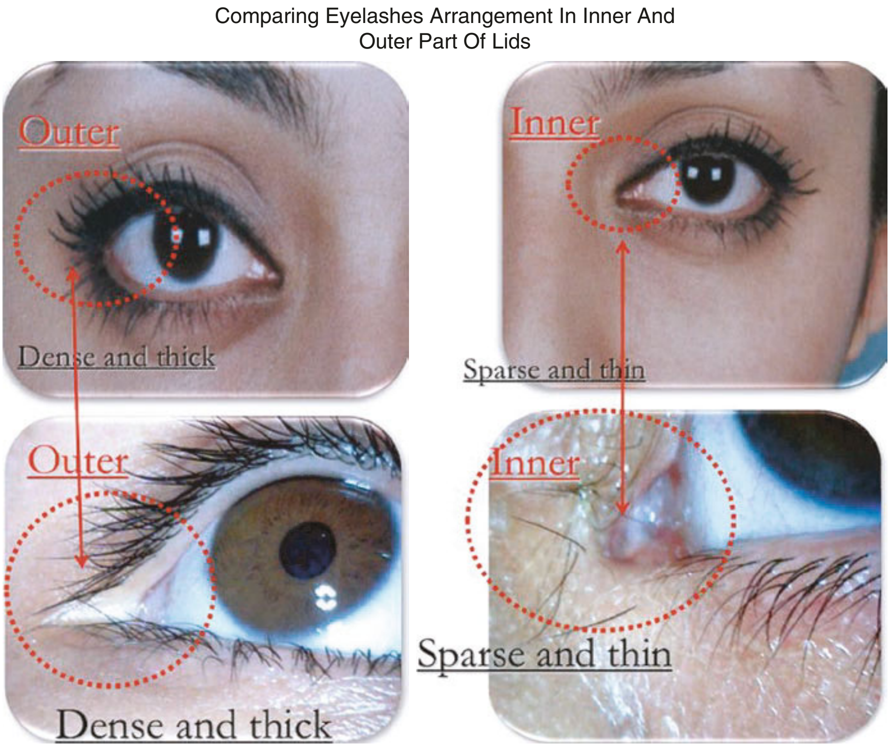

Fig. 59.5 Comparing eyelashes arrangement in inner and outer part of lids

glands located on the margin of the eyelid that secrete an oily lipid substance and forms a tear film. There are roughly 50 glands in the upper eyelids and 25 glands in the lower eyelids [1]. Eyelash follicles are rooted about 2 mm deep into the dermis.

Loss of eyelashes may occur with several conditions, including a variety of skin diseases (alopecia areata, trichotillomania), endocrine disorders, metabolic abnormalities, systemic disease, traumatic insults, inflammations, drug side effects, toxins, psychiatric disorders, and age changes. Eyelash loss as a chemical reaction to mascara is also very common [6]. Eyelash loss may be caused by damage from excessive rubbing and plucking.

59.3 Medical Treatment

Treatment of eyelash loss depends on the underlying etiology, so medical therapy is indicated for eyelash loss induced by skin diseases, drug side effects, endocrine disorders, metabolic abnormalities, inflammation, toxins, psychiatric disorders, aging, and systemic disease. Bimatoprost (Latisse) was introduced in the first quarter of 2009 by Allergan as the first drug to receive FDA approval for eyelash growth. Latisse is a solution of bimatoprost, the active component of the glaucoma medication Lumigan. According to Allergan, noticeable eyelash growth occurs within 16 weeks. Growth is reported to occur primarily on the upper eyelashes. Surgery (eyelash transplantation) is indicated for traumatic insults.

59.4 Eyelash Transplantation

In the author's experience, the indications for eyelashes transplant are limited to burns, trauma, congenital atrichia, and long-standing biopsy proven alopecia areata. When the source of eyelash hair is from the usual scalp donor area, the new eyelashes will continue to grow like scalp hair and will need to be trimmed regularly [7].

Steps in eyelash transplant are the following: (1) finding hair-bearing skin closely resembling to eyelashes; (2) achieving good anesthesia in both donor and recipient areas and taking steps to protect the cornea; (3) selection of single FU grafts; (4) implantation of grafts; (5) postoperative follow-up; and (6) addressing complications.

Contraindications to eyelash transplantation include: (1) secondary eyelash loss due to others diseases; (2) dry eye diseases, such as Sjogren's syndrome; (3) glaucoma; (4) chronic conjunctivitis; and (5) exophthalmos. Before surgery, rule out any risk factors by an internist evaluation for diabetes, hypertension, and cardiac arrhythmias, as well as by an ophthalmologist for any eyelid or ophthalmic diseases.

The selection of implantation method depends on the surgeon's art and experience and includes:

1. Stick and place (Fig. 59.6)
2. Choi implanter, type 21G (Fig. 59.7)
3. The pluck and sew technique with French needle [8–11], as introduced by Caputy, Flower, and Gandelman (Figs. 59.8 and 59.9)

Fig. 59.6 Stick and place method. Making first and second rows of eyelashes

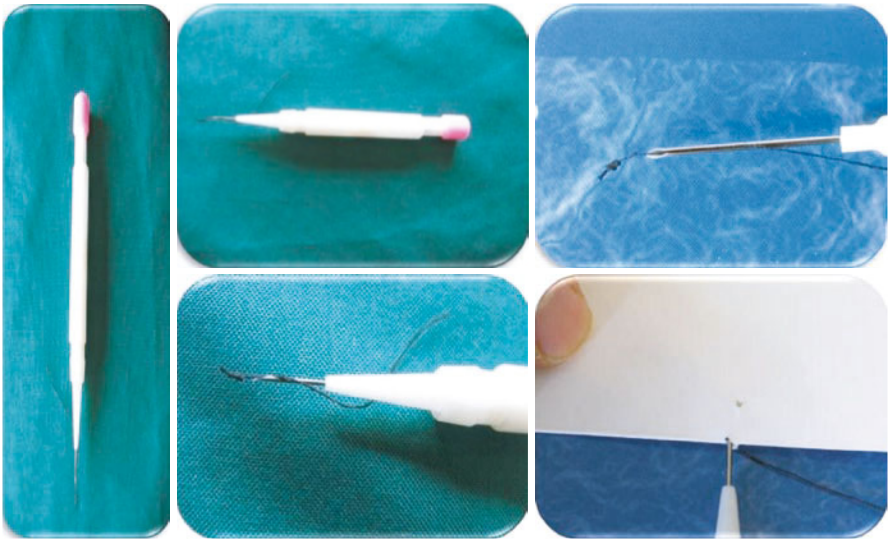

Fig. 59.7 Choi implanter, type 21G

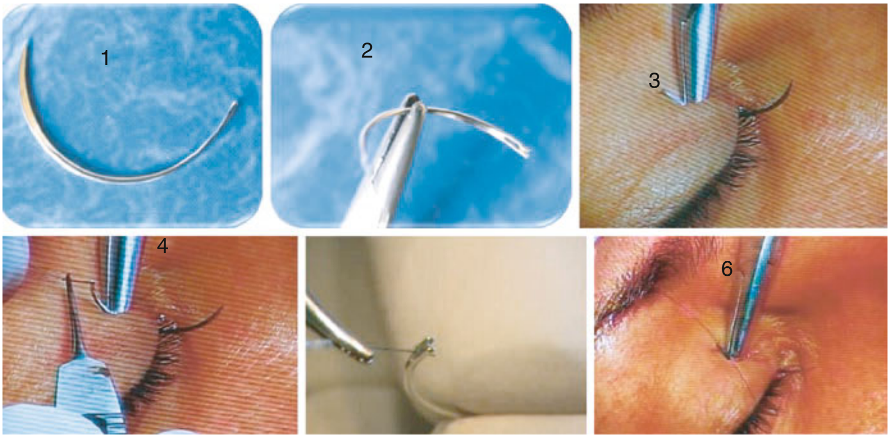

Fig. 59.8 Passing the needle through the eyelid then placing the hair into hole of French needle

Fig. 59.9 Placing the hair into the hole of French needle

4. Composite-free strip graft

Regardless of the implantation method used, only single follicles should be used in eyelash transplantation. After finishing graft implantation (Fig. 59.10a, b, c, and d), cut the new lashes to the desired length, apply ophthalmic ointment, and protect the grafts with goggles and a bandage.

Because the transplanted eyelashes will grow faster than original lashes, the patient must be instructed to regularly trim the eyelashes to the desired length and curl them to achieve a natural shape.

Fig. 59.10 (**a**) Before and after eyelash transplantation. (**b**) Before and after eyelash transplantation. (**c**) Before and after eyelash transplantation. (**d**) Before and after eyelash transplantation

59.5 Complications: Early and Late

Early complications include bruising, hematomas, swelling, corneal injuries, graft displacement, itching, and infection.

Late complications include ingrown hairs, ectropion, entropion, trichiasis, and finally poor esthetic result.

59.6 Conclusion

In summary, medical therapy should always be the first step for all secondary eyelash loss induced by diseases, and patients who suffer from short, thin, and spars eyelashes should be encouraged to try makeup. Those patients suffering from trauma and burns may be good candidates for eyelash transplantation.

After appropriate case selection and candidates for eyelash transplantation, the patients should be informed before surgery regarding the long-term need for curling and trimming, as transplanted hairs have differences in growth, caliber, curl, and color.

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Chapter 60
Beard Hair Transplantation

Kenichiro Imagawa

60.1 Background

Beard transplantation has been discovered back in the "Okuda Papers" published 1939 [1], but his practice was exclusively for reconstruction. Nowadays the appearance of the unshaved beard is in fashion and "cool" because information is available in the media and people are attracted to the unshaven Hollywood celebrities. In addition, the innovations in modern hair transplantation have achieved both naturalness and optimal coverage; hence, aesthetic beard transplantation has become popular.

According to the 2014 ISHRS Practice Census, the global demand for surgical hair restoration in non-scalp area is 10.9% in all surgical procedures, and among them 3.7% was for beard, and this is a remarkable increase compared to that of 1% in 2004 and 1.5% in 2006. Also in all non-scalp areas, 63.8% of male and 0.7% of female patients were most interested in discussing beard transplant at the initial consultation [2].

60.2 Candidacy

Beard transplantation is performed both for reconstruction for congenital absence and scarring alopecia due to trauma, burn, infection, and iatrogenic causes. It is also performed for aesthetic purposes for patients who want to thicken their normal beard to look more masculine or for female to male transgenders. The largest demand is in West and Middle East Asia because a thick beard is important for a strong image of masculinity and allows social status (Table 60.1).

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Table 60.1 Indication of beard transplantation

Reconstructive	Congenital hypotrichia/atrichia Traumatic alopecia prior trauma/burn/surgery/laser Primary cicatricial alopecia (folliculitis) Long-standing alopecia areata Traction alopecia
Aesthetic	Enhancement of normal beard Female-to-male transgender

60.3 Facts About Beard Hair

Except for small areas of beard reconstruction where beard hair is used, scalp hair is routinely used as the donor, and understanding the anatomical features of beard hair and its difference in characteristics from scalp hair is critical to obtain optimal results.

60.3.1 Distribution of Beard

There have been a few articles on the distribution of facial hair. Yu JM divided facial hair into eight sections but gave no name [3], while Dua K. classified it into six zones and named them as sideburns, cheek beard, jaw beard, fore beard, neck beard, and moustache [4] (Fig. 60.1). However in this chapter, the author has roughly and

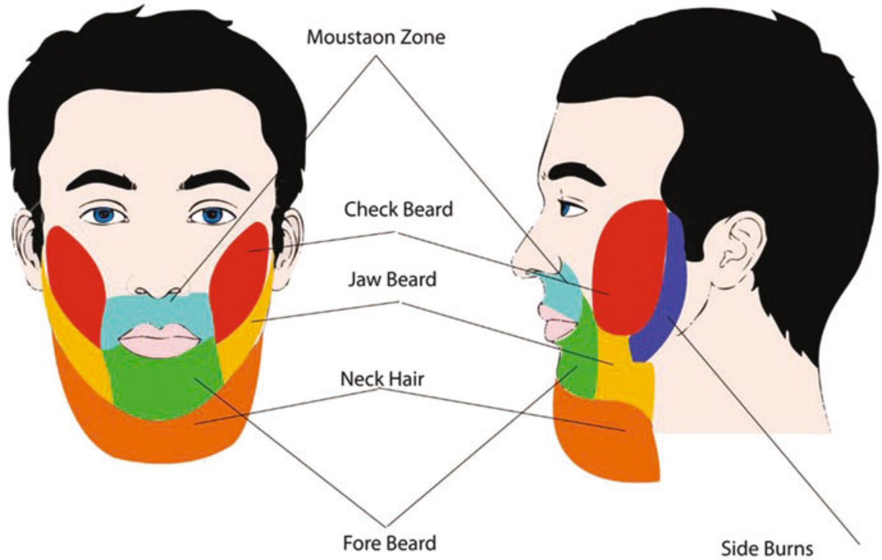

Fig. 60.1 Distribution of beard (Fig. Courtesy: Kapil Dua)

commonly classified it into three zones: moustache, goatee (fore beard and neck hair), and cheek beard (cheek beard, jaw beard, and sideburns).

60.3.2 Morphology of Beard Hair

Tolgyesi et al. performed a comparative study on the morphology and chemistry of beard and scalp hairs in Caucasian, African, and Chinese populations. They concluded that beard hairs in all ethnicities are more elliptical and irregular in shape compared with the more circular or oval shapes of scalp hair. The beard caliber is also the largest of all human hairs and is 70–100% larger than scalp hairs with almost twice its cuticle layer [5].

60.3.3 Hair Cycle

When compared with other body hairs, beard hair has the longest anagen phase and shortest telogen phase, which is most similar to scalp hair [6]. The growth rate of beard hair is 0.35–0.38 mm/day, which is the fastest among all body hairs and almost the same as scalp hair [7].

60.3.4 Follicular Unit

West and South Asians have thick beards, while East and Southeast Asians have the sparsest beards even though the blood level of testosterone is the same.

Two hairs is the dominant follicular grouping in scalp hair, but most beard hair grows as a single follicle.

Follicular density varies widely in individuals as well as ethnicities, e.g., 20–50 FUs/cm^2 in Caucasians and 20–40 FUs/cm^2 in Asians as stated by Akaki and 45–50 FUs/cm^2 to 150–160 FUs/cm^2 in South Asians by Dua [8]. In addition, there are variations according to zones, e.g., the moustache is thicker than other areas, with the philtrum having the maximum follicular density.

60.4 Procedure

60.4.1 Initial Interview

Selection of a good candidate is important, and the underlying medical and mental problems should be assessed. Evaluating the patient's expectations is crucial because of the discrepancy between unrealistic expectations and actual outcome of the surgery, which might result in litigation.

60.4.2 Surgical Planning

There are numerous beard patterns, and it is crucial to determine the patient's preferred shape and density. There is no standard design; hence, every case should be customized (Fig. 60.2). Patients often bring in photographs of unshaven celebrities as examples, which should provide useful information. After the patient decides on his preferred design, the size of recipient area (A cm^2) is calculated by covering the area with plastic wrap, tracing the outline with a marker, and placing it on a graph paper to count the number of squares. The symmetry of the design can be checked when the plastic wrap is turned over and placed on the opposite side.

The average beard density is 25–35 FUGs/cm^2 in the cheek beard and goatee and 35–45 FUGs/cm^2 in the moustache. Assigning FUGs/cm^2 to be determined as D, then the required number of FUGs will be A × D, which is 400–500 grafts for moustache, 400–600 for the goatee, and 800–1000 for the cheek beard.

Fig. 60.2 Variation of beards (Fig. Courtesy: Kapil Dua)

60.4.3 Anesthesia

Infraorbital and mental nerve blocks with 2% lidocaine are recommended. For local infiltration, 1% lidocaine with 1:100,000 epinephrine in a ring block and 0.3% lidocaine with 1:300,000 epinephrine over the whole area are combined. Tumescent solution is not necessary. The face is a very sensitive area, and diazepam 10 mg PO or midazolam 5–7 mg IV with ice cube and vibrator are used to alleviate the pain.

60.4.4 Graft Preparation

Strip or FUE is employed depending on the patient's request. Donor hairs are routinely harvested from the mid-occipital area to obtain coarse hair and trimmed longer than those for the scalp. The harvesting process is similar to scalp hair transplantation.

FUT donor scalp is cut into one and two hair grafts, with the majority as one hair grafts. In FUE the author does not intentionally harvest one hair and two hair follicles, but rather two and three hair follicles are taken and are split into one hair graft under stereoscopic microscopes. Grafts are then kept in chilled saline.

Kuelachi advises using two hair grafts and paired FU grafts because scalp hair is thinner than beard hair [9], but the author prefers single hair grafts in Asian coarse hair.

60.4.5 Placing

Recipient sites are created with 22 or 21 G hypodermic needles for single hair grafts and 20 or 19 G for two hair grafts with loupe magnification. Two hair grafts should be placed only in the central area of moustache or goatee and blended with one hair grafts, and peripheral feathery zones should be covered with exclusively one hair grafts. Needles are covered with silicon sheaths for depth control. Most of the grafts are placed into premade slits, and then the remaining grafts are placed into the vacant spaces with stick-and-place as touch up. The direction and angle of the slits should follow the residual hairs. Stretching the skin by traction and countertraction facilitates this process because facial skin is very loose and mobile (Figs. 60.3, 60.4, 60.5, 60.6 and 60.7).

Fig. 60.3 Graft placement by hypodermic needle with silicon sheath

Fig. 60.4 Before (*upper picture*) and after (*lower picture*) in scarring alopecia prior cleft lip surgery

Fig. 60.5 Before (**a**), immediate post-op (**b**), and 1 year after transplantation of 1488 grafts (**c**)

Fig. 60.6 Before (**a**), immediate post-op (**b**), and 8 months after transplantation of 1434 grafts (**c**)

Fig. 60.7 Before and after hair, eyebrow, and beard transplantation

60.4.6 Postoperative Care

- Check up at 3–6 months
- Antibiotics as prophylaxis
- Analgesics for strip surgery
- No dressing in recipient sites
- Restriction on eating and chewing
- Shaving after 10 days

60.4.7 Complications

- Swelling and bruising are common but self-limited.
- There is always a chance of contamination though the incidence of folliculitis is rare.
- Pitting and ingrown hairs are not seen.

60.5 Conclusion

Aesthetic beard transplantation was not performed until follicular unit grafting was developed, due to the difficulty in obtaining pleasant results with large grafts. Currently, optimal aesthetic results can be achieved with specialized techniques coupled with a skilled team.

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Chapter 61
Pubic Hair Transplantation

Young-Ran Lee

61.1 Introduction

Pubic atrichosis, or hypotrichosis, is a frequent condition among Asian females [1–4]. Despite normal generative functions and sexual ability, females with pubic atrichosis or hypotrichosis experience psychological stress due to low self-esteem and social prejudice. Accordingly, the number of cases in which females suffering from such diseases choose hair transplantation in the pubic area has been increasing. Hair transplantation in the pubic area is considered a definitive treatment for pubic atrichosis and hypotrichosis, and it is the one and only permanent treatment that exists to date [2–5]. In this chapter, the author reviews the practice of hair transplantation using hair implanters in the pubic area.

61.2 Preoperative Assessment

Preoperative clinical considerations or surgical contraindications for pubic hair transplantation are the same as with hair transplantation in the scalp area [3]. The developmental stage of pubic hair is evaluated using Tanner's scale [6]. Tanner's scale divides the development of female pubic hair into five stages, ranging from atrichosis (PH1), a condition of having no pubic hair at all, to a typical female pubic hair pattern (PH5) [6]. There are no absolute criteria for the need to transplant hair in the pubic area. Instead, the decision to undergo the surgery is dependent upon the patient's sense for this condition.

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61.3 Surgical Technique

61.3.1 Donor Harvesting and Graft Preparation

During the procedures of donor harvesting and graft preparation for hair transplantation in the pubic area, the overall surgical technique is the same as with the methods used for hair transplantation in the scalp area using an implanter [3, 4, 7].

The author has used a strip excision in most cases and a follicular unit extraction (FUE) in a few cases. For FUE, the motorized technique was selected, and the 1.0 mm (inside diameter)-sized punch and continuous mode were used. Non-shaven extractions, in which the hair shafts for extraction were selectively cut to lengths of 4–5 mm, were performed. Since follicles extracted through the usual FUE technique with shafts 1–2 mm in length are prone to embedding under the skin, these are considered unsuitable for hair transplanting in the pubic area.

61.3.2 Design

61.3.2.1 Hair Pattern

Horizontal patterns are considered to have the shape closest to that of normal, natural female pubic hair [8]. Of the typical horizontal patterns, the author uses the modified horizontal pattern (escutcheon-like shape or fan shape), a pattern naturally modified according to the anatomical structure of the pubic area (Fig. 61.1a, b). The recommended outline extends 2–3 cm from the inguinal region and 1–2 cm above the pubic sulcus, and it connects the pubic area with a natural curve. Other pattern types include the modified rhomboidal type (Fig. 61.1c), the classical horizontal type, the diffuse type, and so on. In the author's previous study, the modified horizontal pattern was used for 87% of the cases, the modified rhomboidal type was used for 7%, the classical horizontal type was used for 4%, and other types were used for 2%. Drawing

Fig. 61.1 Pubic hair pattern. (**a, b**) Modified horizontal types. (**c**) Modified rhomboidal type

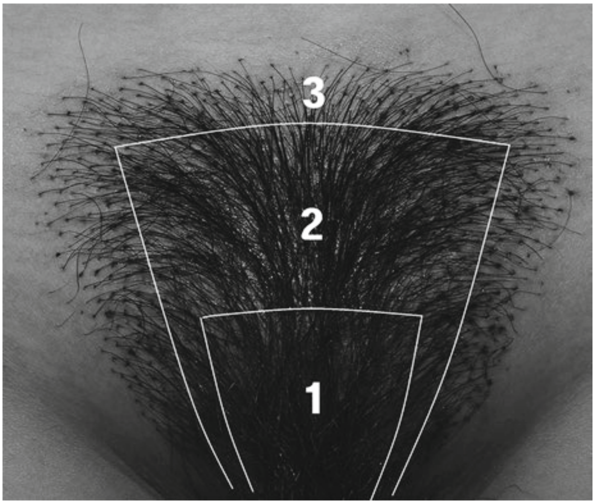

Fig. 61.2 Pubic hair design. (1) Central portion. (2) Middle portion. (3) Peripheral portion

methods and patterns proposed by the author are only suggested standardized guidelines; it is important to design suitable patterns according to circumstances, since the anatomical structure and status of the pubic area vary for each case [4, 5].

61.3.2.2 Density and Distribution

To maintain the density and distribution of the transplanted hairs, the pubic area was divided into three regions: central, middle, and peripheral (Fig. 61.2). The target hair count per region for transplantation was approximately 15–20 hairs/cm^2 for the middle region and 10–15 hairs/cm^2 for the central and peripheral regions [9]. However, the density of the transplanted hairs has to be adjusted according to the number of prepared grafts, the range of the recipient site, and the degree of hypotrichosis [4, 5].

61.3.2.3 Direction and Angle

The direction and flow of the natural pubic hair are almost in compliance with Langer's line, directed toward the upper pole of the labia majora [4, 5, 10]. Accordingly, the direction and flow of the transplanted hairs should follow this line as well. It is also desirable for the angle of the transplanted hairs to be identical to that of the natural hairs. Thus, according to Langer's line, the author inserts grafts at approximately 40° for the central region, approximately 20–40° for the middle region, and approximately 20° or lower for the peripheral regions [4, 5]. These are only recommended angles; it is desirable to adjust them depending on circumstances, since anatomical structures vary for each case.

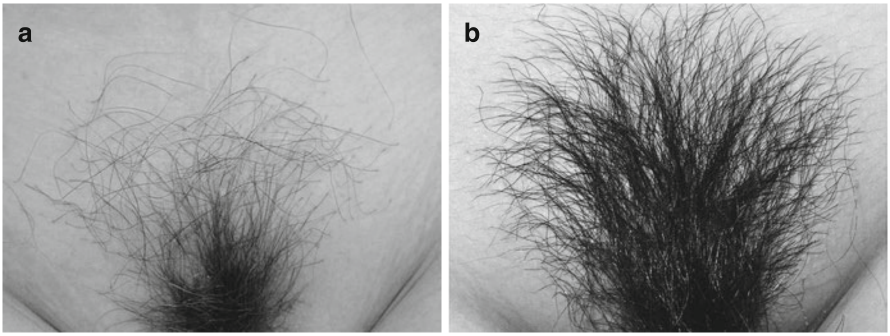

Fig. 61.3 Photos from before and after the procedure. (**a**) Before. (**b**) 12 months later

61.3.3 Graft Insertion

A combination method using micro-slits and hair implanters was adopted for the graft insertion procedures. Subsequently, 19G, 21G, and 23G needles were used to make slits according to the skin status or the size of the hair follicles, and a hair implanter (Follipen, LeadM®, Seoul) was used to insert the grafts into the slits.

For natural results, single-hair follicular units were transplanted in the peripheral region, and one- or two-hair follicular units were transplanted in the remaining regions. Due to local characteristics, such as skin texture and turgor, creating slits contributed to the setting of accurate angles and directions, as well as to the prevention of popping in the hair transplantation. The author prefers a no-touch technique for the following reasons. First, implantation time can be shortened. Second, the transplantation is convenient, regardless of the small size of the slits. Third, bending and crushing can be minimized. Fourth, the follicle placement is more accurate [4, 5]. Preoperative and postoperative pictures are as follows (Fig. 61.3a, b).

61.4 Postoperative Period

61.4.1 Postoperative Progress and Care

Postoperative progress and donor wound care are in accordance with hair transplantations in the scalp area [11]. Postoperative care for the pubic area is as follows: Gauze should be fixed to the area of transplantation with an elastic adhesive band for 2 days. Since the grafts transplanted in the pubic area, compared to grafts in other areas, are not easily fixed, occlusive dressing is adequate [4]. Follow-up observations should be made after 2 days, 10 days, and 1 month.

61.4.2 Potential Complications

Overall complications of hair transplantations in the pubic area are similar to those of hair transplantation for androgenetic alopecia [11, 12]. Hair transplantation in the pubic area has a higher potential for folliculitis and epidermal cysts and lower survival rates than hair transplantations in other areas. The occurrence of folliculitis and epidermal cysts is due to the higher tendency of pubic hair grafts being deeply inserted, as well as their higher tendency to be buried. In the author's experience, as a result of strictly performing de-epithelialization during the graft preparation process, preventing deep insertions during the graft insertion process, leaving the hair long enough on the graft, and removing buried grafts during the follow-up a month after the surgery, no cases of folliculitis or epidermal cysts have been found in surgeries operated in the last 10 years. These results suggest that the prevention methods described above can considerably decrease the occurrence of folliculitis and epidermal cysts.

61.5 Discussions

During puberty, pubic hair follicles are converted from vellus hair to terminal hair. Adrenal cortex and ovarian androgens cause females to begin and maintain such hair change [11–13]. The growth in pubic hair is only possible through low levels of adrenal androgens, and 5α-reductions are not required [14–16]. The reason for pubic atrichosis and hypotrichosis has not been clearly revealed, but genetic factors appear to be involved.

In the author's previous study, the serum androgen levels of the patient group with pubic atrichosis were not significantly different than those of the normal group. This suggests that the androgen effect does not relate to the circulating androgen level [4]. For patients with pubic atrichosis or hypotrichosis, a deficiency of androgen receptors or androgen insensitivity in the pubic hair follicle should be considered; this is likely inherited as a polygenic trait. In addition, there is racial predisposition to pubic atrichosis and hypotrichosis, which are common among Asian women [1].

Pubic hair manifests in a curled-up shape that twists along the axis. The average length has been measured to be approximately 60 mm [17]. Furthermore, while cross section of scalp or body hair is normally round or oval in shape, cross sections of axillary and pubic fibers are contorted. These characteristics facilitate the distribution of apocrine secretions across a wider surface [18].

In the author's previous study, hair transplanted in the pubic area showed lower growth rate than that of scalp hair ($p < 0.05$), though the hair shaft diameters showed no statistically significant difference [5]. This result suggests that the growth rate in a recipient area is influenced by the recipient area. One possible reason the growth rate of transplanted hair is lower than that of the scalp hair transplants is environmental differences, such as vascularity, blood flow, and skin depth [19, 20]. However, further investigation into the influence of the recipient area on the survival and growth of transplanted hairs is recommended.

61.6 Conclusions

At present, hair transplantation in the pubic area is the only permanent treatment for pubic atrichosis and hypotrichosis, and it is the most suitable solution for reducing patients' emotional distress. It is essential to understand the patterns of natural pubic hair and its normal physiologic features in order to design natural and realistically appearing transplanted hair. In addition, to design an abundant look, it is desirable to transplant one- and two-hair follicular unit grafts rather than simply single-hair grafts.

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Chapter 62
Body Hair Transplant

Kapil Dua, Aman Dua, and Monica Chahar

62.1 Body Hair Transplant

Since the beginning of hair transplantation, both the physician and the patient have yearned for a natural density of hair on the scalp. In order to achieve this, physicians have worked hard to stretch the limit of the number of grafts harvested from the scalp, from hundreds to thousands of grafts. Yet, there remain patients who want more density or in whom prior transplants have not worked well, and there are insufficient grafts available from the scalp. In such cases, the only alternative is to harvest grafts from parts of the body other than the scalp. Although body hair can result in adequate coverage of the scalp, cosmetic results are unpredictable. Thus, proper knowledge of the pros and cons of body hair transplantation must be known by the surgeon before undertaking this procedure.

62.1.1 Does Transplanted Body Hair Grow?

Transplanted body hair does grow [1] (Figs. 62.1 and 62.2), but different areas of the body have different success rates. These grafts grow when transplanted to the scalp because they do not have the receptors which respond to dihydrotestosterone (DHT), which is primarily responsible for miniaturization of the hair (donor site influence) [2]. The authors have utilized grafts from practically all areas of the body

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Fig. 62.1 Before body hair transplant

Fig. 62.2 After body hair transplant

including the face, chest, abdomen, pubis, legs, arms, and the back. Of these areas, beard gives the best results possibly because it has the largest percentage of hair in the anagen phase after the scalp (70%). Beards usually grow as single hair units, have a rapid growth rate, are relatively coarser, and grow for a longer duration than other sources of body hair. The second best harvest area is chest hair, which also grows primarily as single hair units but sometimes two and very rarely three hairs in a unit as well. Chest hairs tend to be thinner and curlier compared to beard [3]. Although it is possible to extract and implant hair from other body areas also, the success rate is variable because of different anagen to telogen ratios [4].

62.1.2 Does Body Hair Grow as Long as Scalp Hair?

Normal body hairs are finer, coarser, curlier, or straighter than scalp hair and grow to a shorter length compared to the scalp hair, but when they are implanted into the scalp, the morphological character of the body hair changes under the influence of the scalp. The hairs have an increased growth rate and also tend to grow longer due

Fig. 62.3 Before body hair transplant

Fig. 62.4 After body hair transplant

to the phenomenon of "recipient site influence" demonstrated by Tommy Hwang [5]. In fact, the authors have observed that transplanted body hair placed alongside scalp hair grows in such a way that it is difficult to differentiate between them. The length of the transplanted body hair is less, but in the experience of the authors, they blend very well with hair transplanted from the scalp (Figs. 62.3 and 62.4).

62.1.3 What Are the Indications for Extraction of Body Hair?

Some of the common indications for body hair transplantation are listed below [4, 6]:

1. Patients with poor donor area of scalp
2. Transplantation in certain areas like eyebrows and temple region where finer and shorter length body hairs may be preferred
3. To reconstruct small areas of baldness in the beard where beard can be utilized

4. To cover scars arising from previous strip surgery on the scalp
5. To cover previous FUE sites in the scalp donor area

62.1.4 Which Type of Body Hair Should Be Utilized for Reconstruction of Specific Regions?

Choosing the source for body hair transplantation depends on the objective we are trying to achieve. If we are looking for maximum yield and density, then beards are the best source as described above. However, for certain areas like eyebrows and the temple region, where a cosmetic match is the main aim, some surgeons prefer finer and shorter leg hairs. The authors do not use leg hair alone as the result is unpredictable [4].

62.2 What Is the Procedure for Extraction?

The technique used to harvest grafts for body hair transplantation is follicular unit extraction or FUE. However, there are certain differences in technique for extracting body hairs compared to extracting scalp hair grafts, beginning with the preparation of the donor area. The authors recommend a wet shave of the donor area against the direction of hair growth at least 2–3 days before the procedure to identify hairs in the anagen phase [4, 7]. The anagen hairs appear robust in length and diameter when compared to other hairs, so it is easier to extract these grafts.

62.2.1 Local Anesthesia

Local anesthetic infiltration in the body donor areas may be quite painful. Hence few modifications are advised to reduce the discomfort. The donor area is usually large in body hair transplantation; therefore the authors prefer to give a field block.

62.2.1.1 Beard Area

In the beard area (Fig. 62.5), we start by giving a field block with 1 mL of 1% lidocaine with 1:100,000 adrenaline along the angle of the mandible on both sides and then injecting 5–6 mL of the same solution medially along the lower border of the mandible above and inferiorly along the lower part of the beard. Then 3–4 mL of 1% lidocaine is injected in the shadow area of the beard from where the grafts will be extracted. Finally, 10–12 mL of saline is infiltrated in the donor area to increase turgidity, which facilitates entry of the punch.

Fig. 62.5 Local anesthesia in beard area

Fig. 62.6 Administration of local anesthesia over the chest

62.2.1.2 Chest Area

In the chest area, anesthesia is started by injecting 1 mL of 1% lidocaine with 1:100,000 adrenaline in the intercostal area on one side of the sternum and then injecting laterally until reaching the lateral border of the pectorals muscle. Saline is next infiltrated to increase the turgidity as mentioned earlier (Fig. 62.6). The same procedure is repeated on the other side when the grafts are ready to be extracted from that side. Finally, the saline is injected to increase the turgidity in that area.

62.2.1.3 Procedure of Extraction of Body Hair

In addition to the specialized anesthetic techniques used for body hair transplantation, the extraction techniques also need to be modified for each body area from which grafts are to be extracted. The authors use the motorized FUE technique and adhere to a number of general principles. We use a sharp punch, as it is very difficult

Fig. 62.7 Beard hair grafts having single follicle

Fig. 62.8 Shorter punches used for body hair extraction

to extract grafts with a dull punch due to the increased force required for penetration. In addition, we prefer shorter punch shaft sizes, such as 2.5–3 mm for the chest and 3–3.5 mm for the beard, as the grafts are more superficially located in body areas and deeper penetration will transect the grafts. We also prefer to use smaller diameter punches, such as 0.75–0.8 mm, as the body hair grafts usually consist of single hair, and a very low motor speed of approximately 500 rpm (Figs. 62.7 and 62.8). In the authors' experience, the follicular transection rates tend to be on the higher side (5–10% for beard and 10–20% in chest) when compared to extraction of scalp hairs. The exit angle of the donor hair is very acute in the chest, legs, and the lower part of the beard, so much care is needed while aligning the punch. The advancement of the punch into the body skin is kept superficial, whereas, beard hairs are relatively deeply seated so a slightly longer punch is used. Adequate infiltration, countertraction by the assistant, proper alignment, and superficial advancement of the punch are all required to extract intact grafts.

62.2.2 Extraction from Beard

For beard extraction, the patient is placed in the supine position. The neck is extended by placing support under the shoulder blades (Rose position) [8]. The authors stand or sit on the right, middle, or left side of the patient depending upon the area from where the grafts are to be extracted. The extraction is performed from the undersurface of the beard area. The motor is started at a very low speed (400–500 rpm), and the assistant stretches the skin to facilitate the entry of the punch into the beard. We score only superficially, and the graft usually pops out as the dermal-subdermal adhesions are very weak compared to that of the scalp. It is

Fig. 62.9 Chest hair grafts

easiest to extract the grafts from the areas where there is bony support available such as the lower border of the mandible. The authors score the grafts in an alternating fashion so that the hypopigmented dots (if any) do not coalesce, thereby limiting the number of grafts from beard to around 1000 as opposed to that of 2000–3000 grafts from beard in Caucasians. The speed of extraction is around 500–800 grafts per hour, and the survival rate after implantation is typically between 60 and 100% [1].

62.2.3 Extraction from Chest

For chest extraction, the patient is placed in the supine position, and the surgeon sits or stands on either side depending upon his or her preference. After administering local anesthesia and infiltration of saline, the authors prefer to start the extraction of the grafts from the area which has good underlying pectoralis muscle support. The area above the sternum is avoided due to a higher risk of scarring and discomfort. Chest hair grafts are usually single hairs, and the extraction speed is around 300–400 grafts per hour. In authors' experience, the chest hairs have a growth survival rate of around 50–60% (Fig. 62.9). Back and leg hairs are used less frequently as the duration of the anagen phase is shorter in these areas (Table 62.1). Leg hairs are also fine and relatively fragile; thus the transection rate is increased. In the abdomen region, there is no underlying support, so extraction is relatively more difficult. The expanding needle concept is of potential benefit in this area [9]. Pubic and axillary hairs are very rarely used as they require high expertise (Fig. 62.10). For implantation, the authors rarely use body hair alone. In a megasession of 3000–4000 grafts (2000–2500 grafts from the scalp and 1000–1500 from the body) for the frontal half of the scalp, the hairline zone is constructed using only scalp hair grafts (around 1500 grafts). Behind the hairline area, implantation is performed using scalp and body hair in a 1:1 ratio. The density is slightly decreased; body hair grafts are used when compared to using only scalp hair. If only body hair is available, then the authors prefers to use beard hair grafts in the more important areas as opposed to chest or any other sources due to the better reliability and yield of the beard hair. In that scenario, a lower density of around 25–30 FU/cm^2 is created to provide a better result as suggested by Cole [4].

Table 62.1 Characteristics of hair from various body parts [10]

Body site	% anagen	% telogen	Anagen duration	Telogen duration	Density (hairs) (cm^2)	Follicle depth (mm)
Scalp	85	15	2–6 years	3–4 months	350	5–7
Beard	70	30	1 year	10 weeks	500	2–4
Armpit	30	70	4 months	3 months	65	4–5
Chest/back	30	70	1–2 years	3–6 months	70	2–5
Arms	20	80	13 weeks	5 months	80	2–4
Legs	20	80	16 weeks	6 months	60	2–4.5
Pubic areas	30	70	4 months	3 months	70	4–5

Fig. 62.10 Leg hair grafts

62.3 Results

The yield from body hair transplantation is relatively less and more unpredictable compared to scalp donor hair. As mentioned previously, beard hairs provide the best and most consistent results compared to other body parts. Some patients have undergone exclusively body hair transplantation with good results. However, other such patients also had poor growth, and as a result, the authors prefer to mix scalp and body hair as described above to give the most predictable results (Figs. 62.11, 62.12, 62.13, 62.14, and 62.15).

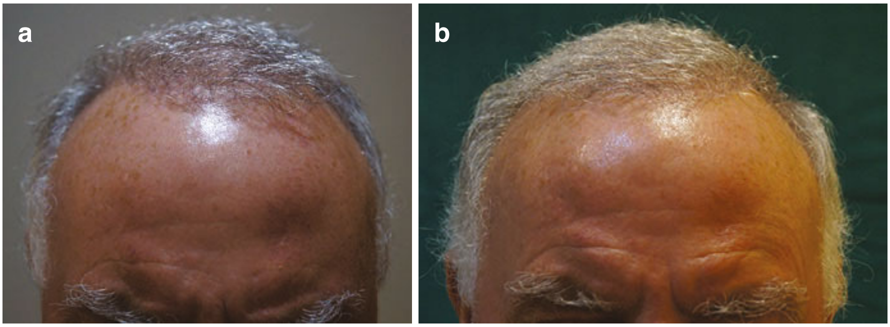

Fig. 62.11 (**a**) Patient I—front view (before). (**b**) Patient I—front view (after 1 year)

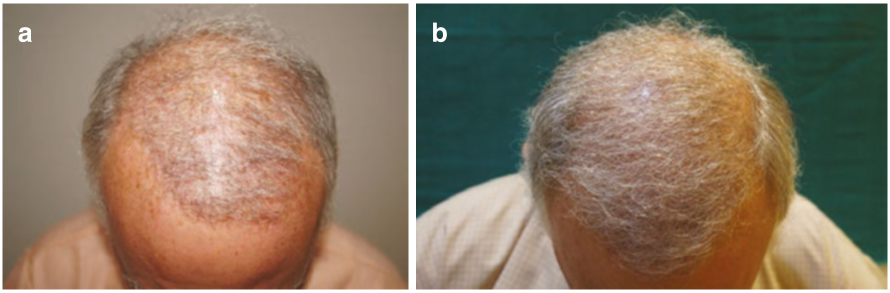

Fig. 62.12 (**a**) Patient I—top view (before). (**b**) Patient I—top view (after 1 year)

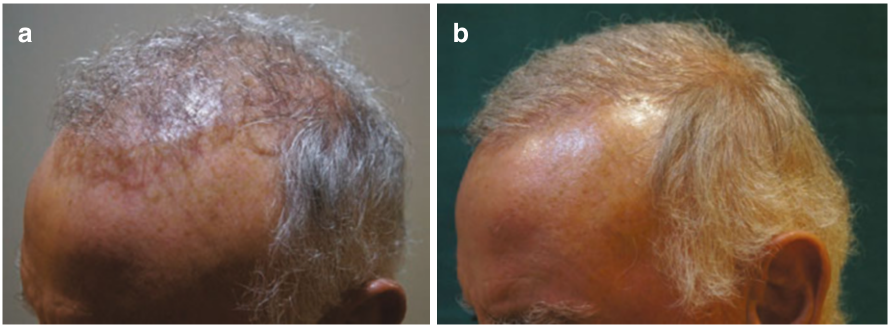

Fig. 62.13 (**a**) Patient I—side view (before). (**b**) Patient I—side view (after 1 year)

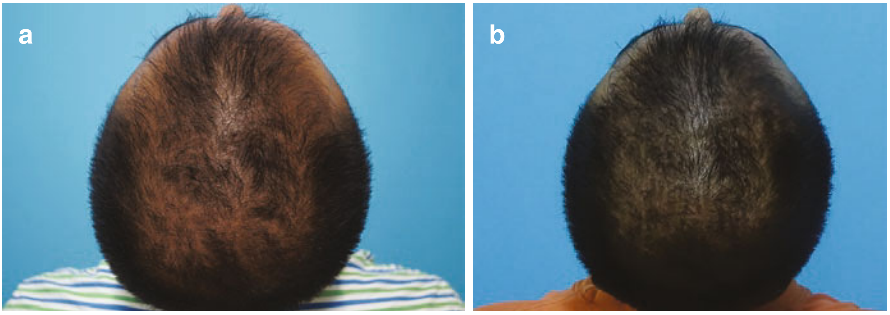

Fig. 62.14 (**a**) Patient II—back top view (before). (**b**) Patient II—back top view (After 5 months)

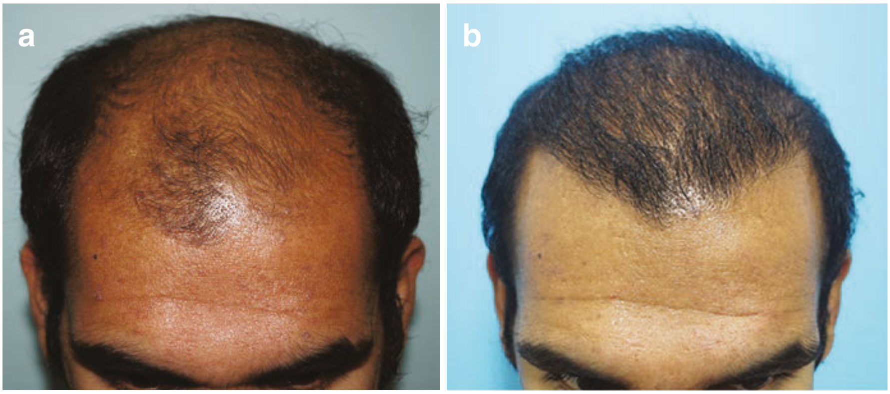

Fig. 62.15 (**a**) Patient III—front view (before). (**b**) Patient III—front view (after 1 year)

62.4 Summary

Body hair transplantation using the FUE technique is a novel and developing technique which provides new hope for hair transplantation in scalp donor-depleted patients. There is a relative lack of literature of cases of body hair transplantation, and more information is needed to gauge the long-term growth patterns with this approach. Because of high individual variations in the characteristics of body hairs, a test trial of few grafts from the body is recommended to evaluate results before performing large sessions.

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Chapter 63
Hair Transplantation to the Axillae

Kenichiro Imagawa

63.1 Background

Bromhidrosis is defined as a hereditary condition of excessive sweating (hyperhidrosis) accompanied by odors that originate in the apocrine gland (osmidrosis). The incidence of bromhidrosis in Asians is smaller than those of other ethnic groups, and the average rate in Japanese is approximately 10% [1]. Those who have bromhidrosis feel ashamed and unconfident and search for all options to improve and conceal the condition. There have been many attempts to relieve the condition, but the minimally invasive approaches often don't satisfy patients, and therefore a radical approach like shaving method is widely performed in Japan. However, loss of axillar hair is associated with the odor reduction, and this is embarrassing for some men due to the impaired masculine appearance. Many physicians think this is an inevitable consequence of surgery, and patients should accept this situation. Hair surgeons are reluctant to perform axillary surgery because of concerns regarding low yield, as the local skin has been handicapped against graft survival and the axillary region is connected to a movable joint making it difficult to immobilize the grafts.

63.2 Correlation Between Hair Regeneration and Shaving Level

The shaving method is performed as follows. A small incision about an inch is made along the axillary crease, the skin is turned over and pushed up by fingers, and then apocrine glands and hair follicles are removed with scissors to leave the skin in split

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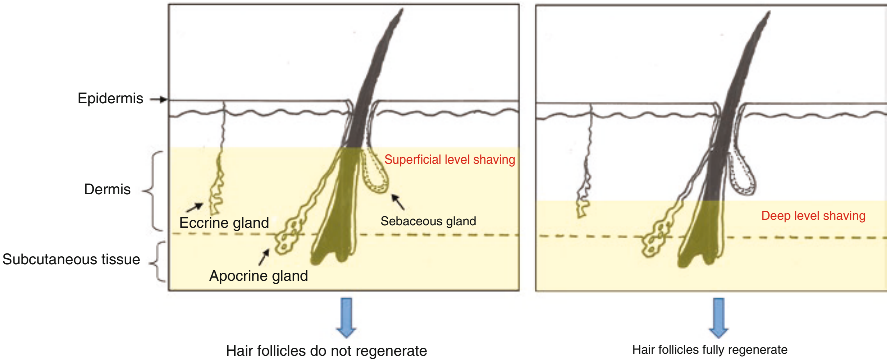

Fig. 63.1 Subcutaneous tissue shaving level (Inaba M and Inaba Y). Axillary hairs regrow when shaving level is below the infundibulum, and axillary hairs are lost when shaving level is up to the infundibulum (the *yellow shade* is shaved)

thickness. Inaba noticed that axillary hairs regrew when the shaving level was below the infundibulum (thick split-thickness skin graft level) and were permanently lost when subcutaneous tissue is completely shaved up to the infundibulum (medium split-thickness skin graft level). He utilized two techniques: the first was a deep level shaving for males that preserved hairs, and the second was superficial level shaving for females to destroy hairs. However most males were still troubled with odor, meaning the surgeon must ask the patient to choose between preserving hair or terminating odor (Fig. 63.1). Inaba later concluded that the stem cells of hair follicles were located in the region of the "bulge" and not the "bulb"; however, it took a long time for his theory to win recognition [2].

63.3 Facts About Axillary Hair

- Armpits contain one- and two-hair follicles and the majority are one-hair follicles.
- At puberty, the axillary vellus hair transforms into terminal hair under the effect of androgens, and growth rate is 0.3 mm/day.
- The distance from the epidermis to the dermal papilla is on average 4–5 mm, compared to 5–7 mm for scalp hair.
- Anagen/telogen ratio is 30 and 70%, and the duration is 4 and 3 months.
- The density of hairs is 65/cm^2 [3, 4].

63.4 Procedure

63.4.1 Initial Interview

Patients should be warned regarding the low yield, and optimal results should not be promised. The author recommends a lower graft density or a test session. Interestingly the majority of patients ask: "Doc, do you have other patients like me?" or "How many cases have you done before?". The author replied that "I've encountered about 50 patients and performed about 30 cases over 20 years, and fortunately none have complained about the results."

63.4.2 Surgical Planning

The outline of the recipient area is traced with a marker. The size is measured, and average planned density is 20–25 FUGs/cm^2.

63.4.3 Anesthesia

Local infiltration with 0.5% lidocaine with 1:100,000 epinephrine ring block combined with 0.3% lidocaine with 1:300,000 epinephrine in a field block is performed. The author uses ice cube and vibrator to relieve the pain before injection. Diazepam 10 mg PO or midazolam 5–7 mg IV is routinely given.

63.4.4 Graft Preparation

Strip or FUE is harvested depending on the patient's request. Donor hairs are routinely harvested from the mid-occipital area to obtain coarse hair, and the harvesting process is similar to scalp hair transplantation. Whether FUT or FUE, two- and three-hair grafts are split into one- and two-hair grafts under the microscope.

63.4.5 Placing

Recipient sites are created with 21 G hypodermic needles for one-hair grafts and 19 G for two-hair grafts with loupe magnification. Two-hair grafts should be placed in the central area, especially into the scar, while the peripheral zone should receive one-hair grafts. Depth control is critical, and needles are covered with silicon sheaths to prevent too deep insertion (Fig. 63.2). The author prefers premade slits and then sticks and places at the end (Fig. 63.3).

63.4.6 Postoperative Care

After placing is completed, patient should lie on operation table for 30 min while the recipient areas are completely blow-dried with hair dryer. The author formerly used medical glues to immobilize the grafts but stopped using them because it was too sticky.

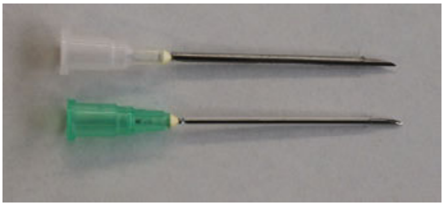

Fig. 63.2 Hypodermic needles for creating slits. Needles are covered with silicon sheaths to control depth of insertion

Fig. 63.3 Immediate postoperative

Telfa strips with K-Y jelly and gauze are applied, and the patient is instructed to keep the arm away from the armpits for at least 3 days.

Antibiotics are given as prophylaxis along with analgesics for pain.

The patient must return the following day to remove the dressing and check for lost grafts. Shampooing is started from the third postoperative day, and a touch-up can be performed at 6 months postoperatively when necessary.

63.5 Complication

- Swelling and bruising are common but are self-limited.
- The incidence of infection is rare.
- Inflammatory process of grafts inserted too deep is common.
- Low yield.

63.6 Result

Before (Fig. 63.4)

Patient underwent shaving method and scar revision.

9 months post-op (Fig. 63.5)

Sixty-six single-hair grafts and 170 two-hair grafts were transplanted.

Fig. 63.4 After bromhidrosis surgery with scar at the axilla

Fig. 63.5 After hair transplantation to the scar at axilla

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Part XI
Selected Categories in Hair Transplantation

Chapter 64
Hair Transplantation in Mainland China

WenYu Wu and JuFang Zhang

64.1 Historical Development

Hair transplantation in China has gone through three stages, namely, the early stage, the developmental stage, and the booming stage.

64.1.1 Early Stage (1980–1995)

Modern hair transplant surgical techniques were first developed in China in the 1980s. Dr. Shan Chang Wang, one representative of the first generation of Chinese hair transplant physicians, reclaimed the virgin land of Chinese hair transplantation. After studying at the Cleveland Clinic hair transplant center in 1985, Dr. Wang introduced hair transplant techniques to China and refined hair transplant equipment to make them suitable for Chinese hair loss patterns. This achievement won him third prize in the Shanghai Science and Technology Progress Award and the Shanghai Clinical Medical Achievement Award. His first written paper titled "Hair transplantation and scalp reduction for treatment of baldness: clinical analysis of 276 cases" was published in 1991 in the Chinese Journal "Journal of Oral and Maxillofacial Surgery" as the first paper in the Chinese hair transplant field [1]. Other doctors in Shanghai and Beijing then entered the field of hair transplantation.

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Unfortunately, however, physicians during this time failed to advance techniques forward and introduce new developments due to poor international communication and limited spreading of hair transplant techniques, delaying progress.

64.1.2 Development Stage (1995–2008)

In the 1990s, more dermatologists and plastic surgeons devoted themselves to hair transplantation. Private hair transplant clinics and hospitals emerged, which greatly promoted the development of the Chinese hair transplantation. From1995 through 2000, several papers were published in the Chinese Medical Journal written by dozens of teams [2–5]. Regarding hair transplant techniques, the early 4 mm punch technique developed into microtissue grafting. In 1998, follicular unit transplantation (FUT) was introduced in China, and in 2000, the first Chinese FUT paper was published [6]. Indications for hair transplantation expanded to include not only the treatment of androgenetic alopecia but also restoration of scars, eyebrows, eyelashes, beard, pubic hair, and other body hair loss, as well as the reconstruction of female hairline [7–10]. A large number of papers were published during this time.

64.1.3 Booming Stage (2009–Present)

The follicular unit extraction (FUE) technique was introduced into China in 2009 and rapidly became popular due to advantages of FUE, including a more suitable distribution of hair follicles for the Asian population, less trauma, more rapid recovery, and lesser requirements for the team members. Currently, hair transplantation in China has entered a period of prosperity [11–13]. According to incomplete statistics, the Chinese hair transplantation market is growing at an annual rate of 15–20%. The market size of Chinese hair transplantation has increased from 19.4 billion RMB in 2006 to 67.5 billion RMB in 2013. There are more than 1000 hair transplant institutions and dozens of growing chain organization in China.

64.2 Present Situation

Despite the rapid development of plastic surgery and dermatologic surgery, most clinicians prefer to perform quick, economic procedures. Because hair transplant procedures are quite time-consuming, relatively few physicians practice in this field. There are about 200 million hair loss patients and a great demand for hair transplant experts. The following table shows the ratio of hair transplant physicians per million population as well as the existing hair transplant associations in the listed Asian countries (see Table 64.1) [14].

Table 64.1 Asian countries' hair transplant association establishment status table

Country	Ratio (physician per million population)	Association
India	2.5	Yes
Japan	5	Yes
Korea	26.6	Yes
Thailand	8.5	Yes
Philippines	1.67	No
Singapore	20	Yes
Mainland China	0.77	No

Currently, there are institutions specializing in hair transplantation in Beijing, Shanghai, Guangzhou, Hangzhou, Changsha, Chengdu, Shenyang, and other cities. However, the availability of medical staff is far from meeting the enormous demands of hair transplant surgery patients. Only a few physicians in Beijing, Shanghai, Hangzhou, and other big cities currently perform hair transplant surgery and even fewer in smaller cities, where hair transplant institutions are rare.

FUT remains the most popular surgical approach, as it can provide the largest number of transplanted hairs to cover significant areas of baldness, produces natural and aesthetic results, and achieves maximum density. However, the percentage of FUE procedures in China has increased annually due to the dispersed occipital scars, simple equipment, easy operation, and smaller team member requirements. In addition, there is only subtle occipital swelling, minimal pain after surgery, no sutures needed, and rapid healing.

In recent years, with the rapid development of Chinese hair transplantation, physicians and institutions have entered the booming phase. Surgeons continue to refine surgical approaches and operative techniques, which improve surgical outcomes and academic environment. Although China has not yet established a regional hair transplant association, there are study groups associated with the China Association of Plastics and Aesthetics, the Plastic Surgery Branch of the Chinese Medical Association, the Plastic Surgery Branch of Chinese Association of Integrative Medicine, as well as other academic organizations which hold annual academic meetings. In addition, the Cosmetic Surgery department of Hang Zhou First People's Hospital (Fig. 64.1) and the Dermatology Department of Huashan Hospital (Fig. 64.2) annually conduct hair transplantation continuing education classes, which are highly rated by participating students and exert great influence in hair transplant field.

There have been great breakthroughs in the development and availability of teaching materials for hair transplantation. The earliest Chinese book of hair transplantation, *Latest hair transplant techniques* [15], was published in 2006 under the direction of GuoDou Zhang and HuiMin Li. In addition, *Procedures in Cosmetic Dermatology Series: Hair transplantation* [16], published in 2010 by Haber and Stough and translated by Dr. WeiXin Fan, is the latest translation on hair transplant techniques and has had important significance bringing the latest world hair

Fig. 64.1 Zhejiang Province first session of hair transplantation education classes held by Hangzhou First People's Hospital in 2008

Fig. 64.2 Hair transplantation education classes held by Huashan Hospital Affiliated to Fudan University

Fig. 64.3 Main teaching materials for hair transplantation in China

transplant techniques into China. In May 2011, "Transplantation of hair follicular unit" [17] was published, edited by Zhang JuFang, a domestic physician with a great reputation, and filled a gap of domestic hair transplant training materials. Also, JuFang Zhang, ZhiQi Hu, and QiMing Zhao as chief editors compiled the cosmetic surgery series Vol. 7 *Hair restoration* (published in 2013) [14]. This is the first edition about hair restoration in this monograph series of cosmetic surgery in China, indicating that hair transplantation has gained a respectable position in the field of cosmetic surgery in China. Finally, "Fashion hair transplant technique," [18] published in 2010 and edited by XianMing Qiao, and "Latest FUE techniques - Practical micro invasive hair transplantation" [19] published in 2014 and edited by XianMing Qiao and HuiMin Li summarized the application and improvements of FUE in China (Fig. 64.3).

With the broad implementation of hair transplant techniques in China, physicians who practice this field have gradually reached out to Asia and the world. In June 2010, Prof. Jufang Zhang attended the Asian Association of Hair Restoration Meeting and communicated with hair transplant physicians from other Asian countries (Fig. 64.4). In September 2011, Prof. Zhang attended the19th Annual

Fig. 64.4 Prof. Jufang Zhang attended the Asian Association of Hair Restoration Meeting in 2010

Conference of the International Society of Hair Restoration Surgery in Anchorage, Alaska. She shared successful experiences with hair transplant physicians from all over the world and received favorable ratings from participants (Fig. 64.5). In May 2015, a joint delegation of Chinese hair transplant physicians participated for the first time in the Asian Association of Hair Restoration Meeting held in Bangkok, Thailand, giving six presentations in total and thus reflecting China's growing prominence in hair restoration in Asia (Fig. 64.6). Currently, 12 Chinese physicians are members of International Society of Hair Restoration Surgery (ISHRS), and more than 20 physicians are life members of the Asian Association of Hair Restoration Surgeons (AAHRS).

In summary, there is an increasing focus on appearance in current society. Hair transplantation as a primary surgical approach to improve appearance has gained recognition for its prominent efficacy, and the number of patients undergoing hair transplantation has increased considerably over the past few years. We definitely believe that plastic surgeons and dermatologists should move forward together to continue to improve hair transplant techniques for the benefit of our patients.

Fig. 64.5 Prof. Jufang Zhang attended the 19th Annual Conference of the International Society of Hair Restoration Surgery in Anchorage, Alaska, in 2011

Fig. 64.6 A joint delegation of Chinese hair transplant physicians participated for the first time in the Asian Association of Hair Restoration Meeting in 2015

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Chapter 65
Should We Do Hair Transplantation in the Poor Candidate?

Damkerng Pathomvanich

65.1 Introduction

Hair transplantation procedures are on the rise all over the world especially in Asian countries [1]. Many doctors are keen to add hair transplantation to their cosmetic practices, instead of referring to a hair specialist, in order to increase their revenue, but many do so without proper training. Unfortunately, there are only a limited number of fellowship training programs in hair restoration surgery available worldwide, and if interested, the reader can search for fellowship training information at www.ISHRS.org. The author is not sure why many experienced hair surgeons close their doors to those interested in training, instead of offering a fellowship training program for physicians who are interested in learning hair restoration surgery, as is routine in other medical subspecialties. The only alternative sources of training are hair workshops and hair meetings, followed by a return to the office to practice on patients and gain more experience. Unfortunately, this approach results in many patients with poor outcomes and complications, requiring patients to seek correction from more experience hands.

There is no accepted definition of who is a poor candidate for hair transplantation, other than a patient with an active serious medical condition. However, most hair surgeons would agree that those patients who have the following characteristics are poor candidates for hair restoration surgery:

1. Norwood VII
2. Diffuse thinning hair throughout the entire scalp
3. Very fine donor hair with limited donor resources

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4. Very low donor density, i.e., below 50 FU/cm^2
5. Large areas of scarring alopecia involving more than 60% of the scalp
6. Significant extent of miniaturized hairs

It would be best to refer the poor candidate to surgeons who have experience in treating these patients. If something goes wrong, it will be very difficult to correct due to limited donor supply.

Hair transplantation in general, either by FUE and FUT, can achieve good cosmetic results in good candidates who have minimum to moderate baldness with good hair density and quality and good scalp laxity in any racial subtype (Figs. 65.1, 65.2, and 65.3). However there are patients whose extent of baldness is very large (Fig. 65.4) and may not be suitable for hair restoration surgery, but yet they wish to have their hair loss restored, so what should we do?

The physician must first evaluate the poor candidate group to determine who might benefit from hair transplantation and then inform the patient that he or she must be realistic regarding the outcome, as results might not match their expectations. The patient must accept low density but will have adequate hair to frame the face. The patient also needs to be informed that there is no guarantee as to whether there will be enough grafts to cover the entire scalp. If the patient has good quality and density of donor hair despite extensive baldness, he might be a potential candidate for hair restoration surgery. If the scalp is loose, FUT is the first choice; if the scalp is tight, FUE is preferred or possibly a combination of FUT and FUE. Body hair might also be considered to add to the density if available at the end. However, the majority of East and Southeast Asians don't have as much body hair compared to South and West Asians. Multiple sessions are needed until either a cosmetically pleasing result is achieved or the patient runs out of donor hair.

The physician must inform the patient regarding medical treatments for hair loss including finasteride, topical minoxidil, ketoconazole shampoo [2], low-level laser therapy [3], and nutrition support (see Chap. 70).

Fig. 65.1 Before and after in Asian

Fig. 65.2 Before and after in Afro-American

Fig. 65.3 Before and after in Caucasian

Fig. 65.4 Patient with extensive hair loss (Class VII)

65.2 The Author Has Outlined the Treatment in His Practice as Follows

65.2.1 Option I: Nonsurgical Treatment

Do nothing. If the surgeon concludes that a patient has very extensive baldness, very fine donor hair, and low density, the result will not be optimal, and it would be best not to proceed with surgery.

Do something. If the patient still desires an improved appearance, he might consider wearing a hairpiece [4] (see Chap. 76). Another alternative option is to have scalp micro-pigmentation [5–7] (see Chap. 74).

65.2.2 Option II: Surgical Treatment

The surface area of the average Caucasian scalp is approximately 500 cm^2 (50,000 mm^2). Since the normal, non-balding scalp has 1 follicular unit/mm^2, and each unit contains on average 2 hairs (yielding a density of 2 hairs/mm^2), the average scalp would have 100,000 hairs in total. In Asians the number is lower.

Williams Rassman and Robert Bernstein reported the permanent zone normally represents approximately 25% of this area and half is available to be moved without the donor area appearing too thin. Thus, in theory, 12.5% of the scalp is available to cover the remaining 75% that could become bald. This donor area would contain 12,500 hairs or 6250 grafts, averaging 2 hairs per graft. If a patient's density is higher, then a greater proportion of the donor hair can be used for transplantation. If these grafts were uniformly spaced, this would produce a recipient density of at most 17% of the original density in Caucasians; however, in Asians the density is lower, as is the total number of grafts available [8].

What is the best solution?

Frame the face by creating a frontal forelock, either an isolated forelock (unacceptable to the majority of Asian patients) or a continuous forelock to both temporal fringes. There are different types of isolated frontal forelocks that the reader can explore in the Hair Transplant Forum International [9].

If the surgeon concludes that the patient has adequate donor hair and wants to proceed further, the hairline must be placed high. For the first session, the hair transplant is planned to address just the front to mid-scalp zones in order to frame the face, with a low density not to exceed 25 graft/cm^2. If the grafts are placed at a flat angle, the shingle effect of the hairs may create the illusion of more hair, but the surgeon must be aware of the surrounding native hair angle so the change will not be abrupt. The patient returns 1 year after surgery, and if he is happy with the outcome, a second session may proceed with grafts placed behind the previously grafted zones. Once these more posterior hair grafts grow in, they will enhance the hair at the front or vice versa depending on how the patient combs and styles his hair. The patient is reassessed once again 10–12 months later, and if the patient is happy, the physician must decide whether there is enough donor hair to place into the crown or to add additional density to the front or mid scalp. If the physician decides to proceed with transplanting the crown, the patient again must be informed of the potential for low density. Again, the patient is reassessed 10–12 months post-op, to determine the availability of more grafts. If not, scalp micro-pigmentation or topical hair fiber camouflage might be helpful to give the patient a look of a full head of hair (Fig. 65.5). The body hair has been used more and more to add density [10]; however, the majority of East and Southeast Asians don't have as much body hair as in South and West Asians. Some poor candidates, who respond to medical treatment, can become a good candidate for hair transplantation (Fig. 65.5).

65.2.3 Option III: Hair Transplantation + Hair Piece

Some patients desire a very thick and full head of hair, but unfortunately hair transplantation cannot achieve his goal. A patient may arrive with a hair system in place that has an unnatural hairline, requesting a hair transplant limited to the front in order to camouflage the hair system. The physician needs to design a

Fig. 65.5 Before and after in a patient who had extensive baldness and underwent multiple sessions of hair transplantation

Fig. 65.5 (continued)

hairline about 2–3 cm in width and then place the hair grafts as densely as possible to camouflage the hairpiece placed posterior to the hairline. The technique is the same as described in Chap. 37. The hair texture and color of the transplanted hairs must match the hairpiece or hair system in order to look natural (Fig. 65.6).

If the patient has a receding temple point to a reversed angle as in Mayer's temporal point classification [11], this hair loss cannot be covered except by a very large and unnatural by hairpiece. It is preferable to transplant a small number of grafts to both temples to frame the patient's face and utilize a smaller and more manageable hairpiece.

Fig. 65.6 Before and after multiple sessions in a patient who has responded to oral minoxidil and became a candidate for hair transplantation

65.3 Conclusion

In selected cases, a poor candidate with extensive hair loss can achieve an adequate cosmetic outcome in spite of low density and a high hairline. Therefore do not ignore this poor candidate group, but rather refer them to surgeons properly experienced in this aspect of hair restoration surgery.

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Chapter 66
The Keys to Achieving Optimal Results

Damkerng Pathomvanich

66.1 Introduction

Hair transplantation continues to develop and advance in its technology. The goal is to create a natural and undetectable outcome with optimal density and minimal scarring which can be achieved under a surgeon's experienced hand (Figs. 66.1, 66.2, and 66.3). There should be no pitting or cobblestoning, no pluggy look, and no poor hair direction [1–3] as seen in the early years of hair restoration.

Hair transplantation can be completed in just one pass with decent density in selected patients as seen in Fig. 66.4. However, things can go wrong when hair transplantation is performed by untrained or inexperienced practitioner, resulting in poor hair angle and direction as well as inadequate density and hair growth (Figs. 66.5, 66.6, and 66.7). As a physician we have to identify who is a good candidate for hair transplantation and who is not. On the other hand, the patient has to find the right doctor to perform the procedure. These go hand in hand to achieve optimal results.

66.2 Face-to-Face Consultation

Face-to-face consultation is very important since initial pictures sent via email correspondences might be deceiving and not clear enough, especially for those who have thinning hair and want to add density. It's possible that hair transplantation might not be feasible when these patients show up at the time of surgery, resulting in the cancelation of the procedure. This scenario results in a waste of time and

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Fig. 66.1 Before and after in male patient in one session

Fig. 66.2 Before and after in male patient with medication in three sessions

Fig. 66.3 Before and after in female patient in one session

money for both surgeon and patient, including travel and lodging costs for a long-distance patient.

During the personal consultation, vital signs must be taken, especially blood pressure and pulse rate. There have been a few instances when I had to cancel surgery in patients with elevated blood pressure at the time of the procedure, when the nurse failed to take vital signs at the time of the consultation.

A thorough history of the patient's hair loss, including duration and genetic pattern in both maternal and fraternal sides, is also mandatory. Identifying the use of any medication that might potentially cause hair fall or any medical treatment for hair regrowth is important. Smoking and drinking are also of concern for post-op

Fig. 66.4 Before and after in one session

Fig. 66.5 Pitting hair grafts

wound healing especially in megasessions. Heavy smokers might have poor or delayed wound healing, and heavy alcohol drinkers might experience excessive bleeding intraoperatively. Any history of back pain is worth noting as this will predict if the patient can withstand long hours lying down. Patients with body dysmorphic disorder [4] should also be identified. In addition, the patient should be asked about his overall general health in detail (Table 66.1).

Fig. 66.6 Poor hair direction

Fig. 66.7 Grafts were transplanted in row with unnatural look

Table 66.1 Notes on history taking

Hair loss history • Duration • Genetic pattern—maternal and fraternal side
Personal history • Smoking • Alcoholic beverage drinker
Medical history • Blood thinners—aspirin, clopidogrel, heparin, others • Supplements—omega-3-fatty acids (fish oil), vitamin E, gingko biloba, others • Genetic bleeding disorders
Psychiatric history • Body dysmorphic disorders

Table 66.2 Physical examination

Preexisting scalp lesions • Alopecia areata • Seborrheic dermatitis • Basal cell carcinoma
Hair characteristics • Color • Caliber—fine vs. coarse hair • Wavy/straight
Hair-to-skin color contrast
Hair pull test
Search for hypertrophic or keloid scars

66.3 Physical Exam

Physical exam involves taking a good look at the patient first in general and then look over the entire scalp noting any preexisting lesions that need to be treated such as alopecia areata, basal cell carcinoma, and seborrheic keratoses. Take note of hair characteristics like caliber, bearing in mind that patients with very fine hair might not provide a good density and may not be good candidates for surgery [5]. Very coarse hair on the other hand might look pluggy and unnatural if transplanted at the hairline. Check also for hair color and skin contrast and whether hairs are straight, wavy, or extremely curly. Perform a hair pull test to elicit active hair loss. Searching for scars over the scalp and other areas will give you a clue if the patient has a tendency toward keloid scar formation (Table 66.2).

Once the physical examination is completed, the length of donor area is measured; the hair density at the temporal, parietal, and occipital regions is taken with a video microscope [6]; and measurement of scalp laxity is performed using Mayer's scale [7]. The scalp is then sprayed wet with sterile water and combed to see the extent of hair loss. The entire potential permanent donor area is marked, and the balding recipient area is also marked and measured as well using the Chang method [8, 9]. If the patient needs to restore the hairline, it first needs to be drawn and modified until the patient and the surgeon agree on the design, and then measurement follows. Now we have the ratio of the donor and recipient areas for assessment and the necessary information from the physical examination for discussion with the patient if he is a good candidate or not a candidate at all for hair transplantation. Last but not least, the patient needs to be informed that hair loss is an ongoing process like aging; hence medical treatment to delay the hair loss is highly recommended (see Chap. 68 for medical treatment of hair loss).

66.4 Candidate for Hair Transplantation

We classify patients for hair transplantation as follows:

I. Excellent candidate:

– Classes II to IV and IIa, who has good donor hair

II. Good candidate:

– Classes IV–VI who has good donor density and scalp laxity

III. Poor candidate (see Chap. 65):

– Class VII: If the patient still has good donor hairs, it might be enough to create the forelock and mid scalp only.

IV. Not a candidate for HT:

– Patient with extensive hair loss or diffuse thinning hair with very low donor density, very fine hair, or more than 20% of miniaturized hair at donor area [10] (Fig. 66.8).

Note that hair loss is progressive; thus Class II patients might progress to Class III or VI with age. If the patient is an excellent or good candidate with good donor hair, he is expected to achieve a good result in good hands. Hairline placement should be high enough to frame the face properly to reducing the balding surface area, thus reducing the number of grafts required for decent look.

Fig. 66.8 Not a candidate for surgery

66.5 Other Important Pearls to Note in HT

- Minimize transection from harvesting whatever technique is used.
- Select a good storage solution.
- Reduce out of the body time for the grafts by making premade incision first.
- Have experienced placers insert the grafts.

As previously stated, there is no single technique that fits the concerns of all patients. With this era of FUE posing as a minor surgery with fast recovery and no linear scars, more than half of the patients insist to go with FUE even for Class VII, resulting in too many patients with poor results and diffuse hair thinning over the entire donor area.

I'm not quite sure how many grafts can be extracted via FUE in Asians without causing diffuse thinning of hair in the donor area. In my experience, after harvesting more than 3000 FUE grafts in an Asian, I don't want to harvest any more out of fear of producing diffuse thinning in the donor area and resulting in an unhappy patient. I was informed by an experienced FUE surgeon that the end result of FUE is diffuse thinning at donor area or a uniform density over the entire scalp. I'm not sure whether this is acceptable among most hair restoration surgeons. I believe for those who have extensive hair loss, FUT should be performed first at least for a few sessions and then followed up by FUE or preferably perform a combination of FUT and FUE [11].

66.6 Conclusion

- Successful hair transplantation can be achieved in properly selected patients (Fig. 66.9) (classified as to whether he or she is a good candidate).
- Class II to VI with good donor hair most likely will achieve optimal results if performed by an experienced surgeon.
- FUE or FUT can both be used effectively in early-stage baldness.
- In the poor candidate (Class VII), frontal forelock should be done first followed by the top if there is still donor hair available. These cases are best handled with FUT first. FUE may be performed for the remaining area if FUT is no longer feasible.
- The use of body hair as an adjunct may be employed if available.
- Be careful of patients with body dysmorphic disorders since these patients will never be happy.

Fig. 66.9 Before and after in good candidate patient

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Chapter 67
Should Hair Transplantation Be Performed in Scalp Psoriasis?

Vaggu Anand Kumar

67.1 Introduction

Psoriasis is a chronic, relapsing inflammatory papulosquamous skin disease. Its prevalence in different population varies from 0.1 to 11.8% [1]. Hair restoration surgery in psoriatic skin is challenging. Surgeons would prefer to avoid incising affected skin due to the potential for aggravating psoriatic lesions (Koebnerization) or producing poor wound healing and increased wound infection due to colonization of *Staphylococcus aureus* in psoriatic lesions [2]. In this chapter, recommendations for hair transplantation in psoriasis patients and also recommendations for the use of anti-psoriatic therapy in the perioperative phase are discussed.

67.2 Recommendations for Hair Transplantation in Psoriasis Patient

There are many studies in orthopedic and podiatric literature regarding surgical procedures like hip or knee joint replacement, osteotomies, arthroplasties, and joint manipulation with respect to psoriatic arthritis [3–5]. Pathomvanich et al. [6] reported a study on hair transplantation in seven cases of psoriasis. In their study, only one of the seven patients developed Koebnerization (Fig. 67.1). No infections were noted at either donor or recipient areas. Normal donor healing occurred in all

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Fig. 67.1 (**a**, **b**) Preoperative Norwood class III vertex. (**c**) Immediately after donor closure. No psoriatic lesions present at both donor and recipient areas. (**d–f**) Erythema, pustules, and crusting developed over both donor and recipient areas (these photographs were mailed by the patient). (**g**, **h**) Excellent growth of transplanted hair at frontal area and vertex. (**i**) Psoriatic lesions developed (Koebnerization) over the left parietal area and also along the scar after subsiding reaction

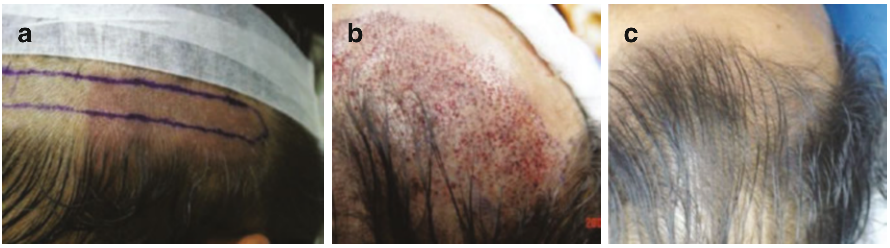

Fig. 67.2 (**a**) Ill-defined psoriatic plaque incorporated in donor area. (**b**) 512 grafts prepared from psoriatic lesion were transplanted on the right frontal area. (**c**) Excellent growth of grafted follicles after 9 months

patients, even in a patient where the skin incision was taken at the edge of a psoriatic plaque in donor area. No complications resulted from incorporating psoriatic skin in the donor strip, and the transplanted grafts prepared from affected skin showed excellent growth (Fig. 67.2).

The risk of Koebnerization was much lower than anticipated, possibly due to the mild and subsiding nature of the psoriasis in their cases, as well as due to the incorporation of triamcinolone in the recipient tumescent anesthesia to mitigate the development of the Koebner phenomenon. Though Koebnerization was seen in one case, all the lesions subsided without any adverse effect on the outcome of the transplanted hair while on active treatment with methotrexate (Fig. 67.1). Additionally, in contrast to reported occurrences of wound infection in orthopedic studies, they did not notice any infection. The reason could be hair transplantation is a superficial surgical procedure and the scalp is richly vascularized.

Richard Shiell [7] stated, anecdotally, that all the lost hair returned back in his psoriasis patient even after a violent reaction with massive encrustation after hair transplantation. Eisenberg [8] reported one patient who developed psoriasis in the transplanted area.

If any psoriatic lesion is present in the donor area, it is prudent to treat the area for at least 2 weeks prior to hair transplantation [9]. However, apart from incision trauma, stress of surgery can also aggravate psoriasis as it is individualized. So, this phenomenon should be kept in mind in every psoriasis case, and the patient should be warned of possible risk of Koebnerization before the surgery.

67.3 Recommendations on the Use of Anti-psoriatic Therapy in Perioperative Phase

Topical therapy for both donor and recipient areas should be discontinued during the 2-week postoperative period [8]. Topical steroids should also be stopped 2 weeks postoperatively considering the potential for secondary infection, delayed wound healing, reduced collagen formation, and impaired angiogenesis.

According to a review by Hernandez and Robinson, [10] different approaches are required for different systemic agents. Methotrexate should be continued at the normal dose except in special situations like renal or hepatic disease or if the patient is diabetic or on glucocorticoids (above 10 mg per day), in which case it should be discontinued for 1 week before and after surgery. A similar protocol should be followed for cyclosporin. However, acitretin can be continued in the normal dose through surgery. Azathioprine should be discontinued on the day of surgery until 1–3 days after. There is no data for both mycophenolate mofetil and biological agents, so these are best discontinued 1 week prior to surgery and resumed 1–2 weeks after if there are no signs of infection.

67.4 Conclusion

Hair transplantation can be performed on psoriasis patients with prior consent and counseling for the possibility of Koebner phenomenon and with adequate management of psoriatic therapy perioperatively. Even if Koebnerization occurs, it will not affect the final outcome of hair transplantation.

Pearls for Hair Transplantation in Psoriasis

1. Hair transplantation can be performed in psoriasis.
2. Prior counseling about Koebnerization is important.
3. Even if Koebnerization occurs, it will not affect the final outcome of hair transplant.

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Part XII
Ancillary Treatment Modality of Hair Loss

Chapter 68
Current and Future Medical Treatment of Androgenetic Alopecia

Chang-Hun Huh

68.1 Introduction

Androgenetic alopecia (AGA) shows typical morphologic changes including M shape recession in the frontal area and vertex thinning. It occurs in both men and women. The key change of AGA is the thinning of hairs caused by miniaturization of hair follicles, not the shedding of hairs. As the terminology implies, androgens (male sex hormones), especially dihydrotestosterone (DHT), play important roles in the pathogenesis of AGA, but no exact pathogenesis has been proven so far. However, several medications are successfully used in AGA through various mechanisms.

68.2 5α-Reductase (5AR) Inhibitor

68.2.1 Finasteride (FNS)

5α-reductases (5AR), also known as 3-oxo-5α-steroid 4-dehydrogenases, are enzymes involved in androgen and estrogen metabolism. They play an important role in converting testosterone (TTT) into DHT. Because the affinity of DHT to the androgen receptor is ten times greater than that of testosterone, its androgen action is more potent.

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There are three isoenzymes of 5AR, 5α-reductase 1, 2, and 3. Type 2 5AR is found in hair follicles and is a key isoenzyme in the pathogenesis of AGA, although type 1 5AR is also found in the scalp. Finasteride inhibits type 2 and type 3 5AR, while dutasteride inhibits all three isoenzymes. Hair thinning by miniaturization of hair follicles is the main phenomenon of AGA and mediated by androgens, in particular DHT. Finasteride effects AGA by inhibiting the function of 5AR resulting in preventing the conversion of less potent testosterone to more potent DHT.

Finasteride has been demonstrated effective in clinical trials, and the recommended dose for the treatment of AGA is 1 mg daily orally. The drug should be taken for at least 6 months to see an effect, and reports of long-term use for greater than 10 years have further proven its safety and efficacy. Finasteride converts miniaturized hair follicles into terminal hairs and elongates the anagen phase of the hair follicle. It is most effective for treating vertex thinning, but also it works on the frontal area [1–5].

Even though finasteride 1 mg/day dose trials in female AGA patients showed unsatisfactory results, a 2.5–5 mg/day regimen for women is currently widely used. Many positive reports including the author's article can be found in the literature [6]. Due to the potential teratogenic effect on a male fetus during the organogenesis, contraception is required for childbearing females. No serious adverse effects (AEs) have been found in females; thus, those who are postmenopausal or who do not plan to have a child are good candidates for finasteride treatment.

It is not known why higher doses are necessary in females. As there is no significant difference in serum or scalp DHT reduction between 1 and 5 mg doses, it is possible that either subtle changes in DHT levels might be enough to affect female AGA or there is another mechanism affecting the pathogenesis of female AGA.

In males, sexual AEs are reported most often, with incidence rates varying from 2.1% to 3.8%. Erectile dysfunction is most commonly followed by ejaculatory disorders and the decreased libido. Most cases occur very early in treatment, and problems return to normal within several days of stopping the medication. AEs may resolve spontaneously even when the medication is continued. The nocebo effect, an AE that results from psychological factors, not pharmacological factors, could explain some reports of sexual AE. Generally, sexual AEs are not major obstacles in using finasteride.

68.2.2 Dutasteride

Dutasteride not only inhibits all three isoenzymes of 5AR, but its inhibition of type 2 5AR, the main isoenzyme involved in AGA pathogenesis, is three times more potent in the hair follicles. A daily dose of 0.5 mg orally, the same dose used in benign prostate hyperplasia, is effective in AGA and officially used in some countries including Korea [7]. Clinically, 0.5 mg dutasteride is more potent in treating AGA than 1 mg finasteride. As seen in the author's article, dutasteride might be indicated for patients recalcitrant to finasteride treatment, but it is not known if this is due to the inhibition of type 1 5AR or the stronger inhibition of type 2 5AR [8].

Dutasteride can be used in postmenopausal women, as well; however, this should be done with caution as the serum half-life of dutasteride is 4 weeks, which is quite a bit longer than that of finasteride which is only 6–8 h. Dutasteride is used in a mesotherapy solution mixed with cytokines, but this is not available in most countries.

68.3 Minoxidil

Minoxidil used orally is an antihypertensive vasodilator but is used topically for hair loss treatment. Hypertrichosis was a frequent AE with oral minoxidil and led to its indication for alopecia treatment in both men and women. It is well known that minoxidil sulfate, a metabolite of minoxidil, opens potassium channels resulting in vasodilation, but the exact mechanism of how it affects hair follicle behavior is still unclear. Minoxidil elongates anagen duration, shortens the telogen period, and helps in recovering miniaturized hair follicles in experiments. As a vasodilator, it also induces neovascularization of the dermal papilla and thus thickening of the hair follicle. Because it does not influence androgen metabolism, it is safely used for both in men and women [9].

Currently, topical minoxidil is available around the world in concentrations of 1–15%, but concentration regulations vary from country to country. Until a few years ago, 2–3% minoxidil twice per day for women and 5% minoxidil twice per day for men was the standard regimen for alopecia treatment. Recently, trends in women have changed to 5% minoxidil once per day. According to the author's published paper, there is a strong correlation between the quantity of minoxidil use and efficacy, and compliance is not as good as expected [10]. Thus, when we recommend minoxidil for AGA, we encourage patients to keep applying the agent regularly with indicated dose.

The commonest AE with topical minoxidil is scalp irritation. Eight percent of patients reported irritation and this was more common with 5% minoxidil than 2% minoxidil [11]. Propylene glycol present in minoxidil solution is a well-known causative agent, and the incidence of irritation is decreased in products with no propylene glycol. Hypertrichosis, not hirsutism, is another well-known AE. The fact that both cheeks and jaw are prevalent locations, and which are far from area of application, implies that hypertrichosis may be caused by systemic absorption rather than regional overdose. Some scientists regard hypertrichosis as the most sensitive marker of systemic absorption of minoxidil. Some patient may experience transient shedding for the first 1–2 months after starting application.

68.4 17 Alpha Estradiol

Administration of estrogen (female sex hormone) increases sex hormone-binding globulin (SHBG) production, which results in the decrease of free testosterone. For AGA, this might be helpful, but we cannot use it specifically for this indication, because of feminization in men and increased risk of breast and ovarian cancer in women.

17α-Estradiol (alfatradiol) is a stereoisomer of the endogenous steroid hormone 17β-estradiol, commonly known as estrogen, the primary female sex hormone. Because it does not bind to the estrogen receptor, it does not have any estrogen effect in the body. However, it does show an inhibitory effect on 5AR in animals. Topical application of 0.025% 17α-estradiol once daily is the standard regimen. It causes less irritation and is easier to apply than minoxidil, and thus, it has been used widely especially in Latin America and Europe [12].

There are still questions about its efficacy in clinical trials, but the most recently published phase 4 study data in Korea demonstrates efficacy in hair density and diameter over an 8-month observation period without any complications [13]. It can be a good alternative or adjuvant treatment modality for AGA patients both men and women.

68.5 Antiandrogen

There is no established standard oral medication for female AGA. In addition to 5AR inhibitors, antiandrogens can be successfully used in women with AGA. Clinical evidence is lacking and no multicenter trial can be found, but three kinds of antiandrogens have been used empirically: spironolactone, a diuretic; flutamide, a prostate cancer medication; and cyproterone acetate, an acne treatment agent [14]. As for 5AR inhibitors, all female AGA patients of childbearing potential should be warned about the risk of feminization of a male fetus. Patients taking these medications must use an effective method of contraception from the outset.

68.5.1 Spironolactone

Spironolactone is a potassium-sparing diuretic but also prevents the production of testosterone in the adrenal gland and conjugation of DHT to the androgen receptor by competitive inhibition. It has been used for many years to treat acne and hirsutism in hyper-androgenic patients.

Spironolactone has been used to treat hirsutism at a dosage of 100–200 mg per day. The minimum dose for AGA treatment is 100 mg/day, but no study has been conducted to prove a dose-efficacy correlation. In spite of little evidence supporting its use, spironolactone is widely used for female AGA, especially for those with hyperandrogenism [15].

Hyperkalemia may be induced due to potassium-sparing effect, so potassium levels should be checked regularly during the use. Hydration is important, and breast pain, dysmenorrhea, and mood changes have all been reported.

68.5.2 Cyproterone Acetate

Cyproterone acetate is a derivative of 17-hydroxyprogesterone, a type of anabolic androgen, and inhibits the binding of DHT to its androgen receptor.

In premenopausal females, two standard regimens of cyproterone acetate for antiandrogen effects have been introduced, a cyclical antiandrogen therapy, consisting of taking cyproterone acetate and estrogen one by one, and a combination formulation of cyproterone acetate with ethyl estradiol. These can be used in dysmenorrhea to normalize menstrual cycle, and 50 mg monotherapy can be used for postmenopausal women. Clinical responses in female AGA patients are controversial [16].

Possible AEs include dysmenorrhea, weight gain, breast pain, decreased libido, depression, and nausea and are usually related to dose.

68.5.3 Flutamide

Flutamide and 2-hydroxyflutamide, the metabolite of flutamite, are nonsteroidal antiandrogens and have no effect on intrinsic androgen. These inhibit testosterone and DHT binding to its androgen receptor. Flutamide is used for those who have female pattern baldness or hirsutism with hyperandrogenism.

Diarrhea is the commonest AE, but severe liver toxicities that might be fatal have been reported.

68.6 Keratin Complex

Keratin complex is a composition including keratin, yeast extract, thiamine nitrate, calcium D-pantothenate, L-cystine, etc. The ratio of components is different for each product, but it is taken three times a day in general. Its efficacy in telogen effluvium has been proven, and it is widely used as a dietary supplement for the hair and nails. No evidence has been provided for AGA treatment [17].

68.7 Oral Iron

There remains a debate about the relation between iron levels and AGA, with some report claiming that oral supplementation of iron is helpful for female AGA. Serum ferritin level, not serum iron level, is the indicator of the need for iron supplementation. In general, those females who are under 20 ug/L are indicated for iron supplementation as an adjuvant therapy [18]. Unfortunately, no report has been found that iron monotherapy is effective.

68.8 Mesotherapy

Even though mesotherapy is not a medical term, it has been widely used for years as an intralesional, usually intradermal, injection of various solutions. For hair loss treatment, injected solutions have included agents to increase blood circulation, supply nutrients, inhibit 5AR, decrease inflammation, and increase cellular growth. Usually, it is administered with a mixture of therapeutic solutions, and the formulations differ according to each physician.

There are few reports found in the literature, but it could be considered as an adjuvant therapy [19]. Many physicians agree that it might be helpful for early recovery of AGA, but there is no standardized regimen or treatment schedule. Fibrosis of scalp tissue in some patients with long-term treatment, especially when injected with large-gauge needles, might be an additional problem.

68.9 Low-Level Laser Treatment

Since 1962, when lasers were introduced in the medical field, low-level laser therapy (LLLT) has been tried in many diseases. In 1976, during animal experiments to see the carcinogenic effect of lasers, hypertrichosis was found on the laser-irradiated area. LLLT was not popular as a hair loss treatment until 2011, when the first laser device for hair loss was introduced to the public. Currently, many devices have been cleared, most of them for home use.

The mechanism of action is still unclear, but it is proposed that cytochrome C oxidase in cell mitochondria is a photoreceptor. Activated cytochrome C oxidase by specific wavelengths results in enhanced ATP production which results in activation of cellular function and duplication. Four peaks of effective wavelength have been proposed: 614–624, 668–684, 751–772, and 813–846 nm. However, other wavelengths including 1550 nm have also shown its efficacy in animal and human experiments [20].

68.10 Cell-Based Treatment

Currently, the term “stem cell” is very popular and represents high technology in both biology and medicine. The promise of stem cell and other cell-based therapies guides the future direction of medicine and is still considered as a cure-all treatment to be tried in all kind of diseases. However, while cell-based trials have been already tried and reported for some conditions, it will take some time to determine the application of stem cells for AGA.

Platelet-rich plasma (PRP) collected from peripheral blood is also widely used, because it is easy to obtain. After centrifugation of patients’ blood, PRP can be prepared easily, and injection techniques are similar to mesotherapy. Initially, many physicians criticized the use of PRP because of the lack of evidence in hair loss treatment, but the situation has been changed due to many positive reports of PRP efficacy [21]. There is still no standardized regimen regarding how to prepare PRP, the quality requirements of PRP, or injection intervals.

Cell culture media is also used for hair loss patients. Media collected after cultivation of fibroblasts or stem cells contain many cytokines that enhance cell proliferation [22]. There have been attempts to inject or topically apply these media with the aid of a microroller to treat hair loss, and some evidence of clinical improvement, but more evidence is needed to ensure efficacy and safety.

Cultured cell mixture injections have also been tried in humans. These techniques represent so-called hair cloning or hair multiplication and claim to administer cultivated hair follicles from patient scalp biopsies. Cultured dermal sheath fibroblasts alone or in a mixture of cultured outer root sheath and dermal papilla cells have been tried, but no strikingly good effects have been reported so far. Another trial attempting to induce hairs during the wound healing process has been proposed. However, the unknown cost-benefit ratio and absence of long-term safety data suggest caution with these approaches.

68.11 Conclusion

Many medical treatments for AGA have been introduced. Currently, 5AR inhibitor like finasteride or dutasteride and minoxidil remains mainstream. However, 17α-estradiol, mesotherapy, and LLLT can be used as a second line in some countries for both men and women. Antiandrogens can be successfully used in female as well.

Cell-based treatments most likely represent the future of medical treatment of hair loss, but more time is needed to assess cost-effectiveness and technical success.

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Chapter 69
LLLT: Does It Work?

Shigeki Inui

69.1 LLLT and Paradoxical Hypertrichosis

In 1968 Mester et al. examined the carcinogenic potential of a low-power ruby laser (694 nm) using mice. Although there was no carcinogenesis, incidentally finding of hair growth was noted [1]. More recently in humans, undesirable hair growth was observed around treated areas after the laser-assisted hair removal, and this phenomenon has been known as "paradoxical hypertrichosis" [2]. This fact suggested the potential photobiostimulation of hair growth by low-level laser therapy (LLLT). Many basic and clinical studies of LLLT on hair growth have been reported, and several LLLT devices have received FDA 510 (k) clearance [3, 4]. In spite of this clearance for safety and efficacy, LLLT effect on hair loss diseases is still a matter of controversy especially for male pattern hair loss or androgenetic alopecia (MPHL) and female patter hair loss (FPHL). In this review, the randomized controlled trials (RCTs) are surveyed, and the question "Does LLLT work?" is discussed.

69.2 Clinical Trials of LLLT for Hair Loss Diseases

As of the date of this publication, five RCTs of LLLT use for MPHL have been published. Two utilized a comb device [3, 5] and three used a helmet/cap [6–8].

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69.2.1 Effect of LLLT on Hair Density and Thickness

Jimenez et al. [5] designed the largest study of LLLT thus far. Four multicenter prospective randomized, double-blinded studies were performed. In the trials #1 and #2, FPHL patients were treated with a 9-beam (655 nm) (#1, $n = 53$; sham = 25) or a dual 12-beam (6–655 nm, 6–635 nm) (#2, $n = 42$; sham = 21). In the trials #3 and #4, MPHL patients were treated with a 7-beam (655 nm) (#3, $n = 33$; sham = 16) or a 9- (655 nm) or 12-beam (6–655 nm, 6–635 nm) (#4, 9-beam, $n = 25$; 12-beam, $n = 28$; sham = 26) laser combs. The subjects applied the device three times a week. The irradiation periods were 15 min for the 7-beam, 11 min for the 9-beam, and 8 min for the 12-beam device. The treatment was continued for 26 weeks. Scalp assessment, global and macro digital imaging after hair clipping, and computer-aided hair counts were carried out. All four studies showed significant terminal hair density increase by LLLT compared with the sham treatments. Global photographs to show hair volume increase were provided only in a female subject. The result of self-assessment did not always reach statistical significance. Laser comb-related adverse events were dry skin (5.1%), pruritus (2.5%), scalp tenderness (1.3%), irritation (1.3%), and a warm sensation at the treated site (1.3%). However, there were no serious adverse events that resulted in discontinuation of the treatments.

Leavitt et al. [3] reported similar results by comparing the laser comb ($n = 71$) and sham device ($n = 39$). The LLLT showed significant terminal hair density increase compared with the sham after 26 weeks.

Kim et al. [6] evaluated a helmet-type LLLT device consisting of LEDs (630 nm) and laser diodes (650 nm) for MPHL and FPHL at two research centers. Treatments were performed once a day for 24 weeks. The duration of each treatment was 18 minutes, and its irradiation energy was 47.90 J/cm^2. LLLT significantly increased hair density and thickness ($n = 15$) compared with the sham treatment ($n = 14$). The investigator global assessment (excellent, good, slight, no change, worse) was good or excellent in 26.7% in the treatment group, but no sham group subjects were rated good or excellent, demonstrating significant positive effect on hair appearance ($p = 0.002$, Wilcoxon ran sum test). However, the global photographs were not provided.

Similarly, two other trials reported by the same author showed significant hair growth in MPHL [7] and FPHL [8] by the helmet/cap devices containing laser diodes and LEDs (both, 655 nm).

Together, these five RCTs demonstrated significant hair regrowth by LLLT. Therefore, LLLT is a well-evidenced and safe treatment for MPHL and FPHL. These evaluations primarily examined precise objective hair parameters such as density and width. However, the subjective effect on hair appearance was demonstrated only by global photographs of one case by Jimenez et al. [5] and by global point assessment by Kim et al. [6]. Moreover, no study compared LLLT and conventional drugs such as topical minoxidil [9, 10], oral finasteride [11, 12], and dutasteride [13]. Therefore, at present, LLLT should be considered as an adjunctive therapy to these treatments. Further, if patients dislike currently available medical treatments, LLLT may be offered as an alternative method.

69.3 Potential Mechanism of LLLT/LED Effect

For LLLT to be effective, light must penetrate the skin and reach hair follicles. Therefore, red or near-infrared lights (600–950 nm) are appropriate for hair treatments. In general, light must reach receptors in the cells, known as photoacceptors or chromophores [14]. Cytochrome C oxidase, which catalyzes the final step in the mitochondrial electron transfer chain, is a potential photoacceptor of red or near-infrared lights [15]. However, the mechanism downstream from the photoacceptor is not clear, and the search continues for potential mediators to exert the biological functions of red or near-infrared lights, particularly using LED [16]. First, to examine effect of LED light on hair growth, the dorsa hairs of 7-week-old female BL-6 mice were shaved off. Starting the next day (day 1), red LED light (638 nm/1.0 J/cm^2) was irradiated for 20 minutes three times a week. Thereafter, we took photos of the dorsa skin and measured the percentage of hair regrowth. No LED light was irradiated elsewhere for a control. At days 18 and 22, hair regrowth areas were significantly increased by red LED light irradiation when compared to controls. In addition, the dorsa skin of the red LED irradiation group at day 22 was colored black, indicating anagen induction. Furthermore, we searched molecular mechanisms of LED stimulation on hair growth using cultured normal human dermal papilla cells irradiated with red (638 nm/1.5 J/cm^2) LED. RNA samples were extracted from the cells and subjected to semiquantitative RT-PCR for various growth factors and cytokines. Analysis revealed mRNA of HGF, leptin, and VEGF-A was increased. Then, we confirmed the enhanced production of these factors by red LED light at the protein level from cultured normal human dermal papilla. The conditioned media of dermal papilla cells irradiated with red LED were harvested and used to measure the protein levels of the cytokines by ELISA. We found that HGF, leptin, and VEGF-A were significantly increased, agreeing with previous observations: (1) upregulation of HGF reportedly accelerates hair growth and retards entry to catagen in hair cycling [17, 18], (2) leptin induces the anagen phase of hair cycle [19], and (3) VEGF-A induces perifollicular angiogenesis, accelerating hair regrowth [20].

Recently, the wavelength-dependent effects of hair growth were examined using laser diodes with wavelengths of 632, 670, 785, and 830 nm in Sprague-Dawley rats. Results revealed that LLLT with a 830-nm wavelength induced greater stimulation of hair growth than the other wavelengths examined [21]. Accordingly, LLLT of longer wavelengths than utilized today may have more potent effects on hair growth.

69.4 Conclusion

The stimulatory effect of LLLT/LED has been convincingly demonstrated by several RCTs, but its potency has not been definitively established. At present, LLLT should be considered as an adjunctive or alternative therapy to conventional treatments. Therefore, further basic and clinical studies are needed for refinement of the devices and light sources.

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Chapter 70
Retrospective Analysis of Nutrition Status for Asian Female Pattern Hair Loss Patients

Akiko Kaneko

70.1 Introduction

Evidence-based guidelines are practiced worldwide for the treatment of androgenetic alopecia in women, which is synonymous with female pattern hair loss (FPHL) [1–3]. According to the Japanese guidelines, topical minoxidil is a first-line treatment for FPHL with the highest level of evidence [3], but its efficacy is limited. For FPHL patients who have not shown sufficient improvement with topical minoxidil, Japanese guidelines recommend hair transplantation. However, hair transplantation is not appropriate for patients with hair thinning in their donor area [4]. Only 40–50% of FPHL patients have enough donor hair for surgery based on consultations with experienced hair restoration surgeons [5]. As such, how can we help those women who are not good candidates for surgery?

FPHL is a complex process, and there is evidence that nutrition influences hair loss and hair condition [6]; thus, the author investigated nutritional status in Asian FPHL patients.

70.2 Materials and Methods

A retrospective chart review was conducted in premenopausal women (16–49 years old) who visited Bona Dea Clinic (Yokohama, Japan) with the diagnosis of FPHL. Exclusion criteria were as follows:

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1. Women who had any systemic diseases or scalp diseases
2. Women who had taken drugs known to cause hair loss
3. Women who had low hemoglobin (less than 11.0 g/dL) or abnormal levels of thyroid or androgenic hormones in laboratory tests [7, 8]
4. Women diagnosed with both telogen effluvium and FPHL

Laboratory tests studied included serum ferritin, serum zinc, alkaline phosphatase (ALP), high-density lipoprotein cholesterol (HDL-C), serum albumin, and blood urea nitrogen (BUN). All these laboratory tests were performed at the same laboratory, and results were expressed as mean ± standard deviation.

70.3 Results

Two hundred and eighty-five FPHL patients (Japanese 282, Korean 2, Taiwanese 1) met all the inclusion criteria in this study. The mean age of the enrolled patients was 35 years old (range 16–49 years old). Japanese women with a family history of hair loss was 51.6%. As for severity, 86.5% of patients were classified as Ludwig I, and the rest were classified as Ludwig II.

70.3.1 Iron Status

The mean serum ferritin concentration was 36.4 ± 27.9 ng/mL. Iron deficiency defined as serum ferritin concentrations less than or equal to 15 ng/mL [9] was found in 21.1% of patients (Fig. 70.1).

70.3.2 Zinc Status

The mean serum zinc level was 81.3 ± 12.3 μg/dL. Zinc insufficiency defined as zinc levels below 70 μg/dL [10, 11] was found in 18%. Mean serum alkaline phosphatase (ALP), which is known as a zinc-dependent enzyme [12, 13], was 174 ± 49.2 U/L. Low ALP levels defined as below 100 U/L were seen in 1.8% of patients.

70.3.3 Lipid Status

The mean serum HDL-C level was 71 ± 15.3 mg/dL. Dyslipidemia defined as serum HDL-C levels less than 40 mg/d [14] was found in 2.5% of patients.

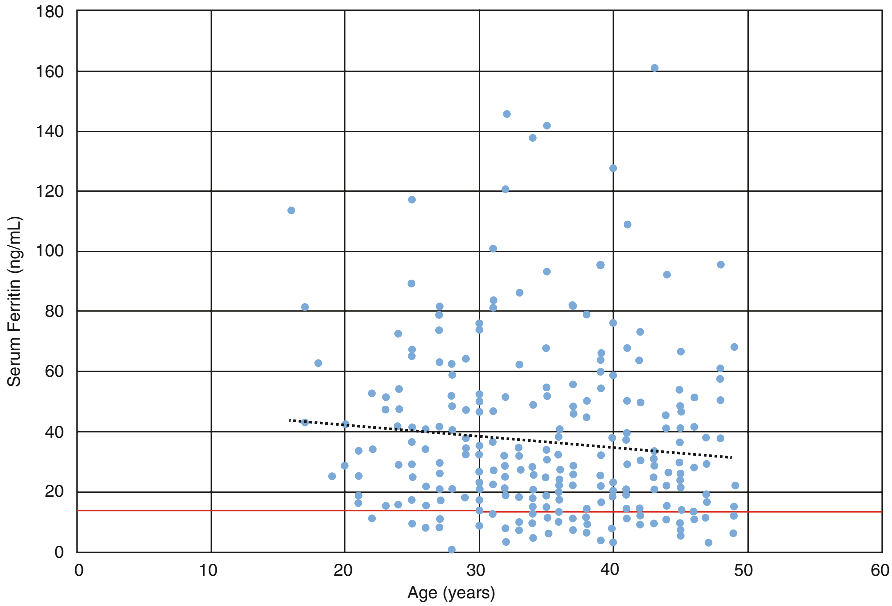

Fig. 70.1 Serum ferritin concentrations. Mean serum ferritin concentration was 36.4 ng/mL. When 15 ng/mL was used as criteria (*solid line*), iron deficiency was found in 21.1%. This tended to decrease slightly with age (*dotted line*)

70.3.4 Protein Status

The mean serum albumin level was 4.5 ± 0.25 g/dL. Hypoalbuminemia defined as a serum albumin level below 4 g/d was found in 1.8% of patients. The mean BUN level was 12.1 ± 3 mg/dL, and low BUN levels defined as BUN levels less than 8 mg/dL [15] were seen in 7.4% of patients.

70.4 Discussion

Hair follicle cells are known to have a high rate of turnover; therefore, various nutritional deficiency or excess could influence hair growth [16].

70.4.1 Iron Status and FPHL

Iron deficiency is considered one of the causes of telogen effluvium (TE) [8, 17], and only iron deficiency causes very low serum ferritin concentrations [18]. However, an undiminished serum ferritin level is not a guarantee of an optimal

Table 70.1 Comparison of proportion of iron deficiency in FPHL patients

Country	Author	Number	Age (years old)	Cutoff (ng/mL)	Proportion of iron deficiency in FPHL
USA	Olsen EA	170	(premenopausal)	15 ≧ ferritin	12.4%
Korea	Park SY et al.	113	42.9 ± 13	15 > ferritin	20.4%
Japan	Kaneko A (current study)	285	(Premenopausal) 36.4 ± 27.9	15 ≧ ferritin	21.1%

level. Serum ferritin levels increase due to infection, inflammation, liver damage, cancer [8, 9, 17, 18], and metabolic syndrome [19, 20], and thus iron deficiency can be masked by these conditions. Park et al. excluded patients who had evidence of active infection or inflammation from their study and concluded that iron may play a particular role, especially in premenopausal FPHL [21].

Comparing serum ferritin level in US and Asian studies, the frequency of iron deficiency was higher in Asian FPHL patients than in American FPHL patients (Table 70.1) [9, 21].

Physicians should consider iron deficiency not only in TE but also in FPHL patients.

70.4.2 Zinc Metabolism and FPHL

Zinc is an essential micronutrient for the human body including hair [22]. It is known that acquired zinc deficiency can cause hair loss [12, 23]. The mean serum zinc concentration in this study was similar to that of a Korean study (Table 70.2) [10].

Some researchers believe that the serum zinc level is not an optimal measurement method for various reasons [11, 24, 25]. Serum zinc level shows circadian variation and also varies under the influence of foods, drugs, and stress [12]. Moreover the serum zinc level can be decreased as a result of a systemic inflammatory response or hypoalbuminemia [25].

To interpret zinc deficiency more accurately, alkaline phosphatase (ALP) activity, which is a zinc metalloenzyme [12], was measured along with serum zinc level in this study, because ALP activity in the plasma of rats consuming a zinc-deficient diet was significantly decreased compared with rats taking a zinc-adequate diet [13]. Although 18% of patients had a low serum zinc level, only 1.8% of the patients had a plasma ALP activity below the normal range in this study.

Zinc deficiency may not have been detected by serum zinc level alone.

Table 70.2 Comparison of serum zinc concentrations in FPHL patients

Country	Author	Number	Age (years old)	Average zinc level (μg/dL)
Korea	Kil MS et al.	77	37.7 ± 13.5	79.61 ± 19.39
Japan	Kaneko A (current study)	285	35.0 ± 7.7	81.3 ± 12.3

70.4.3 *Lipid Status and FPHL*

The prevalence of dyslipidemia in women with FPHL was similar to that found in the Japanese national survey [14]. However, in other regions of the world, this finding is different, as HDL-C levels of Spanish women with androgenetic alopecia (FPHL) were significantly lower than that of a control group [26, 27]. In Asia, there was a higher prevalence of metabolic syndrome in Korean women with androgenetic alopecia (FPHL) [28].

Dyslipidemia and/or metabolic syndrome can be one of the risk factors of FPHL.

70.4.4 *Protein Metabolism and FPHL*

Albumin is the most abundant protein in serum and is widely used as a clinical indicator of relatively long-term nutritional status [29]. The incidence of hypoalbuminemia was not different between FPHL patients and the subjects of the Japanese national survey [14]. This suggests that most FPHL patients have sufficient protein.

However, serum albumin is not necessarily a guarantee of dietary protein sufficiency [15]. Protein will be generated by the decomposition of body protein if dietary protein supply is insufficient. In a study of the relation between albumin level and hair synthesis, Jordan revealed that synthesis of hair root protein decreased before serum albumin decreased when protein intake was decreased [30]. BUN, a waste product from the decomposition of protein, can be used as an indicator of protein intake [15] in patients with normal renal and liver function. Although hypoalbuminemia was seen only in 1.8% of patients, low BUN levels were seen in 7.4% of patients in this study.

BUN levels suggest that some Asian FPHL patients do not have sufficient protein to meet their metabolic demands.

70.4.5 Vitamin D

The serum 25-hydroxyvitamin D [25(OH)D] level is regarded as the most appropriate index of vitamin D sufficiency [31]; however, this was not measured in this study. Although the role of vitamin D in the hair cycle is not well understood [32], vitamin D receptor activation has been known to play an important role in the hair cycle [33–35].

70.4.6 Use of Nutrition in the Treatment of FPHL

From the standpoint of evidence-based medicine, the effectiveness of nutritional supplementation in the treatment of FPHL is still being investigated [36]. However, not a few physicians believe in the necessity of nutritional supplementation for hair growth as an adjuvant therapy [37, 38].

As shown in this study, even within the same phenomenon as FPHL, a variety of suboptimal or nonoptimal nutrition status appeared in each individual. It appears difficult to determine the relation of each single nutritive factor and FPHL separately because nutritive factors serve multiple functions while interacting with each other. However, the results in this study may suggest the necessity of personalized conditioning of nutrition status for FPHL patients.

> Nutritional supplementation can be useful as an adjuvant therapy for FPHL.

70.5 Conclusion

While no causal relationship between abnormal laboratory values and FPHL can be determined from this study, the presence of nutritional deficiencies in many women with FPHL suggests that nutritive imbalances could interrupt optimal hair growth in FPHL patients. Further studies are needed to clarify the significance of these abnormalities so that specific nutritional recommendations can be made.

> Alteration to personalized nutritional status may support appropriate hair growth.

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Chapter 71
Nutritional Correction for Hair Loss, Thinning of Hair, and Achieving New Hair Regrowth

Rajesh Rajput Rajendrasingh

71.1 Nutritional Correction for Hair Loss, Thinning of Hair, and Achieving New Hair Regrowth

As medical students, we are trained to recognize, investigate, and treat disease. Hair loss is not a disease which can be treated with medications to grant a permanent cure. Hair loss is a derangement or disregulation [1, 2] of the hair growth cycles in the body caused by multiple factors acting in tandem. There is a role of genetic predisposition. However, the outcome is influenced by environmental factors, pollution [3–13], stress [14, 15], lifestyle, aging [16–19], diet [20–22], scalp care, and hygiene. Baldness occurs not due to hair loss but rather because lost hair is not replaced with new hair. Treating hair loss is more about how to retain hair, strengthen the roots, promote hair growth, and stimulate the hair cycles to continue rather than fighting hair fall.

Unlike most medical conditions, the agents causing hair loss do not affect all the hair roots uniformly at the same time. Less than 10% of the roots are affected in any given cycle, and thus it takes a few years for baldness to become apparent. In fighting hair loss with antiandrogens and enzyme blockers, we have overlooked the fact that the remaining 90% hair is healthy and growing. Our approach is to strengthen the hair roots and promote growth of the remaining 90% hair rather than fight the smaller percentage which is falling and has doubtful response. The falling hair originates from the original 90–95% hair roots. Fighting hair loss requires the use of enzyme blockers and antiandrogens, which may not always deliver the same benefit [2, 23] and may propagate fear of side effects. Promotion of growth and strengthening of hair roots require the use of antioxidants, vitamins, minerals, supplements

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[24–28], low-dose 2% and 5% topical minoxidil applications, medicated shampoos, regular use of shampoos, and LLLT [29–31]. Growing hair is more of a care program than a medical cure. Hair loss treatment continues for a long time, at least a few years, and the use of topicals and supplements is well accepted, delivering wellness, good health, and hair growth, with a reduced incidence of side effects.

71.2 The Vitamin-Mineral Supplement Therapy

Growing hair follicles require a toxin-free environment for the cells to divide. This is aided by the use of antioxidants. Formation of new hair requires trace elements such as iron, calcium, zinc, and magnesium that form the structure of the hair. Amino acids are also required as these are the building blocks for the hair. Biotin, B-complex, vitamin C, and omega 3 all act as catalysts and regulators, facilitating the metabolic processes required for hair growth. All these vitamins, minerals, and nutrients, if administered together, can interfere with the absorption and efficiency of one another. For example, iron and calcium administered together can reduce absorption by 30–40% [32]. Excess of vitamin A [33, 34], or vitamin D, [35], can lead to hair loss instead of hair growth. Excess supplements can interfere with keratinization of the cells and prevent generation of hair and nails. Hair is an unusual structure that depends on the programmed cell death involved in keratinization. Patients who indiscriminately take pills for wellness are often seen to have poor hair growth.

We have thus developed a cyclical vitamin therapy program in which we do not recommend multiple vitamins and supplements on the same day. In the new approach, in order to reduce the dose and improve efficiency, we combine complimentary formulations that work better together. We administer six formulations, two per day over 3 days in a repeating cycle [36, 37]. An addition, topical application of biomimetic peptide is advised every morning to promote hair growth, and topical minoxidil 2% in females and 5% in males is advised every night. Ketoconazole 2% shampoo is recommended once every 3 days and regular pH balanced shampoo twice a week or up to every day as desired. There is no use of antiandrogens and no use of finasteride. The therapy is summarized in Table 71.1. For the past 5 years, we have combined the use of LLLT hair growth for 20 min once a week [29–31]. Clinical photographs show new hair growth and thickening of hair along the front

Table 71.1 Cyclical vitamin therapy for hair loss management

Stimulation of hair growth with daily application	Minoxidil, procapil, peptides, epigenin, biochinin, LLLT, PRP, growth factors
Support rapid cell division and hair growth cycles	
Day 1	Antioxidants, calcium
Day 2	Iron, folic acid, vit. C, omega 3
Day 3	Amino acids, B-complex, and biotin
Antidandruff head wash every 3 days	2% ketoconazole
Regular use of or daily use of shampoo	Mild shampoo, Ph balanced without any additives

hair line, parting line, and borders of the bald areas and overall improved volume and body to the hair within 2 months [36, 37]. The before and after results with less than 3 months (one telogen cycle) of following the nutritional correction regimen can be seen in Figs. 71.1, 71.2, 71.3, 71.4, 71.5, and 71.6 respectively (Table 71.1).

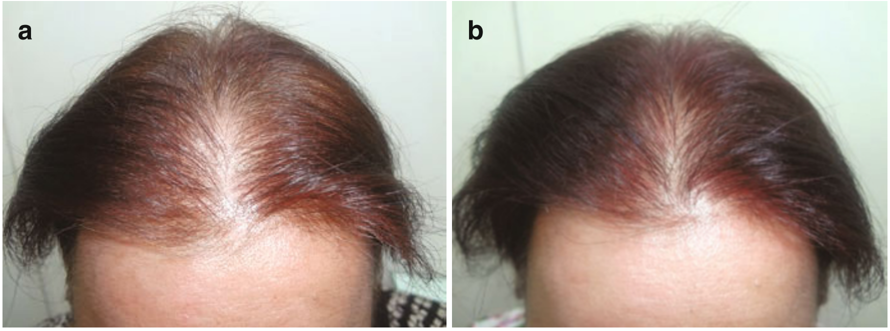

Fig. 71.1 (**a**) Postmenopausal thinning. (**b**) Improved hair growth within 9 weeks of minoxidil and nutritional therapy

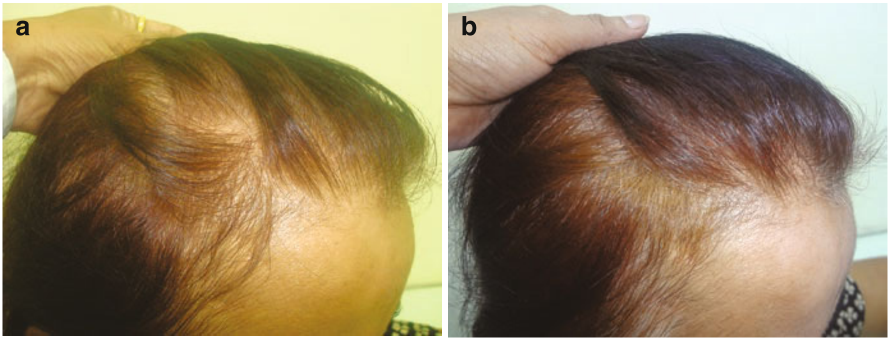

Fig. 71.2 (**a**) Temporal receding and thinning. (**b**) Improved growth within 8 weeks of minoxidil and nutritional therapy

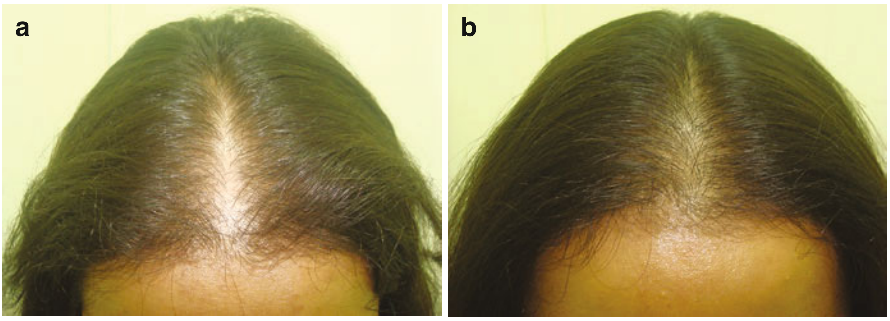

Fig. 71.3 (**a**) Widening along the center parting. (**b**) Improved hair growth within 10 weeks minoxidil nutritional therapy

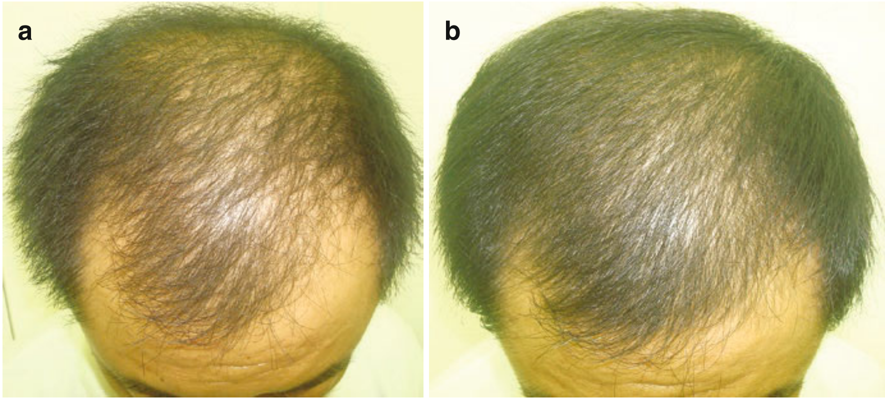

Fig. 71.4 (**a**) Hereditary hair loss. (**b**) Hair regrowth within 10 weeks of minoxidil and nutritional therapy

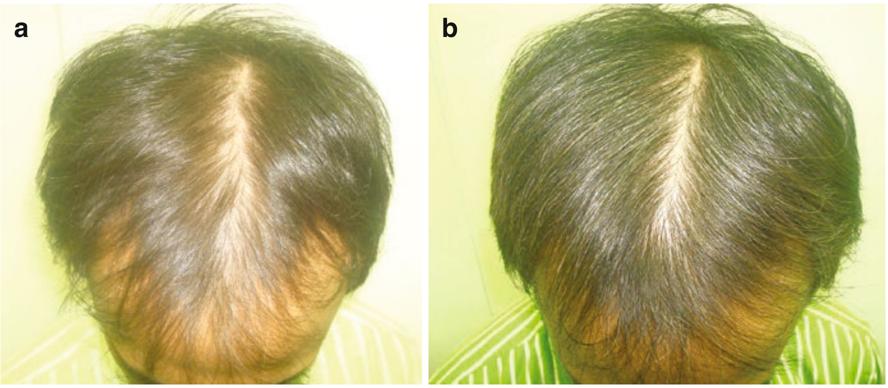

Fig. 71.5 (**a**) Fronto-temporal thinning. (**b**) Improved caliber and density within 10 weeks of minoxidil and nutritional therapy

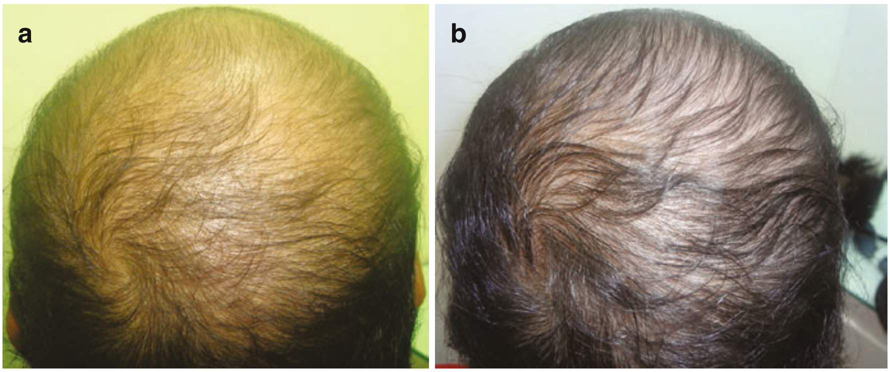

Fig. 71.6 (**a**) Miniaturization frontal to occipital areas. (**b**) Improved growth frontal to occipital areas within 9 weeks of minoxidil and nutritional therapy

Table 71.2 Various factors causing hair loss apart from androgenetic alopecia where the mechanism does not involve DHT as a mediator of hair loss

Internal factors	External factors
Iron deficiency	Smoking and passive smoking
Calcium deficiency	Stress
Zinc deficiency	Alcoholism
Vits. A, C, E, and D deficiency	Lack of sleep
Obesity, insulin resistance	Crash dieting, fad diets, high protein diet
Thyroid imbalance	Exposure to excess heat or cold
Metabolic disorders, gout, PCOS	Dryness, poor fluid intake
Seborrheic scalp	Poor scalp hygiene
Prolonged illness, surgery,	Dust, pollution, fumes
Prolonged medication	Endocrine disrupting chemicals

71.3 Causes for Hair Loss Other Than Mechanisms Mediated Through DHT

Though we primarily aim at countering effects of DHT, DHT levels in most hair loss patients are not raised. There are many more common causes that lead to hair loss in routine life. Correction of these causes can deliver good hair growth without concern for DHT and without using DHT blockers. The causes for hair loss where the mechanism does not involve DHT as mediator for hair loss are summarized in Table 71.2.

71.4 Role of Individual Nutrients in Hair Growth

Every nutrient has a beneficial role in strengthening and providing benefits for hair growth. No single nutrient alone can deliver good hair growth. We should plan to create a balance of micronutrients and essential minerals and amino acids that improve the wellness quotient and create an environment conducive for hair growth. The role of nutrients is summarized in Table 71.3.

71.5 Diet for Promoting Hair Growth

Promotion of good hair growth and control of hair loss requires antioxidants, vitamin A, vitamin C, B-complex, biotin, protein, biominerals [24–28], adequate water intake, and an organized lifestyle.

Green tea provides effective antioxidants. Polyphenol epigallocatechin-3-gallte is known to regulate androgens and mediator hormones leading to hair loss [38].

Table 71.3 Role of individual nutrients in hair growth

No	Vitamin supplements	Benefit
1.	Biotin—vitamin B7	Hair growth and dry skin
2.	Nicotinamide—vitamin B3	Anti-inflammatory
3.	Cyanocobalamin—vitamin B12	Prevents anemia
4.	Pyridoxine HCl—vitamin B6	Prevents anemia and water retention
5.	Vit. C	Antioxidant, collagen synthesis,
6.	Vit. A	Antioxidant,
7.	Vit. E	Protects cell membrane from free radicals
8.	Folic acid—B9	Prevents anemia, required for DNA synthesis
9.	Vit. D3	Calcium metabolism
10.	Tyrosine	Improves hair growth
11.	Lysine mono HCl	Hair growth in telogen effluvium
12.	L-Ornithine	DNA and protein synthesis
13.	L-Arginine	Rapid cell division, repair, and endothelial stability
14.	Taurine (2 aminoethanesulfonic acid)	Protects from exercise-induced and other toxicity
15.	Glycine	Precursor to biosynthesis of various proteins
16.	L-Selenomethionine/sodium selenate	Rapidly absorbed antioxidant, elasticity, UV damage, and aging
17.	Sulfur-methylsulfonylmethane	Prevents brittle and dry hair
18.	L-Histidine hydrochloride	Protein metabolism
19.	Ferrous fumarate	Prevention of anemia
20.	Calcium D—pantothenate-B5	Hair color and premature aging, CoA and TCA cycle
21.	Magnesium hydroxide	Calcium, potassium, parathyroid, and insulin Metabolism
22.	Cupric oxide/sulfate	Hair elasticity, pigmentation, and skin tone
23.	Zinc gluconate/zinc sulfate (25 mg), elemental zinc 7 mg	Cell division, collagen formation, and oxidative damage
24.	Manganese sulfate	Accelerates hair growth and prevents UV damage
25.	Iodine	Growth, protein synthesis, and cell metabolism
26.	Molybdenum	Assists use of iron stores, fat burning
27.	Vanadium sulfate	Insulin-like anabolic, Na, and K transport
28.	Gamma-linolenic acid	Anti-inflammatory
29.	Chromium polynicotinate	Cellular metabolism
30.	Para aminobenzoic acid	Prevents premature graying of hair
31.	Inositol	Prevents hair thinning
32.	Green apple extract—proanthocyanidin	Flavonoid and free radical scavenger
33.	Green tea extract—catechins	Antioxidant and protection from UV damage
34.	Saw palmetto	Antiandrogenic
35.	Co enzyme Q10	Rapid energy for growing cells

(a) Vitamin A—a very good antioxidant required in moderate amounts. In excess, it can interfere with keratinization and lead to hair loss. Twice a week, include green, yellow, and orange fruits and vegetables in your diet. Spinach, broccoli, carrots, apricots, and melons are all good sources of vitamin A. Add to it antioxidant-rich sweet potato. Steamed carrots provide better availability of beta-carotene and are the precursor of vitamin A, and consuming it with olive oil or cheese dip increases the absorption of beta-carotene.
(b) Vitamin C—It is an important water-soluble antioxidant which can act inside the cell as well as in the medium outside or in between the growing cells. It is required in high amounts for smokers. Citrus fruits, strawberries, red pepper, guava, and amla are good sources of vitamin C. It also reduces wrinkles.

B6, B12, and folic acid—Its good sources include eggs, meat, poultry, and fish. Vegetarians always have deficiency of these vitamins. Vegetarian sources are milk, wheat germ, sprouts, bananas, sweet potato, and spinach. Vitamin B6 improves oxygenation to the hair roots. B-complex vitamins are important components in all body metabolic processes.

(c) Biotin—It has received undue popularity as a hair vitamin or vitamin H. Biotin is not the only vitamin required for hair growth. Often people consume only biotin and expect hair to improve. Biotin is a general promoter of all body metabolism. Good sources are oats, nuts, and brown rice.
(d) Essential fatty acids and fat-soluble vitamins—Vitamins are of two kinds, water soluble and fat soluble. In today's weight watchers' culture, we ensure our diet is low fat. This leads to rapid deficiencies of fat-soluble vitamins A, D, E, and K, which are essential for hair growth and good soft glowing skin. Omega 3 and omega 6 fatty acids maintain favorable protein lipid layer on the scalp. They also give shine, bounce, and luster to the hair which otherwise will look dry, frizzy, flat, and lifeless. Good sources are fish and meat. Vegetarians can get fatty acids from walnuts, flaxseed, and avocado. Add milk, yogurt, occasional slice of cheese, or a spoon of ghee in your diet for healthy skin and hair.
(e) Protein—Achieving adequate natural protein intake necessary for hair growth is misunderstood. People take whey protein which contains preservatives, body-building supplements, and branch chain amino acids which increase anabolic rate and raise androgen levels leading the hair loss. High protein diet leads to acidic blood pH which requires reabsorption of calcium to neutralize the acidity, leading to indirect calcium deficiency and hair loss. Nonvegetarian foods have invisible fat content. Blood androgen levels are known to increase after high meat and fat meals. High androgens lead to hair loss. Chicken are artificially fattened by injecting hormones, antibiotics, antifungals, and tranquilizers, which wreak havoc with our body systems when consumed every day. Please rotate the source of protein to include beans, dals, chick peas, soy, mushrooms, milk, yogurt, egg, fish, and some meat.
(f) Water—Scalp hydration and preventing dryness are very important for good hair growth. Drink ten glasses of water daily especially people working in night shifts who forget to drink water at night. Flight attendants and frequent fliers easily get dehydrated in pressurized air cabins. Please remember to drink enough water.

(g) Lifestyle changes—Unhealthy eating habits, inadequate sleep, competitive life, stress, and poor scalp hygiene need to be addressed. Smoking reduces blood flow to the hair roots. Alcohol reduces absorption of vitamins and minerals from the gut. Any kind of exercise that promotes heavy breathing and good oxygenation through the lungs is good for hair growth. Hanging upside down does not increase the blood flow toward the head because there are valves in the body to ensure unidirectional blood flow. Consuming processed, artificially flavored foods with poor nutritional value leads to stomach fullness without health benefits and is known as hidden hunger.

71.6 Selection of Foods for Good Hair Growth

(a) Spinach—a good source of beta-carotene, iron, folic acid, vitamin C, vitamin B6, and vitamin E.
(b) Mustard greens—available all throughout the year and a good source of antioxidants, vitamin C, and vitamin E.
(c) Bok Choy—a good source of iron and antioxidants.
(d) Oats—a good source of copper, iron, zinc, biotin, and omega 6, and also some poly-unsaturated fatty acids, along with benefits of fiber. Copper can prevent premature graying of hair. Soak oats can allow enzymatic break down of phytates which form an insoluble complex with calcium, iron, and minerals making them unavailable for absorption.
(e) Prunes—a good source of biominerals, copper, zinc, and magnesium.
(f) Wheat germ—a good source of vitamins E and B6 and vegetarian source for zinc. Can be added to food recipes and health drinks.
(g) Walnuts—a good source of omega 6; iron; vitamins B1, B6, and B9; and zinc selenium
(h) Eggs—a good source of protein, iron, zinc, sulfur, omega 6, biotin, and vitamin B12. Eggs provide easily digestible protein which has the highest biological value.
(i) Shrimp—a good source of vitamin B12, iron, and zinc and a better choice when red meat is to be avoided.
(j) Chick peas—a good source of protein, zinc, vitamin B, and vitamin C.
(k) Sweet potato—often neglected, yet a good source of antioxidants, beta-carotene, iron, copper, and vitamin C for hair growth.

71.7 Source of Nutrients for Strengthening the Hair Roots

(a) Keratin—The hair structure is made of keratin protein. Methylsulfonylmethane (MSM) facilitates keratin formation and strengthening of the hair shaft. Good sources of MSM are cabbage, watercress, Swiss chard called raspalak, beet root, and radish leaves. MSM is better available in raw vegetables than cooked.

(b) Silica—It strengthens the hair. Its sources are green and red pepper, millet, barley, wheat, cucumber, mango, beans, celery, asparagus, and green vegetables. Silica is destroyed by fertilizers, best available from organic foods.
(c) Vitamin E—It acts as antioxidant; excess can lead to hair loss. Its sources are sunflower seeds, almonds, pine nuts, dried apricots, olives, spinach, mustard greens, wheat germ, and spirulina.
(d) Zinc—It is required for strong hair as well as thyroid hormone which again is important for hair growth. Its sources are pumpkin seeds, lentils, whole grains, Brazil nuts, pecans, walnuts, eggs, and oyster.
(e) Copper—It gives strength and prevents premature graying. Its sources are black sesame, soy, spirulina, cashew nuts, walnuts, prunes, and oats.
(f) Iodine—It is important for hair strengthening and thyroid function. Its sources are sea food, sea weeds, and iodinized common salt, being the most common.
(g) Sulfur—It is a beauty support from nature; deficiency causes dry skin and brittle hair. Its sources are meat, fish egg, legumes, garlic, cabbage, onions, turnips, sea weeds, lettuce, and Brussel sprouts.

71.8 Requirement of Nutritional Support for Preventing Hair Loss

Hair growth is a continuous cycle of anagen, catagen, and telogen; then regrowth begins again with anagen. After the fall phase, the hair has to come back into the growth phase with sudden rapid cell division at high rate. Good hair growth requires a toxin-free environment and supply of good nutrients to support rapidly dividing cells. Food consumption today is irregular, at odd hours, against the body rhythm or cycle. Food consumed is a mix up, against local, climatic, regional, or seasonal preferences.

The food consumed today is often not natural. It is man-made and modified, and yield is increased by using artificial chemicals, hormones, insecticides, and fertilizers. Chicken are force fed, keeping lights on at night to make them feel it is day time. Residues of antibiotics, steroids, oral contraceptives, and vaccines are consumed with the meat [39]. No carbohydrate diets and high protein diets favored by fitness experts can cause the blood to become acidic leading to reabsorption of iron, calcium into blood to counter the acidity. There is increase in the urea nitrogenous waste from high protein consumption; accumulation of these metabolic toxins makes the internal body environment unsuitable for rapid cell division and hair growth.

Masumi Inaba of Japan has shown a cause and effect relationship between the diet and the severity of hair loss through documentation and scalp biopsies [40]. We advise our patients to avoid fried foods, bakery foods, and red meat to reduce the over activity of oil and sebum glands, as these are the sites for 5AR enzyme activity and hyperactive glands may lead to more formation of DHT [40]. This diet modification also reduces the accumulation of free radicals which are unfavorable for rapidly dividing cells [40].

Next is to avoid sugar-based foods, as chocolates, pastries, and sweets (some sugar in tea or coffee is permitted). Increased sugar leads to insulin release, which in turn causes release of testosterone from its binding protein and makes it available for conversion to DHT.

Foods with artificial flavors, taste makers, additives, preservatives, and colas are avoided as these chemicals lead to the formation of free radicals in the body. Juices are best avoided for their fruit sugar, better is to eat fruits along with the fruit skin. Nutrients and vitamins in the fruit are concentrated just below the fruit skin; pulp contains only fructose and water. Having fruits with the fruit skin provides fiber and nutrients.

Fast foods and junk foods are avoided for the lack of nutrition and the use of chemical flavoring agents, additives, and preservatives. Chinese foods made with Ajinomoto MSG can adversely affect hair.

Including a variety of protein sources and antioxidants in your diet, like steamed sprouts, green vegetables, salads, all kinds of beans, pulses, mushrooms, cottage cheese, chick peas, and nuts, can improve hair growth but still reduce the ill effects of meat.

Vitamins are of two kinds: water-soluble and fat-soluble vitamins A, D, E, and K. Adding a spoon of ghee or a slice of cheese can provide the fat-soluble vitamins required for the bounce and luster in the hair. A strictly no fat diet makes the hair dry, lifeless, and falling flat. Also having ten glasses of water in a day maintains skin hydration and prevents dryness.

One of the theories for hair loss is the reduced blood flow or ischemia theory. Avoid smoking if you are losing hair, as it will constrict blood flow to the hair roots inducing ischemia leading to hair loss. Smoking also causes accumulation of free radicals which are harmful to growing hair roots.

You could count many friends who do not follow any diet or lifestyle modification but have nice growing hair. Please remember that they are born with a different type of hair. If you are losing hair, you must follow these guidelines. We do not ask you to stop your favorite foods but to restrict them in frequency and quantity. Do not restrict to one kind of food choice, give all foods a chance to provide you all the variety of nutrients.

List of foods to avoid:
• Avoid chicken, you can have it not more than twice a week. Prefer grilled beef, pork, lamb, fish, and sea food, any of which not more than 2–3 times a week. Avoid potato, pasta, cream, and melted cheese not more than twice a week.
• Avoid chips, fries, tortillas, nachos, Doritos, processed foods, and snacks
• Avoid sugar foods—chocolates, pastries, cakes, ice cream, desserts, etc.
• Avoid colas, coke, Pepsi, soft drinks, and all kinds of prepacked juices
• Avoid bakery foods—biscuits, puffs, rolls, croissants, doughnuts, and white bread
• Chinese foods—Ajinomoto or Chinese salt is bad for the hair
• Fast foods—pizzas, burgers, and canned foods
• Restrict alcohol to two beers or two hard drinks 2–3 times a week
• Coffee and tea are restricted to 2–3 cups a day
• Strictly NO SMOKING, keep away from second-hand smoke as well

List of foods to add in your diet:
• Steamed sprouts 2 times a week
• Green leafy vegetables 2 times a week
• Lima beans, fava beans, French beans, broad beans, colored beans, black beans, kidney beans—rotate the choice—3 times a week
• Salads with one meal everyday—beet root, carrot, cucumber, tomato, and greens; add salt, pepper, a dash of lime, no mayonnaise, no salad dressing, no sauces
• Cottage cheese, chick peas, tofu, mushroom, lentils—rotate the choice—3 times a week
• Ten to twelve non-salted walnuts, almonds, and nuts everyday by rotation Avoid peanuts and cashew nuts and macadamia nuts
• Low fat dairy products, slice of cheese, olive oil dressing—3 times a week
• Two fresh fruits per day—Cut and eat with the fruit skin when possible. Freshly squeezed juice can be consumed within 10–15 min
• Have 2–3 cups of green tea or hot water every day
• Have 3–4 L of water every day
• Have a balanced diet and avoid high protein intake, regular whey protein, and extreme diets

71.9 Loss of Nutritive Values of the Foods

A study comparing the nutrient value of foods in 1950 and 1990 shows 30–40% drop in nutritional content of the foods [26, 41–44]. Hence nutritional needs cannot be full filled by diet alone. The use of nutritional supplements is required to meet the body requirements for normal health and routine biological functions.

71.10 Scientific Awareness on Nutritional Deficiencies Causing Disease and Hair Loss

Incidence of poor nutrition is on the rise due to vegetarian diets, lacto vegetarian diets [45, 46], purely nonvegetarian diets, and high protein diets. Restricted eating has become a way of life due to appreciation of super slim bodies seen in media promotions targeting children of all ages.

There are international studies on the nutritional basis of endocrine disease as follows:

- Bajwa SJ, Sethi E, Kaur R. Nutritional risk factors in endocrine diseases J Med Nutr Nutraceut, 2013
- Langley-Evans SC. Nutritional programming of disease: Unravelling the mechanism. J. Anat 215:36–51, 2009
- Habito RC, Ball MJ. Postprandial changes in sex hormones after meals of different composition. Metabolism. 2001
- Rushton DH—Nutritional factors and hair loss**,** Clin Exp Dermatol. 2002, School of Pharmacy and Biomedical Sciences, University of Portsmouth, UK

- Kantor et al. confirmed, Ferritin- 70 μ g/L, with a normal erythrocyte sedimentation rate (<10 mm/h)
- Double-blind data–response to L-lysine & iron therapy.

In the Indian scenario, several Indian institutes have presented the rampant nutritional deficiencies in our country which justify the use of vitamins in the treatment and prevention of disease. New terms like “Hidden Hunger” by Indian National Science Academy and creation of Adult Micronutrient Quality Index by Agharkar Research Institute highlight the seriousness of nutrition. Important references are as follows:

- Indian National Science Academy (INSA) brought out a position paper on—Nutrition Security for India, 2009. Cereal-pulse based Indian diets are qualitatively deficient in micronutrients particularly iron, calcium, vitamin A, riboflavin and folic acid (hidden hunger),
- Pathak, Department of Human Nutrition, AIMS—Deficiencies of micronutrients, zinc, copper, magnesium, ferritin, folic acid, iodine & TSH, Indian J Pediatr. 2004
- Multiple micronutrient deficiencies, diet meets less than 50% of requirement
- Kawade R, Glob Health Action. 2012 Biometry & Nutrition Group, Agharkar Research Institute, Pune—Adolescent Micronutrient Quality Index (AMQI)
- Tupe R, Chiplonkar SA, Diet patterns of lactovegetarian adolescent girls: need for devising recipes with high zinc bioavailability. Nutrition. 2010, Agharkar Research Institute, Pune, India.

Zinc deficiency is another neglected cause for hair loss. Some good studies that draw attention toward this problem and the causes of hair loss are as follows:

- Ambooken Betsy, MP Binitha, and S Sarita, Zinc Deficiency Associated with Hypothyroidism: An Overlooked Cause of Severe Alopecia. Int J Trichology. 2013.
- Zinc, copper, selenium are required for synthesis of thyroid hormones. Hair loss may not improve with thyroxin unless zinc supplements are added.
- Acquired Zinc deficiency due to inadequate intake, increased requirement in pregnancy and lactation, malabsorption, alcoholism, HIV, renal disease. Improper proportion in diet forming insoluble complexes with calcium, fiber, and phytates.
- Loss of appetite, depression, psoriasiform, annular or crusted plaques, dryness, brittle hair & nails. Plasma, Serum levels unreliable, therapeutic response is diagnostic.

71.11 Evidence for Role of Antioxidants in Hair Loss Management and Hair Regrowth

Lipid peroxidation, glutathione derivatives, and nitric oxide are indicators of cellular destruction by ROS through oxidation. All these markers have been identified to be significantly raised in hair loss patients, providing evidence of the role of ROS in the mechanism of hair loss [47, 48]. Inui, Fukuzato, and Itami established that androgens inhibit hair growth through secretion of TGF ß1 [49, 50]. Hee, Shin, Yoo, and Inui analyzed details of this mechanism showing that androgens rise levels of ROS in the dermal papilla cells which in turn leads to secretion of TGF ß1 that inhibits hair growth. The experiment further demonstrated that the use of ROS scavengers blocked the release of TGF ß1 and reversed the inhibition of hair growth [51, 52]. The evidence suggests that antioxidants can promote hair growth without the direct use of antiandrogens, and utilizing antiandrogens alone may not achieve complete clinical response in all patients of hair loss.

Kalkan et al. proposed that the ROS forms covalent bond with endogenous proteins in the cells, producing structural changes in the proteins, leading to changes in their immune signature. The normal proteins are now recognized as new antigens, making them targets of immunity, inflammation, and autoimmune reactions. The study indicates the importance of ROS scavengers and provides a rationale, for benefit from the use of antioxidants in hair loss management and alopecia areata [53].

71.12 Apoptosis and Altered Immune Response in Nutritional Deficiency

Apoptosis and autophagy are triggered by the lack of calories, poor nutrition, and mineral deficiencies. Studies by Kubibidila and Yu and the research by Fraker and King showed altered immune response in protein calorie malnutrition and individual nutrient deficiencies [54, 55]. Trueb recognized these mechanisms in androgenetic alopecia where nutritional deficiencies could lead to apoptosis of hair follicle cells [56].

71.13 Compensation in Nutrient Deficiency by Autophagy

Yoshinori Ohsumi of Japan has been granted the 2016 Nobel Prize in Medicine for his research on autophagy. Autophagy is a process of regulated destruction of intracellular proteins and organelles by partial self-destruction to tide over amino acid, mineral, and nutritional deficiencies. It is an attempt to prevent apoptosis. Autophagy arrests the progress of cellular metabolism, new cell division, and growth. Guimaraes, Yoshimori, and Freker noted that autophagy occurs before subjecting the cells to apoptosis [57–59]. Autophagy has been recognized to play a role for providing nutrients during metabolic stress, nutritional deficiencies, and starvation-like conditions. When applied to hair cycles, autophagy explains the mechanism leading to telogen effluvium after illness, high fever, surgical trauma, states of interrupted or poor nutrition, etc. Autophagy is the mechanism by which the body maintains normal blood levels of nutrients by arresting and discontinuing hair growth. Clinically the nutrient levels may not show frank deficiencies as they are compensated and maintained by arresting hair growth. The body is in a state of compensated failure. As soon as we provide stimulation and restore nutrition, the hair regrowth begins. The evidence supports correction of nutritional deficiencies to prevent hair loss and promote hair growth [57–59].

71.14 Hair Loss in States of Poor Nutrition

Goette and Odumin (1976) reported alopecia in crash dieters which may be due to the role of mechanisms like autophagy and uncorrected nutritional balance [60]. Freker points out that zinc deficiency induces secretion of glucocorticoids leading to programmed cell death by initiating apoptosis. The effect is first seen in lymphocytes, T cells, B cells, thymus, liver, kidney, and testes; it compromises host defense, increases inflammation, and propagates damage to other cell systems. Fibroblasts exhibit DNA breakage [59]. Zinc deficiency is a well-documented cause for hair loss [61, 62]. The scientific facts suggest that providing adequate nutrients and avoiding deficiency states can play a role in preventing hair loss and achieving new hair growth.

71.15 Lifestyle Indications for Benefit with Nutritional Correction

1. Teenagers selecting fast foods and junk foods
2. Weight watchers with restricted diet to control weight
3. High consumption of fried foods and red meat
4. High consumption of sugar-based foods, packed juice, colas, and soft drinks
5. High consumption of processed foods, packed foods, and MSG/Ajinomoto
6. High consumption of coffee, alcohol, and energy drinks
7. Body building supplements, protein powders, and high protein diet
8. Indiscriminate use of vitamins for good skin, fitness, and stamina
9. Stress, inadequate sleep, and go get attitude

71.15.1 Medical Indications for Benefit from Nutritional Correction

1. Anemia, low ferritin, low calcium, hypoproteinemia.
2. Low vitamins D and B12.
3. Hypothyroid patients benefit for supporting better metabolism raising BMR.
4. Hyperthyroid patients benefit for supplying adequate nutrients in high BMR.
5. Post-pregnancy hair loss.

6. Hair loss after bariatric surgery.
7. Hair loss during recovery from episode of illness, trauma, or surgery.
8. Boosting slow metabolism in diabetics, cardiac, and all chronic illness.
9. Hair loss from metabolic syndrome and insulin resistance.
10. Hair loss from polycystic ovary syndrome.
11. Diffuse unpatterned hair loss with no known cause.
12. Promoting growth of unaffected and partially affected hair in androgenic alopecia.
13. Defects of hair shaft formation: monilethrix, trichorrhexis nodosa, and split ends.
14. Loose anagen syndrome, short anagen syndrome, and chronic telogen effluvium.
15. Post-hair transplant shock loss.
16. Hair loss during recovery from chemotherapy.
17. Though nutrition cannot alter the course of alopecia areata or scarring alopecia, it can definitely improve the thickness, quality, and growth of the remaining hair.

71.15.2 Summary

Genetic predisposition, DHT, and various internal and external factors damage a small percentage of hair follicles in every cycle, gradually resulting in progressive baldness over the years. Weak hair roots are easily affected by the causes for hair loss. We can either fight the causes with traditional approaches or strengthen hair roots and promote hair growth with specific nutrients. A nutritional program and diet advice have been successfully used to enhance new hair growth. The program can be effective by itself or can be an adjunct for enhanced results in hair transplant, PRP, meso-therapy, growth factor injections, and LLLT or used along with biomimetic peptides. In order to prevent interaction, avoid overdose of vitamins, hypervitaminosis, and improve efficiency of individual nutrients; low-dose supplements are used in a once in 3 days cycle. With patients now often refusing finasteride and there being the concern of post-finasteride syndrome, the cyclical vitamin therapy program is well received as a long-term option. There is no lack of stem cells in a balding scalp, even though the hair follicles are miniaturized and becoming invisible to the eye. Hair growth stimulation along with a correct nutritional balance to support the rapid cell division results in natural rejuvenation of dormant stem cells leading to the visible growth of new hair. There is evidence that mechanism of action of DHT is mediated through accumulation of ROS. Immunity is altered by micronutrient deficiencies. Food selection and low-dose supplements have a pivotal role in hair loss management and ensuring hair regrowth.

71.15.3 Tips and Pearls

1. Hair loss is not a disease that can be cured with medicines. Growing hair is more of a care, promotion, and maintenance program rather than a cure.
2. We are in an era of abuse and overuse of vitamins. Excess in vitamin A and vitamin D can cause hair loss instead of hair growth.
3. The hair is a very unusual structure that grows when cells die as they undergo keratinization. Oversaturation of nutrients, proteins, vitamins and supplements interfere with keratinization, preventing the formation of new hair and leading to hair loss instead of hair growth. This fact can be appreciated in fitness-concerned patients who are over doing gym and taking too many supplements.
4. Hair growth has a low priority among the body functions. Only when the body is in good health can you expect hair to grow. We improve hair growth by achieving wellness and good health.
5. If you have sensitive hair, then exposure to smoking, pollution, excess heat, and excess cold will result in hair loss, whereas others whose hair is not sensitive can very well remain unaffected by the same exposures.
6. Baldness occurs not due to hair loss but rather because lost hair is not replaced with new hair as the growth cycle has stopped.
7. There are two parts to hair regrowth: inducing new growth by stimulation of the hair growth cycles and supporting rapid cell division with nutrients to ensure the creation and growth of new hair.
8. Accumulation of free radicals can hamper growth of all rapidly dividing cells in the body. The hair follicle is affected by free radicals from environmental pollution, smoking, preservatives, taste makers in processed foods, packed juices, etc. Reducing the free radical load and countering the effect with antioxidants help in good hair growth.
9. Hair growth is achieved by converting telogen hair to anagen. Since telogen normally lasts for 3.5–4 months, any hair treatment that is effective must begin to show improvement within 2 months, which is half the cycle.

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Chapter 72
Low Anabolic Profile in Assessing a Patient's Overall Hair Loss

Lawrence J. Shapiro and Douglas B. Shapiro

72.1 Introduction

In today's world, a person's lifestyle choices and supplements play an important role in regulating their nutritional diet. However, certain supplements can modify the body's metabolic processes so significantly that they lead to hair loss. Knowing the identity of each supplement has aided in diagnosing and understanding the effects they have on the patient. The purpose of this study was to identify different supplementations and assess them relative to hair loss and provide hair loss specialists with a method to identify and correct a patient's hair loss risk. Supplements previously studied were included and explored further. This scientific paper provides an in-depth explanation on numerous supplements and investigates their metabolic pathways to see how they affect hair growth and hair loss.

72.2 Substantiating Data (Fig. 72.1)

72.2.1 Pathway 1

(a) "Anabolism" is defined as "any state in which nitrogen is differentially retained in lean body mass, either through stimulation of protein synthesis or decreased breakdown of protein anywhere in the body." Anabolic steroids are extremely common, and almost 1.5% of 12th graders have tried them at least once. Anabolic steroids are technically called anabolic-androgen steroids (AAS).

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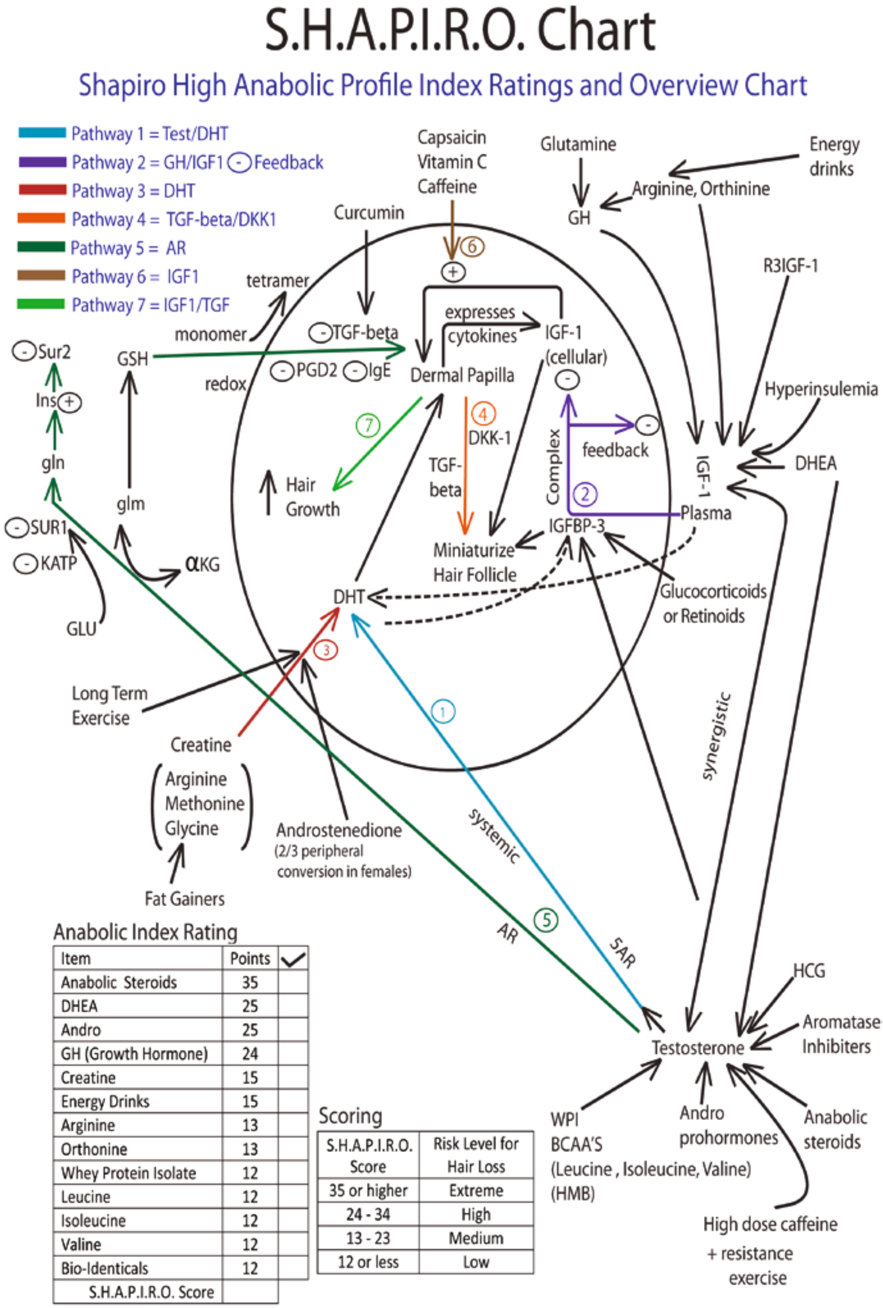

Anabolic Index Rating

Item	Points	✓
Anabolic Steroids	35	
DHEA	25	
Andro	25	
GH (Growth Hormone)	24	
Creatine	15	
Energy Drinks	15	
Arginine	13	
Orthonine	13	
Whey Protein Isolate	12	
Leucine	12	
Isoleucine	12	
Valine	12	
Bio-Identicals	12	
S.H.A.P.I.R.O. Score		

Scoring

S.H.A.P.I.R.O. Score	Risk Level for Hair Loss
35 or higher	Extreme
24 - 34	High
13 - 23	Medium
12 or less	Low

Fig. 72.1 SHAPIRO chart

Anabolic steroids are technically called anabolic-androgen steroids (AAS). They are drugs that mimic the effects of testosterone (T). Anabolic steroids increase the protein synthesis that takes place within cells. This has the consequence of cellular tissue buildup (anabolism), particularly in the muscles.

In skeletal muscles, anabolic steroids increase protein synthesis. They reverse catabolic processes. Anabolic steroids are often blamed for causing adverse effects. Serious adverse effects include endocrine dysfunction, hepatic dysfunction, cardiovascular changes, and behavioral changes.

All anabolic steroids currently in use are either derivatives of testosterone, or they are structural modifications of testosterone.

Testosterone binds to the androgen receptor to exert its androgenic activity but is also 5 alpha reduced in some target tissues (including the male urogenital tract, skin, liver, and sebaceous glands) to dihydrotestosterone (DHT). It can also be aromatized to estradiol and exert estrogenic activities.

The latter two actions are highly undesirable in anabolic drugs. 5 alpha-reduction is the major cause of hair loss and aromatization causes feminizing side effects.

Dimethandrolone (DMA: 7α,11β-dimethyl-19-nortestosterone) and 11β-methyl-19-nortestosterone (MNT), synthetic androgens, are exceptional because they do not need to convert to DHT to act as potent steroids. They are being developed for male hormonal therapy. A study on them may have shown that "inhibition of 5α-reductase activity in vivo does not affect the androgenic potency of DMA, MNT, or MENT."

This is important because as hair loss physicians, we need to also look at supplements that cause hair loss and their anabolic effects on secondary pathways in addition to DHT.

(b) The BCAAs in whey protein isolate (WPI) are the real culprit in raising the testosterone levels during and after exercise as shown in the Sharp study. In the Sharp study, subjects consumed high branched-chain amino acids (BCAA) with high-intensity total-body resistance training. Blood serum was analyzed for testosterone. "Serum testosterone levels were significantly higher in the BCAA group during and following resistance training."

Whey protein is in general prevalence and usage compared to proteins such as soy or pea and is due to its low cost, availability, and easy digestibility. Whey protein also has a high BV or high biological value and is absorbed easily due to its small molecular weight.

(c) Many muscle magazines advertise that WPI will make you more "cut" by raising your testosterone levels. Being "cut" is referred to as having a body composition primarily of lean muscle while decreasing visibility of body fat.

WPI (80–100%) is made when cow's milk is homogenized and separated into curds and whey. The percentage represents the amount of protein. The whey is a liquid that is then dried using various filters. The sweet whey is then processed to whey protein concentrate (WPC-34%) by removing the lactose and fat.

WPC is further processed to WPI by several methods such as ion exchange or cross-flow microfiltration (CFM). This further processing leaves a higher percentage of branched-chain amino acids (BCAA). BCAAs including leucine, isoleucine, and valine are of special importance for athletes because they are metabolized in the muscle, rather than in the liver. This is important since there is increased protein synthesis in the muscle and therefore less muscle breakdown and therefore faster recovery time for the muscle after workout.

Leucine is a major amino acid for protein synthesis. BCAAs, especially leucine, are the key amino acids to modulate muscle protein metabolism and lead to muscle protein anabolism. It is thought that leucine is a nutritional signal to indicate that amino acids are available after a meal containing protein. It has been shown that BCAAs promote muscle protein synthesis and inhibit muscle protein breakdown.

(d) But we also need to look at the various milk proteins effect on IGF-1 (Pathway 2).

Milk increases both fasting insulin and insulin-like growth factor-1 (IGF-1). Casein is a byproduct of milk. It is considered the "curds" in "curds and whey." When we compare whey and casein, whey protein doesn't increase SERUM IGF-1. However, there is an increase in serum IGF-1 with casein which can increase DHT. Whey does increase fasting insulin levels but casein has no effect.

"Between milk mineral groups (high, low) and milk protein groups (whey, casein), serum IGF-1 increased by 15% ($P < 0.0001$), whereas there was no change in fasting insulin ($P = 0.36$) in the casein group. In the whey group, fasting insulin increased by 21% ($P = 0.006$), with no change in IGF-1 ($P = 0.27$)".

(e) Enhanced whey protein with low branched-chain amino acids given to patients after a hair transplant in conjunction with the low anabolic profile has shown to accelerate regrowth. Currently over 800 patients have started to grow by 6–8 weeks and full growth at 5–6 months. This is called AFR or Accelerated Follicular Restoration. Normally regrowth after a hair transplant starts at 4–6 months and could take up to 18 months to regrow. Patients also report less shock loss after the procedure.
(f) Another new supplement touted by medical clinics is human chorionic gonadotropin (HCG). Homeopathic concentrations of HCG are a new fad weight loss diet that has been banned by the federal government. Regular concentrations of HCG have been shown to increase testosterone levels. There is no evidence supporting that HCG works to reduce weight.

72.2.1.1 Pathways 1, 2

DHEA is a supplement used mostly by pre- and postmenopausal women, a precursor to androstenedione. With aging humans, there is a progressive decline in the secretion of the adrenal androgens. DHEA is extremely anabolic because it raises testosterone, androstenedione, and DHT levels.

In women, but not in men, serums A, T, and DHT were increased to levels above gender-specific young adult ranges. This is due to peripheral conversion because DHEA is a precursor to androstenedione.

Testosterone and androstenedione are precursors (prehormones) for plasma dihydrotestosterone. Pathway 3 testosterone conversion accounts for at least 70% of plasma DHT in the male but less than 20% in the normal female. "Androstenedione appears to be a major prehormone of plasma dihydrotestosterone, accounting for at least two-thirds plasma dihydrotestosterone by peripheral conversion in adult females."

Androstenedione is a naturally occurring OTC drug used by muscle builders. It is a prohormone that goes by the street name "andro" and it directly converts to testosterone. This is the most common performance enhancing drug on the market in professional sports. Andro has no real effect on performance.

DHEA has also been shown to raise IGF-1 levels which has been shown to raise DHT and testosterone but had no effect on GH or IGFB-3. Many weight lifters are under the false impression that they can block just DHT (Pathway 1) with a DHT blocker and continue to take anabolic supplements without hair loss as a side effect. The effects of supplements on IGF-1 must be considered when assessing a patient's hair loss situation.

72.2.2 Pathway 2

There is a secondary pathway referred to as a "parallel axis" which consists of both GH and insulin-like growth factor-1 (GH-IGF-1).

The effects of supplements on IGF-1 must be considered when assessing a patient's hair loss situation.

IGF-1 is a major player on Pathway 2 of the SHAPIRO chart. To understand the SHAPIRO chart, we must have a basic understanding of this polypeptide.

1. Insulin-like growth factor-1 plays a specific role in the regulation of growth and metabolism. IGF-1 circulates with specific binding proteins (BPs). Six different IGFBPs circulate as a high-affinity complex by binding with IGF-1.
2. IGF-1 binds as a high-affinity complex to IGFBP-3, limiting its effects on metabolism.
3. IGF-1 also binds to low molecular weight IGFBP-1, which is produced in the liver. It is a major short-term modulator of IGF-1 bioavailability.
4. Less than 1% of IGF-1 is circulating in a free state. It is readily "available to mediate effects on target tissues through an endocrine mechanism, similar to the situation with steroid and thyroid hormones."

72.2.2.1 GH-IGF-1 Pathway

Growth hormone is another very common supplement and is synergistic with testosterone. Both boost IGF-1 levels which can affect DHT directly by increasing 5AR. IGF-1 is increased in men with vertex baldness. GF-1 correlated in women with higher acne levels. IGF-1 in women with acne was correlated with increased DHT.

Both increased GH and IGF lower sex hormone-binding globulin (SHBG) and release free testosterone (T) into the bloodstream to produce an anabolic effect. "Insulin and IGF-1" stimulate the synthesis of androgens in ovarian and testicular tissues. Furthermore, insulin and IGF-1 inhibit the hepatic synthesis of sex hormone-binding globulin (SHBG), thereby increasing the bioavailability of circulating androgens to tissues. Cross-sectional studies demonstrate inverse relationships between.

GH also increases leucine metabolism at rest and during and after exercise, which then exerts an anabolic effect.

There is much controversy with growth hormone as many people consider it to be the fountain of youth. Bioidenticals, which are given as low doses of growth hormone, are touted to promote hair growth; however, there is no evidence of this effect. On the contrary, hair loss can occur from growth hormone because the serum levels of elevated IGF-1 cause hair loss directly through increased DHT even though the cytokines papilla are producing their own IGF-1 independently of serum IGF-1 and may cause growth. There is no evidence that growth hormone affects the dermal papilla directly; however, "there is mounting evidence that suggests that GH exerts its anabolic affect mainly by locally produced IGF-1 rather than liver-derived circulating IGF-1." DHT, however, does affect IGF-1 cellular by inhibiting production in the dermal papillae.

To make matters worse, growth hormone increases both serum IGF-1 and IGFBP-3, and this binding molecule binds both serum and cellular IGF-1 to reduce the concentration of IGF-1 cellular available for hair stimulation. IGFB3-1 is less sensitive than IGF-1 to growth hormone stimulation, and this may account for some patients thinking that initially their hair has some positive effects because growth hormone affects cellular IGF-1 initially, but then the binding molecule acts to decrease cellular IGF-1 decreasing hair growth.

The study showed that in normal young adults, the IGF-1 and IGFBP-3 responses to rhGH depend on gender and dosage. The minimum rhGH dose able to increase IGF-1 and IGFBP-3 levels was lower than expected. They concluded that IGFBP-3 is less sensitive than IGF-1 to rhGH stimulation.

The researchers also found that "IGFBP-3 is less sensitive than IGF-1 to rhGH stimulation, in agreement with previous results in GH-deficient adults. Actually, IGFBP-3 synthesis and release depend on GH but probably also on IGF-1. This could also explain why the timing of the IGFBP-3 response is delayed with respect to that of IGF-1."

Testosterone plays a factor in modulation of IGF-1 and IGFBP-3 by increasing their production in rats and had an additive effect with IGF-1 raising IGFBP-3. IGFBP-3 is increased by glucocorticoids and retinoids. Plasma IGF-1 has a negative feedback on growth hormone in the pituitary. Insulin-like growth factor-binding protein-3 has been shown to regulate DHT.

As long as formation of DHT is minimal or nonexistent (Pathways 1, 3), then blocking IGFBP-3 formation or even blocking its ability to bind IGF-1 (Pathway 2) would allow for the possibility of cellular IGF-1 to produce growth uninhibited in the cytokines.

72.2.3 Pathway 3

Some workout products can lead to hair loss. Creatine is a common OTC product used by weight lifters to gain muscle mass, and in addition, it is used as a weight gainer. Creatine is made up of three amino acids: arginine, glycine, and L-methionine. It raises DHT directly without affecting serum testosterone levels although IGF-1 is elevated.

A study showed that after 7 days (1 week) of creatine loading or a further 2 weeks of creatine maintenance dose, "there was no change in serum T levels. However, DHT levels increased by 56% after a week of creatine loading and remained 40% above baseline after 2 weeks of maintenance".

The effect of IGF-1 was about 100× that of androgen.

The researchers studied whether androgen induction of the enzyme activity could be via IGF-1 production. Adding a monoclonal antibody against IGF-1 significantly reduced the effect of DHT. The study showed that "…simultaneous addition of a specific IGF-1 receptor antibody blocked the expected induction of 5 alpha R activity (control, 4.9 ± 0.5; DHT, 8.0 ± 1.9; DHT plus IGF-1 receptor antibody, 3.7 ± 0.4%). These studies indicate that IGF-1 may be an important regulator of skin 5 alpha R activity and, thus, may influence DHT formation." The previously known androgen induction of this peripheral steroidogenic enzyme may be via paracrine/ autocrine production of an IGF-1-type growth factor."

Even though IGF-1 increases DHT and T, there may be an increased rate of conversion from T to DHT since IGF-1 increases 5AR.

72.2.3.1 Pathways 2, 3

Arginine and ornithine are extremely anabolic amino acids and increase both growth hormone and IGF-1 levels. However, leucine, found in WPI, had no effect on GH and IGF-1 levels.

> Of the amino acids, arginine is the most potent GH secretagogue in man. It potentiates the GH response to GHRH, exerts a weaker PRL-releasing effect, stimulates insulin and glucagon, and induces a biphasic glucose variation… His and Leu did not significantly modify either basal or GHRH-induced GH secretion nor basal PRL, insulin, and glucose levels.

Arginine is one of three amino acids found in creatine which affects DHT directly. Interesting though is arginine and ornithine-decreased IGFBP-3 levels.

Photos below: examples of texture change of hair in patients taking supplements (Fig. 72.2).

Anabolic Index Rating

Rating and evaluating a patient's anabolic index rating will allow the health-care physician to give an actual index of hair loss risk. Reviewing the patients supplement use is essential. The review of systems (ROS) must include the amount of

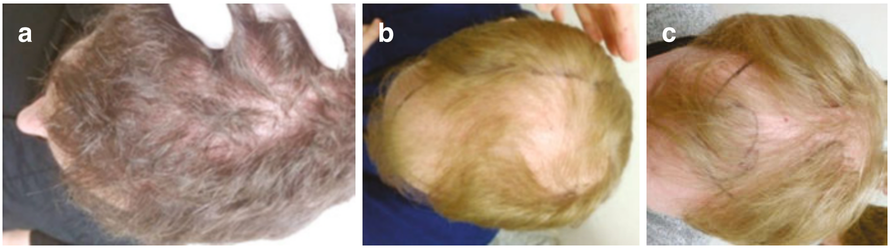

Fig. 72.2 Texture change of hair in patients taking supplements: change of texture of hair and even diffuse thinning throughout affected areas. This 27-year-old male (**a**) used creatine for 4–5 months. His hair loss is commonly recognized to be from anabolic creatine since it has a very even, diffused pattern, and the hair has a change in texture. Identical twins: twin on the left took creatine and had more hair loss than his identical twin brother on the right. (**b**) Took anabolics (creatine) and (**c**) did not take anabolics

Table 72.1 Anabolic index rating from the SHAPIRO chart

Anabolic index rating		
Item	Points	✓
Anabolic Steroids	35	
DHEA	25	
Andro	25	
GH (Growth Hormones)	24	
Creatine	15	
Arginine	13	
Orthonine	13	
Whey Protein Isolate	12	
Leucine	12	
Isoleucine	12	
Valine	12	
S.H.A.P.I.R.O. Score		

Scoring	
S.H.A.P.I.R.O. Score	Risk level for hair loss
35 or higher	Extreme
24–34	High
13–23	Medium
12 or less	Low

supplements used and duration of use. The patient must be made aware of the delayed effects of the hair loss from supplement use. Usually a period of 6–9 months after the consumption of anabolics is the period when hair loss will be noticed. This usually makes it harder to identify the immediate cause. Scoring with the anabolic index rating is evaluated at the initial consultation and followed up at 2 months intervals. Long-term assessment of the patient's condition will change as the patient's education of supplement usage is curtailed (Table 72.1).

Two other lifestyle choices should be mentioned when reviewing a patient's low anabolic profile.

"DHT increased 14.5% in exercisers versus 1.7% in controls at 3 months (P = 0.04); at 12 months, it remained 8.6% above baseline in exercisers versus a 3.1% decrease in controls (P = 0.03). SHBG increased 14.3% in exercisers versus 5.7% in controls at 3 months (P = 0.04); at 12 months, it remained 8.9% above baseline in exercisers versus 4.0% in controls (P = 0.13). A yearlong, moderate-intensity aerobic exercise program increased DHT and SHBG, but it had no effect on other androgens in middle-aged to older men."

Another study showed that serum levels of total and free IGF-1 and IGFBP-3 are increased and maintained in long-term training.

A second lifestyle choice compared vegetarians and meat eaters. In vegetarians, there was no evidence that available androgens were higher. Although IGF-1 was 9% higher in meat eaters, further studies should be done to determine the amount of actual hair loss from elevated levels.

A further study showed there was very little difference in IGF-1 levels with animal or vegetarian diets.

Soy is another very common protein for working out. Surprisingly though, of all the supplemental proteins, it has the highest amount of arginine per 100 g:

Arginine (per 100 g)
Soy 7.6 g
Beef 6.3 g
Egg 5.8 g
Casein 3.7 g
Whey 2.9 g

But soy isoflavones also have some goitrogenic and estrogenic activity.

> Iodine deficiency greatly increases soy antithyroid effects, whereas iodine supplementation is protective. Thus, soy effects on the thyroid involve the critical relationship between iodine status and thyroid function. In rats consuming genistein-fortified diets, genistein was measured in the thyroid at levels that produced dose-dependent and significant inactivation of rat and human thyroid peroxidase (TPO) in vitro.

Another common protein used for working out is egg protein. Biotin binds with streptavidin, which is a similar compound to avidin. Avidin is found in egg whites, which also binds with biotin.

Most interesting is there is still 25% residual avidin activity in cooked egg white.

Caffeine, a common stimulant, increases T and cortisol levels in resistance exercise. Caffeine increased testosterone levels 15% during exercise. Caffeine raised this concentration in a dose dependent. Cortisol increased moderately—with an 800-mg dose of caffeine. The study concluded that caffeine might have a benefit to training outcomes due to the anabolic effects of the increase in testosterone concentration. However, "this benefit might be counteracted by the opposing catabolic effects of the increase in cortisol."

72.3 Conclusion

In conclusion, certain supplements have a negative effect on hair loss (as illuminated though various metabolic pathways). In entirety, it is crucial for hair loss professionals to properly educate themselves and their patients about the effects of supplements, whey protein isolate, growth hormones, and anabolic precursors. By understanding the multiple biochemical pathways causing hair loss, modern day and future hair loss professionals can look for further prevention, growth, and faster regrowth. A good history of the patient's supplement intake over their lifetime and suggesting that they avoid potentially anabolic products in the future will help them reduce future hair loss. Supplemental hormonal modulation of hair regrowth (HMH) is the next step in hair loss prevention.

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Chapter 73
Ageing Hair in Asians and Caucasians

Yi Shan Lim and Thomas L. Dawson Jr

73.1 Introduction

Regardless of ethnicity, men and women lose satisfaction with their hair as they age [1]. Women most often present at the clinic reporting loss of hair amount or volume, with Asian women particularly concerned with an increase in the visibility of the scalp [2]. Most biological factors known to regulate hair growth and changes with age have not yet been thoroughly investigated in Asian populations and are therefore often assumed to be ubiquitous across ethnicities. These include androgens and oestrogens [1, 3], menopause [4] and disease [5]. Many other nonhormonal factors related to hair loss remain to be investigated in other than Caucasians of European descent, including ageing, nutritional status and stress levels. Key drivers of hair appearance are number density, hair fibre diameter and colour (pigmentation) [6], and these are all affected by age [7]. Unfortunately, very little information exists regarding biological differences in Asian and Caucasian hair. Finally, care must be taken to avoid damage of new hairs, so patients should be instructed on good hair care practice and cautioned against damaging treatments such as colouring, perming and straightening.

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73.2 Greying Hair

Hair greying (canities) is a natural characteristic of ageing. The onset and progression is closely associated with chronological age, health, response to hormones and varies amongst gender, race and genetics. Changes in climate and seasons, exposure to chemical toxins and environmental pollutants and stress levels can also affect hair pigmentation [8, 9].

Hair greying typically occurs at 34 ± 9.6 years in Caucasians and the late 30s for Asians. Hair greying before 20 in Caucasians and 25 in Asians is considered to be *premature.* Keogh and Walsh state that at 50 years of age, 50% of people exhibit 50% grey hair. However, Tobin and Paus report that while 50% of grey hairs appear in Caucasians from age 49, it is expected to occur in Asians about 5 years later [6, 9–11]. This approximation could be subjected to geo-ethnic differences, as the grey hair ratio (number of grey hairs of the total hairs tabulated) reportedly increases about 40% in Korean women in their 60s, suggesting that greying happens later in East Asians [12].

On the human scalp, greying in men usually begins at the temples and sideburns, while in women grey hairs tend to appear first along the hairline [8]. Beginning from the temporal and frontal regions, grey hairs gradually spread to the vertex or crown and finally show up in the occipital area [7].

Although greying is generally understood to be a gradual reduction of pigmentation, or melanin, in the hair shaft, its exact cellular and molecular pathways remain unclear. It is known that loss of melanin is due to the decrease in specialized melanin-producing cells located proximally to the hair bulb [9]. During anagen, hair follicular melanocytes exhibit an extraordinary ability to produce and store high levels of melanin. In fact, as few as 100 melanocytes per human hair follicle are able to supply an intensely pigmented hair fibre of up to 1.5 m in length [7, 9]. On average, melanocytes in one follicle experience 7–15 different hair cycles to produce pigmented hairs for over 45 years [9]. Reportedly, as age advances beyond 30 years, approximately 10% of melanocytes are lost every decade [13].

Mostly based on studies in murine models, the onset of greying is attributed to well-known theories such as depletion of enzymes involved in melanin production (for instance, the melanin synthesizing enzyme, tyrosinase, which exhibits significantly lower activity during the resting telogen phase compared to the proliferative anagen phase [14]), as well as oxidative stress. Since Harman and authors first proposed the free radical theory of ageing in 1956 [15], there has been mounting evidence suggesting that oxidative stress has a major role in ageing. Free radicals or *r*eactive *o*xygen *s*pecies (ROS) are by-products of cellular metabolism and are induced by exposure to external environmental stresses like ultraviolet (UV) rays as well as in normal metabolism. They directly damage various structural membranes, lipids, proteins and DNA. Our bodies possess antioxidant enzymes such as superoxide dismutase and glutathione peroxidase, as well as non-enzymatic antioxidants like vitamins C and E, and glutathione to reduce and neutralize free radicals [16, 17]. However, as we age, free radicals accumulate while our endogenous defence mechanisms decrease. In this context, with the bulbar melanocytes each synthesizing melanin at remarkable rates for up to a decade, it is inevitable that large amounts of ROS are produced as a result of hydroxylation of tyrosine and oxidation of dihydroxyphenylalanine (DOPA) to melanin [17]. This all together increases the oxidative stress in melanocytes and the hair bulb epithelium, leading to an adverse effect on their function and hence a decrease in hair melanin production and the appearance of grey hairs.

73.3 Morphology and Properties of Hair

Apart from hair greying, hair fibre properties like cuticle layers, diameter and fibre elasticity change with age. To date, previous studies have been unable to show an age-related effect on hair fibre ellipticity [7]. However, it has long been known that there are many differences between Asian and Caucasian hair fibres, substantiated by numerous studies reporting variations of hair diameter, ellipticity and presence of medulla. For instance, Asian scalp hair density is less than Caucasian. On the other hand, hair fibres of East Asians are generally twice larger in diameter and thicker in innermost layers of medulla compared to Caucasian fibres [18–20]. These variations likely contribute to differences observed during hair ageing in different ethnicities and should be taken into consideration.

73.3.1 Scalp Hair Cuticles

The cuticle is the outermost layer of the fibre and is composed of closely compacted keratinized cell layers. It serves to protect the hair fibre from mechanical stress and friction (daily combing and brushing), as well as chemical degradation. Damage to the cuticle can compromise its protective function. Based on studies comparing hair cuticle characteristics of Asian and Caucasian females, Asian hairs had significantly thicker cuticle layers and more densely packed cuticles than Caucasian hairs [21, 22]. Cuticular components exocuticle and endocuticle in Asian hairs were also found to be similar in hardness, suggesting that Asian hair fibres are harder and less elastic than Caucasian hairs [21]. In addition, Asian hair cuticular cells are visibly larger in width, with smoother and flatter surfaces, cuticular intervals narrower and cuticular edges steeper relative to Caucasian hairs [21, 22]. Taken together, Asian hair fibres appear to have a more solid and rigid structure. Upon extension stress, the cohesion between Asian cuticle cells absorbs the stimuli and breaks apart, resulting in the lifting up of whole cuticle cells. Further stress applied eventually causes the Asian hair cuticles to break into large pieces. In contrast, as the cuticles in Caucasian hairs are more structurally fragile (flatter cuticular edges and surfaces), extension stress results in small fragments of cuticular cells breaking away from the hair fibre but not the removal of entire cuticle cells [21]. From this study, the inflexibility of

Asian hair towards environmental damage suggests that it is more likely to suffer from cuticle abrasion over time, for instance, from the daily processes of hair grooming [21, 23].

73.3.2 Hair Diameter

In a rare study of Caucasian children by Trotter and Duggins, they tracked changes in scalp hair diameter at regular intervals from infancy through childhood to about 10 years of age. Beginning with the smallest diameter at about 1 month old, as these children mature in age, the fine hairs were gradually replaced with hairs that were longer and wider in diameter [24].

After which, hair diameter changes as both males and females age. Based on several studies carried out in both Caucasian and Japanese (assumingly Asian) males, there is a strong correlation observed between age and fibre diameter. Otsuka and Nemoto, as well as Trotter and Dawson, showed that hair shaft diameter increases and peaks during the late teenage years in Japanese and French Canadian males, respectively [25, 26]. Subsequently, beginning at about age 25 to advanced ages from late 40s up to 89, diameter of the hair shaft steadily declines with increased age [25–27].

Unlike males, diameter of female scalp hairs is not linearly proportional to age. Parietal scalp hair diameter of Japanese and Caucasian females steadily increases from age 20 to early 40s, before it starts declining [6, 7, 25]. Interestingly, in addition to ageing, data suggests physiological or hormonal changes brought about by menopause possibly influence changes in females' scalp hair diameter. In a comparison between postmenopausal and premenopausal groups of Caucasian women, there was a significant reduction in hair fibre diameter in postmenopausal women [4]. However, a more thorough study of the correlation between hormonal level changes (during and after menopause) and scalp hair diameter still has to be done to validate this physiological effect.

73.3.3 Tensile Strength and Torsionality of Hair

It has been shown that the hair fibre's ability to stretch (elastic modulus), bend (bending modulus) and twist (torsional modulus) before it deforms irreversibly is directly proportional to the fibre diameter [7, 28–30]. Since the hair diameter decreases with age, the hair's ability to resist these stresses also decreases. In addition, due to gender differences, while Asian and Caucasian men begin to observe a decrease of the mechanical properties of their scalp hairs in their 20s, Asian [12] and Caucasian women likely only start experiencing a lower threshold for these stresses in their early 40s. Notably, Persaud and Kamath have suggested that hair cuticle has a more significant role towards maintaining torsional resistance compared to elasticity [30], implying that the differing cuticle characteristics amongst different ethnic races as mentioned earlier could also affect the ability of hair fibres to withstand mechanical stresses in advanced ages.

73.4 Biochemical Properties

73.4.1 Hair Lipids

Equally important as protein is to hair composition, lipids are critical to minimise moisture loss, provide a permeability barrier and maintain hair integrity (such as stiffness). Lipid modification is also essential for signalling pathway proteins, which play key roles in hair follicle morphogenesis and hair growth cycling [31, 32]. The major source of hair lipids are either the hair follicle matrix cells or the follicular sebaceous glands [7]. Lipids have been found to be covalently bound to wool and hair fibres, as well as in the epidermal stratum corneum. Notably, human scalp hair lipids are mostly composed of fatty acids, wax esters, ceramides, hydrocarbons and cholesterol. Taken together, they account for approximately 0.7–1.3% of the total chemical content of the hair [32, 33]. 18-Methyleicosanoic acid (18-MEA), the most abundant fatty acid found in hair, is linked to the proteins of the cuticle cell outer layer via thioester bonds [34]. This essentially constitutes the fatty layer, also known as the F-layer, which contributes to the surface properties of the fibre and gives hair the smooth and silky texture (Fig. 73.1).

Currently, there is lack of comprehensive studies with regard to hair lipid composition and age. However, other literature suggests potential differences in lipid composition in different age groups due to hormonal changes before and after puberty. For instance, Nicolaides and Rothman show the cholesterol content of the hairs of Caucasian boys 6–12 years of age are significantly greater than adult men and women, while the squalene content and total free acid content were less compared to the pooled hair of the adults [35, 36]. These differences are possibly a result

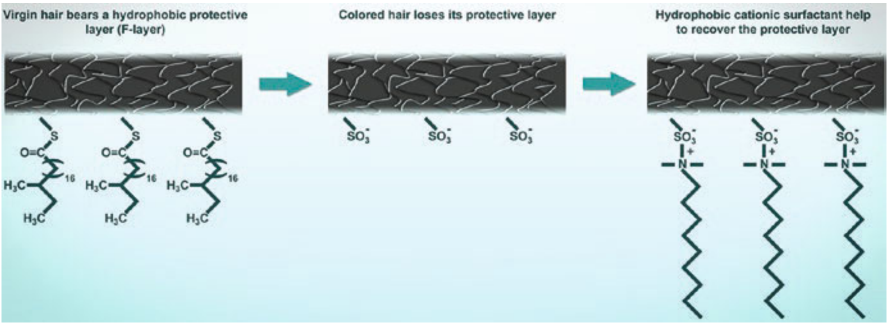

Fig. 73.1 Repairing hair cuticle damage. Virgin hair, which refers to hair that has not been exposed to chemical treatments—such as perming, straightening, dyeing or bleaching—has a hydrophobic fatty layer (F-layer) surrounding the outer surface of the hair cuticle. This F-layer, mostly constituted of 18-methyleicosanoic acid (or 18-MEA), is covalently bound to the hair cuticular proteins by thioester linkages. It serves to protect the hair fibre from everyday grooming, UV exposure, environmental stress and chemical processes. Upon chemical treatment like colouring, these bonds are cleaved, rendering the hair fibre hydrophilic and prone to friction. Damaged hair cannot be "repaired" nor can the effects of self-induced damage be "reversed". However, hydrophobic cationic surfactants present in hair conditioners can be deposited onto the hair fibres, restoring hydrophobicity to the outer cuticular surface and thus recovering the hair protective layer

of an increased production of squalene and fatty acids by hair follicular sebaceous glands after puberty. In a related study carried out to quantify general sebaceous gland activity in various age groups, Pochi and authors determined that the ratio of wax esters, cholesterol and cholesterol esters increased from 0.35 in children ages 9–13 to 7.47 in young adult women in their 20s (after puberty) and then declined to about 1.46 in postmenopausal women [37]. While overall hair lipid composition between Caucasian, Asian and African populations did not differ, Asian hair has a higher concentration of integral hair lipids, in particular free fatty acids, compared to the two other populations. After UV irradiation, it appears that Asian hair samples exhibit less damage compared to European and African hair [32]. Although it is possible that higher integral hair lipids have a contributory role in overall hair protection, more comprehensive studies are required to reach a direct correlation.

73.5 Hair Care

73.5.1 Hair Damage

Clear ethnic differences exist in hair structure and preferences between Asian and Caucasian. Asian hair is straighter and almost uniformly black. Generally Asian women prefer to have straight, smooth hair, while Caucasian women prefer "volume" (lift). Hence, the needs for hair care products differ substantially.

In order to make the most of existing hair, one must use care to avoid excessive damage. Damage to hair shafts will lead to breakage and the perception of less hair than is actually in place. Ironically, many common hair care practices applied to fight off ageing and increase hair volume, result in irreversible damage to hair fibres and result in even greater hair loss. The hair shaft itself is "dead" and non-renewable, damage accumulates and is progressive. The aforementioned differences in hair fibre structure, particularly the differences in fibre cuticle, mean that generally Asian hairs are more resistant to damage than Caucasian hairs (due to the thicker cuticle with more layers).

The main types of hair damage are, in order of increasing danger, are thermal, UV, mechanical and chemical. The first minor stages result from thermal and UV and are for the most part unavoidable. Normally, these result only in minimal damage which manifests as frayed hair cuticle edges. Frayed cuticle edges result in loss of volume and shine. However, as the cuticle is the hair's protective layer, this damage makes hairs more susceptible to further damage.

Mechanical damage may result from habits as simple as combing and brushing. This is a minimal and generally unavoidable insult and mostly an issue with longer hair more common in Asia. The best prevention of combing-related damage is the use of a quality separate rinse-off conditioner. As hair is much more fragile when wet, extra care must be taken when handling wet hair. Patients should be counselled to avoid more damaging habits of teasing and backcombing. While these techniques add volume to hair and may in the short-term hide thinning, they break open and rip off cuticle layers, significantly weakening the hair structure. Chemical damage should be avoided if at all possible. Even with great care and minimal chemical exposure, bleaching, colouring and chemical straightening will remove most cuticle and expose the cortex, causing the hair fibre to break easily.

The progression of hair damage is categorized as slight, moderate and severe. Slight damage is characterized by uplifting and fraying of the cuticle and is marked only by a loss of shine. Moderate damage is the uplifting and then loss of cuticle, progressing to exposure of the cortex and resulting in a dull dry look and feel, loss of elasticity and manageability and frizz or flyaway hairs. Once the cortex is exposed, it is inevitable that damage will progress to severe, resulting in fractured hairs and split ends. After excessive chemical treatment, severe damage can even present as hair loss.

73.5.2 Care and Repair

As previously mentioned, damaged hair shaft cannot as such be "repaired". However, some chemical treatments, such as cosmetic conditioners, can deposit materials onto the hair, "repairing" or "reversing" effects of self-induced damage (Figs. 73.1 and 73.2; Table 73.1). These conditioning products also reduce tangling

Fig. 73.2 Range of conditioning products. Various conditioning products, such as 2-in-1 shampoos, spray-in conditioners, rinse-off conditioners, treatment conditioners, leave-in conditioners and styling aids, oil, creams and pomades sorted in increasing conditioning levels

Table 73.1 Effects of common conditioning treatments

Treatment characteristic	Effect
External lubrication	Prevents mechanical damage
Restore/enhance hydrophobicity	Improves shine, flexibility
Cuticle "gluing" or flattening	Improves smoothness, shine
Disperse static, neutralize charge	Reduce frizz, flyaways
Internal penetrants	Add strength

Table 73.2 Effects of compounds/materials commonly used in hair conditioners

Materials	Effect
Silicones *Dimethicone, cyclomethicone, cyclopentacyloxane*	Smooth hair feel, reduce friction, easier combing
Cationic polymers *Polyquaternium 10, hydrolysed protein, keratin amino acids*	Positive charge attracts preferentially to areas of damage Fortify damaged areas, add volume
Oil emollients *Mineral oil, glycerine, propylene glycol, natural oils, petrolatum*	Moisturize hair and makes it feel softer
Fatty alcohols and acids *Acetyl alcohol, stearyl alcohol*	Smooth hair feel and improved moisture retention
Quats/amines *Quaternium,* stearamidopropyl *dimethylamine, Ditallow methyl ammonium chloride*	Easier combing, charge dispersal helps reduce static
Cationic surfactants *Behenamidopropyl dimethyl Amine + glutamic acid, behenyltrimethylammonium chloride*	Replace F-layer lost due to colour treating, restore hydrophobicity, reduce friction (Fig. 73.1)
Pro B vitamins, amino acids *Panthenol, Pantethine, panthenyl ethyl ether, tyrosine, lysine, histidine*	Deep penetration into cortex, strengthens, humectants, moisture retention

and interfibre friction so are generally "protective". It is important to match the needs of the patient with the correct product. Asian hair is thicker and darker, and generally Asian subjects prefer straight, smooth hair, so they will be more satisfied with higher conditioning products (Fig. 73.2). Caucasians, on the other hand, are looking more for lift and volume so should be counselled towards lower conditioning.

There are many common conditioning agents, and due to package labelling convention, they can be very complex. Table 73.2 presents several common actives and their uses. The best advice for patients will be to use a separate shampoo and conditioner, as this provides more conditioning and better active deposition than a combination or "2-in-1" product. They should also be advised to use quality conditioners—from reputable sources. The cost does not always predict a better product, so careful selection of products from companies who have a strong reputation to protect will provide the best results (Fig. 73.2).

73.6 Conclusions

There are many changes in hair across ethnicities and in how different ethnicities hair change with age. Interestingly, while limited in amount, most literature today agree that Asian ethnicities grey at a later age onset than Caucasians, beginning at least 5 years later and perhaps regionally even more. However, there does not seem to be a difference in ethnicity as much as gender in the location where hair greying initiates. In males, greying usually begins at the temples and sideburns, while in women, it happens along the hairline.

Generally, Asian hair is more regular in cross-sectional shape and of a larger diameter compared to Caucasian hair. This is accompanied by a larger number of cuticle layers, and larger, and more densely packed cuticle cells. This provides for stronger hair, more resistant to mechanical and chemical damage. However, the denser and larger cuticles in Asian hairs also make them more susceptible to stretching-related damage. In males, hair diameter decreases linearly with age, leading to an onset of noticeable changes in hair properties by the mid to late 20s. In women, the reduction in diameter is associated with menopause, and hence the reduction in hair properties is not usually felt until the mid to late 40s. There seems also to be minimal differences between Asian and Caucasian hair in terms of lipid content, but if any difference is there, it also supports that Asian hair would be more resilient to damage at all ages. Minimal data has been collected in Asians, so while today Asian and Caucasian hair look similar in terms of age, undiscovered differences may still remain.

Appropriate care of Asian hair differs mostly due to the differences in basic structure and susceptibility to damage. Asian subjects most often prefer smooth, straight hair. This is supported by the use of hair care products with higher levels of deposition and is achieved by using separate rinse-off conditioning. Older subjects should also be careful to avoid damage as much as possible. This means being gentle with wet hair, avoiding excessive mechanical damage from backcombing or teasing and refraining from chemical damage as in colouring, straightening or perming.

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Chapter 74
Scalp Micropigmentation (SMP), a Cosmetic Treatment for Hair Restoration in Asians

Jino Kim, Jae P. Pak, and William R. Rassman

74.1 Introduction

There are millions of men and women who have thinning hair as a result of genetic balding, aging, disease, and surgical hair transplant procedures that have failed to achieve the fullness that the patient desired. Scalp micropigmentation has been used by these authors to treat many iatrogenic deformities in men from hair restoration procedures done between the 1950s and 1990s and in scars created with open donor techniques, strip surgeries, or FUE. Since hair loss is frequently a progressive process, genetic and iatrogenic conditions often become more pronounced over time. Scalp micropigmentation (SMP) uses a tattoo in a stippling pattern that mimics hair follicles that are cut close to the scalp and can be used in many cases as hair loss progresses [1, 2]. This relatively new technique can significantly address the cosmetic problems derived from the conditions noted above. SMP is the great scalp "cover-up" especially in Asians with their black hair and light skin color!

The tattoo industry is in the midst of a cultural expansion, growing from 14% in 2008 to 21% in 2012 of the US population [3] and present to almost 30% of the world's population. This helps make SMP a more socially acceptable cosmetic solution for covering appropriate scalp and hair problems, particularly when it can be done without detection for treating the contrast between hair and skin color.

This article discusses how the SMP process is used and demonstrates its use in thinning hair in men and women in a variety of clinical applications and in particular with Asians with black hair and light skin. We will show how SMP will have a great impact on people who, heretofore, have had no acceptable long-term solutions for treating thinning hair created by a broad variety of diseases, traumas, inadequate surgeries, and the aging process.

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74.2 SMP, a Permanent Hair Concealer

Scalp concealers are most frequently products used by men and women and constitute a multimillion dollar industry today. A concealer includes pastes or fibers that are frequently applied to the scalp that approximates hair color and lessens the contrast between hair and scalp color. Scalp micropigmentation (SMP) has arisen as a permanent solution and as a replacement for topical concealers that are messy to use and difficult to maintain in many life activities such as swimming, etc. The SMP art form has been defined by these authors to get around the problems created by poor and outdated techniques that have prevailed in the hair transplant field. Doctors or cosmetologists have adopted tattoo techniques and are presently offering them as a response to rising consumer demands. Our recent refinement of the tattoo process for scalp applications blends the technical components of a tattoo instrument and carefully selected pigments. When this is combined with the artistic and technical skills of a provider, it can address coverage for many scalp and hair cosmetic conditions including but not limited to an inability to complete a hair transplant process in Asian patients to meet a demanding need.

SMP can be utilized in a variety of ways, greatly expanding cosmetic treatment options for various forms of alopecia. It has great value as part of any effort to make a person's hair appear more plentiful. It is very effective in camouflaging scars [4].

Alopecia (e.g., genetic alopecia or female genetic unpatterned alopecia) generally reflects reduced hair densities but varies by degree and distribution. For early thinning or balding, styling manipulations are the first step taken by people (e.g., comb-over or bouffant) to cover a balding "pate." These styling options often evolve over long periods of time as hair loss progresses and until the balding or thinning progresses to the point that these styling options no longer work. Many Asians with chronic alopecia may change their hair color from dark to light (light brown), effectively reducing the contrast between a dark hair color and a lighter skin color. Such changes can camouflage diffuse or regional areas of localized alopecia. The use of powered or fiber concealers can match scalp color and, when combined with styling modifications, can be effective in areas of the scalp where balding or thinning is occurring. Many temporary concealers, however, interact with the person's environment with shedding on clothing or bedspreads, becoming runny in the rain or with perspiration. These topical concealers often require restrictions on a user's activities and lifestyle. SMP is an alternative, a permanent concealer that obviates the need for temporary concealers.

74.2.1 The SMP Process

The skin of the scalp has an intricate anatomy; however, the actual SMP process does not go deeper than the first 0.2–0.3 mm of the upper dermis when done correctly, thereby avoiding any significant organ structures found in the dermis such as the hair follicle. The epidermis usually measures 0.5 mm (±0.2 mm), and the pigment material must be deposited just below the epidermis. When hair bulk is lost through miniaturization or apoptosis, the supporting infrastructure is reduced in proportion to the loss of the hair.

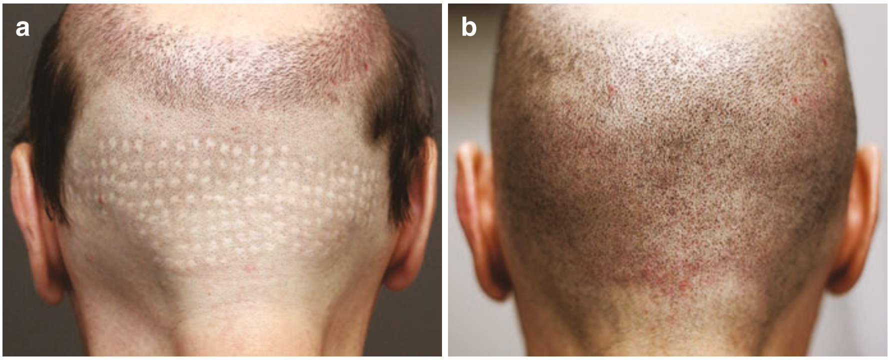

Fig. 74.1 Patient with scar from multiple surgeries with significant donor area depletion with a shaved scalp (**a** before and **b** after SMP)

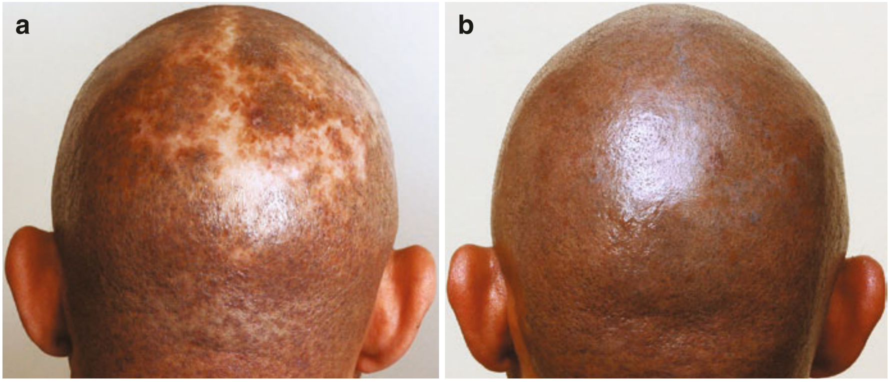

Fig. 74.2 Patient with scarring alopecia (**a** before and **b** after SMP)

Regional microscopic variations in the manner that each individual reacts to SMP depend on the health of the epidermis and dermis. The atrophic scalp of a bald man, with its reduction of blood flow and dermal fat, will respond differently to the introduction and retention of scalp pigments than would a normal hair-bearing scalp. Many incurable scalp diseases produce skin deformities that persist despite treatment. The SMP process offers a good, creative, cosmetic solution to these deformities, but it does not address the underlying process.

There are many "surgically corrected patients" where the donor hair has been heavily depleted from numerous surgical procedures. The authors estimate that patients living with a see-through donor area with donor area hair depletion and/or severe donor area scarring, number in the hundreds of thousands of patients across the globe (Fig. 74.1a, b).

The medical and surgical problems which can be addressed by SMP concealment include [5]:

1. Scalp scars from scarring alopecias (Fig. 74.2a, b)
2. People with autoimmune diseases like refractory alopecia areata or alopecia totalis (Figs. 74.3a, b and 74.4a, b)

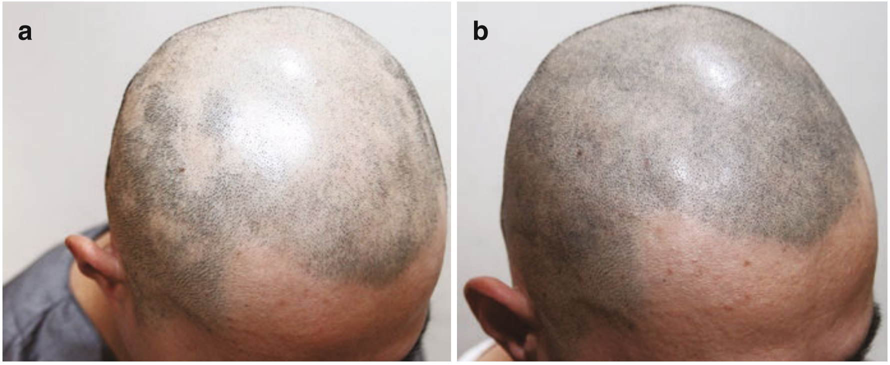

Fig. 74.3 Patient with alopecia areata (**a** before and **b** after SMP)

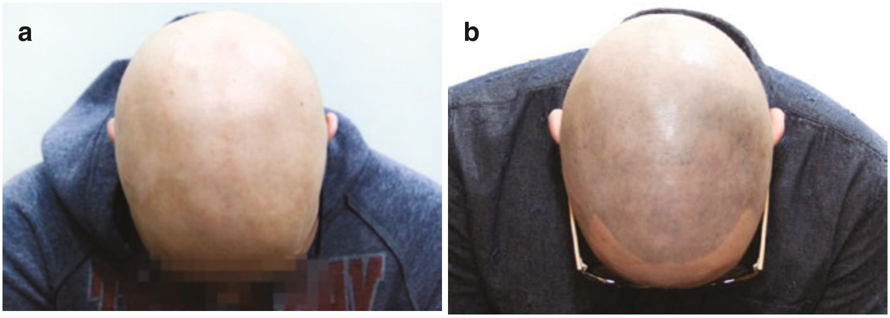

Fig. 74.4 Patient with alopecia totalis (**a** before and **b** after SMP)

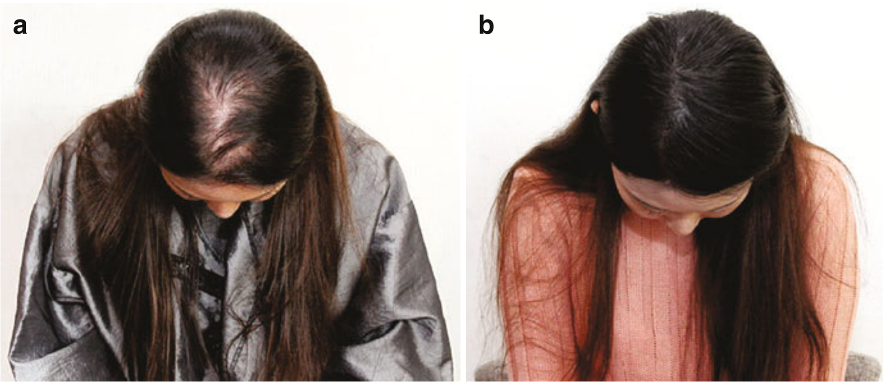

Fig. 74.5 Woman with thinning hair from female genetic alopecia (**a** before and **b** after SMP)

3. Woman who are balding or thinning who are not responsive to minoxidil or other medical treatments and do not qualify for hair transplantation (Fig. 74.5a, b)
4. Neurosurgery scars and scars from head trauma, surgeries, and/or hair restoration procedures

5. Chemotherapy patients, who do not grow back significant amounts of their hair after treatment
6. Deformities in hair restoration patients resulting from unplanned progressive hair loss in men, whose hair transplants have failed to achieve the amount of "fullness" they expected
7. People with wide scars from donor strip harvesting techniques (Fig. 74.6a, b)
8. People who have open donor scars, as a complication of hair transplant surgery from harvesting techniques between the 1950s and the early 1990s, from strip harvesting surgeries or from the more modern follicular unit extraction techniques that create punctate scars (Fig. 74.7a, b)
9. Patients who have the old pluggy or cornrow look with or without donor site depletion and a see-through donor area

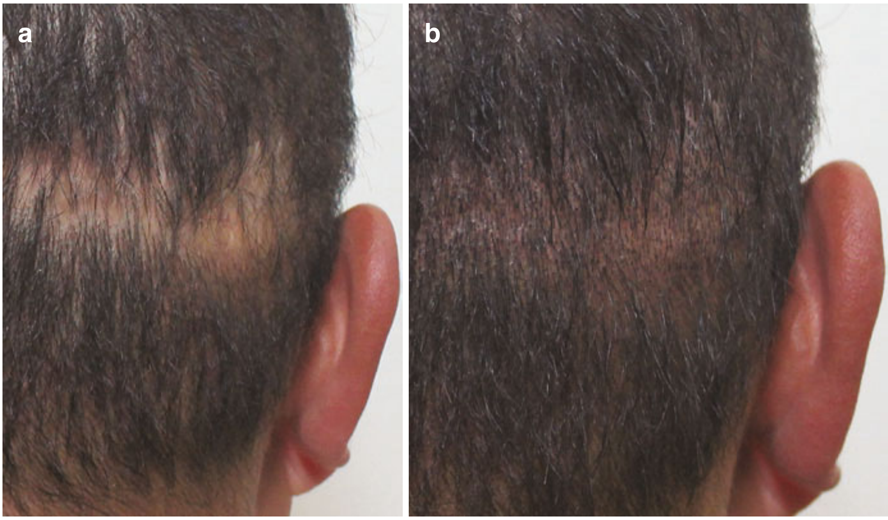

Fig. 74.6 Typical wide scar from hair transplant with strip harvesting (**a** before and **b** after SMP)

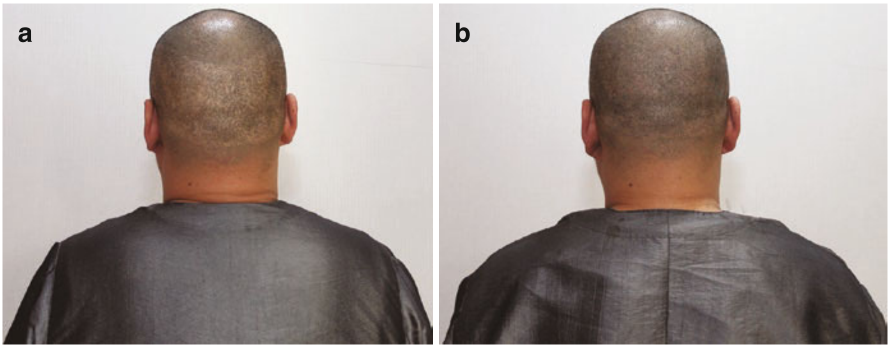

Fig. 74.7 Typical punctate scars from follicular unit extraction (**a** before and **b** after SMP)

10. People who dislike using topical concealers or wigs
11. Hair thinning or regional balding, where the patient desires to *appear to have* a fuller head of hair, with or without a shaved scalp

74.3 How SMP is Performed

SMP uses a stippled painting as dots created between the pores of a balding or thinning scalp. This can be done with the hair remaining long or on a shaved scalp. The density of the stippling does not necessarily match the number of pores that contain the hair as this is an artistic judgment. The average Asians has an average of 40,000 pores (i.e., 40,000 follicular units) on their scalp, 20% less than their Caucasian counterparts. The density of the stippling created in the SMP process can be designed to produce shading and create the illusion of texture and fullness to address the desired results and can often exceed 40,000 dots.

The establishment of a realistic expectation is a critical goal in the first consultation. What the patient sees and what the provider can provide must be discussed in great detail to meet patient's initial objectives; however, if the patient wants to change his or her goal after the procedure is complete, considerable discussions are necessary.

The SMP process begins by insertion of a microdroplet of pigment through the skin and into the upper dermis, using a standard tattoo instrument, which supports between 1 and 6 needles cycling between 100 and 150 cycles per second. The needle(s) must perforate the epidermis to get to the upper dermis, and the pigment (ink) is drawn in by the movement of the needles against each other through surface tension physics not through an injection process as with a needle and syringe. The depth of needle insertions varies by "feel" and visual judgments that are made by the operator that reflects the undulating thickness of the epidermis at the point of introduction. Different skin turgor will be seen when an atrophic or scarred scalp is compared to a normal scalp, and the operator feels and sees the pigment as it is deposited as the SMP process is performed. The operator creates a constant mental feedback loop as he/she constantly adjusts to the effects that are felt and seen. There are additional factors that become important to place the correct amount of pigment, at the correct level and into the scalp for the desired effect.

Because every patient is different, every area of the scalp is different, and every point of insertion is different from the prior and subsequent points; the operator is trained to make technical and artistic judgments as the process advances, while the process is being done, millimeter by millimeter. Scars retain pigment very differently than the skin of an atrophic or normal scalp. It is not unusual to have both normal and abnormal scalp conditions proximate to each other in the same patient. The artistic judgments in managing this often extend into the normal scalp, since a scar that is white will have to blend into the tan or dark skin that surrounds the scar.

The stippling will vary in dot size, based upon artistic judgments needed once the process starts. If the pigment is placed only in the epidermis, the process will fail because the pigment will leak out within a few days after the procedure is done. If the pigment is placed too deep into the dermis, it will fail because it will diffuse outside the confines of its original area of placement (Figs. 74.8 and 74.9). The observable size of the stippling may change into a noticeable confluent visual amalgam (bleeding) of ink.

We usually recommend multiple sessions for SMP. The number of "dots" may be higher than 40,000 follicular pores present in typical Asians. The sessions are often long, extending up to 8 h per session.

Fig. 74.8 Pigment bleeding from irregular pigment depth placement

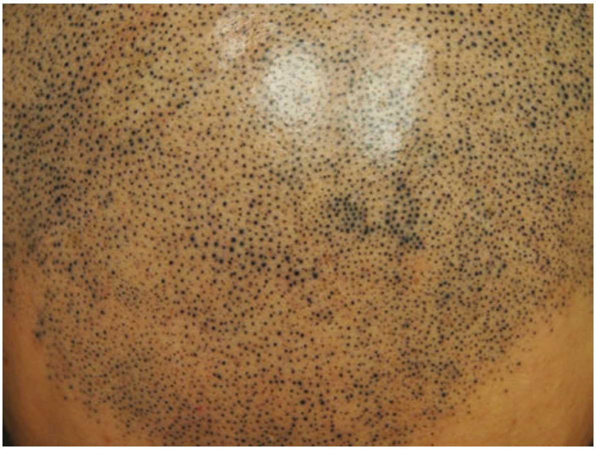

Fig. 74.9 Photographs of pigment in scalp proximate to follicles. On the left, the depth is placed correctly; on the right, the pigment is placed too deep

Many of our patients will have two to four sessions before the process is complete, since we want to have good assurance that only the upper layer of the dermis is penetrated so we often "undershoot" the end point at the initial session. Pigment bleeding will be minimized with a cautious, slow, and judicious approach in each session.

74.4 Color Changes

It is important to explain to the patient that there may be a blue or green tint to the pigment. The greenish color of the black or gray pigment is similar to how the red blood vessels appear green under the skin, where the increased absorption of the red spectrum of light gives rise to a phenomenon explained by the trichromatic theory of color vision [6]. The actual color of some pigments may actually change as well, resulting from direct ultraviolet light exposure on the pigment through the skin, and, as such, it can enhance the trichromatic process.

74.5 Conclusion

Scalp micropigmentation (SMP) is a relatively new modality for hair transplant surgeons and is critical to help the very bald Asian male to achieve the fullness they want when the supply of donor hair is limited. It is also useful for patients who are not candidates for hair transplants. Since SMP is a cosmetic tattoo, the elegance of the results reflects the technical and artistic skills of experienced providers. Gaining experience in this process will bring great happiness to millions of people who have, heretofore, had few options in treating their hair thinning resulting from natural genetic alopecia or when their donor supply does not meet the demands of the recipient area in a hair transplant.

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Chapter 75
Training Module in Hair Restoration Surgery, a Simple Method for Beginner Surgeons and Assistants

Anil Kumar Garg, Ishita Garg, and Seema Garg

75.1 Introduction

The demand for hair transplantation is constantly increasing, and new hair transplant centres are opening all over the world. However, there are very few training centres and fellowship programmes globally to fulfil the demand for trained assistants and technicians.

The author has developed a very effective, user-friendly and economical model [1, 2] to learn and practise all steps of hair transplantation. Materials required for this training model are readily available. Materials like foam, money plant leaf (thick leaf), simple stitching black thread, needles and wooden spatula are needed for this model. The second stage of the model utilises goat skin and a helmet.

75.2 Microsurgery Position

The entire process of hair transplantation is microsurgery. All basic principles of microsurgery should be followed, including magnification, proper position of surgeon, instrument quality and range of hand movements.

The position of the surgeon or assistant should be such that all body joints are at a functional position. The feet should rest on the floor, the leg and thigh should be at a 90° angle, the spine should be straight and supported, the forearm should rest

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on the dissection table, and all movement should be at the wrist. This position allows the surgeon or assistant to work for a longer period. Poor posture invites early fatigue and affects surgeon's performance and efficiency (Fig. 75.1).

Fig. 75.1 (**a**, **b**) Microsurgery position. (**c**, **d**) Forearm resting on dissection table

Fig. 75.1 (continued)

75.3 Paper Model

75.3.1 Training of Movements at Wrist

Proper microsurgery hand position allows the surgeon to isolate movements at the wrist. Follicle dissection requires wrist movements in a forward and backward direction, while slivering and implantation need downward and upward wrist movements. No side to side movements are required during the entire process of hair transplantation. These motions can be learned and practised by making straight lines on paper using pencil or pen.

Material—Plane paper and a pencil, suitable magnification.

Method—Make small rectangle/square boxes on paper. Require assistant to make straight parallel equidistant lines in a box while maintaining proper

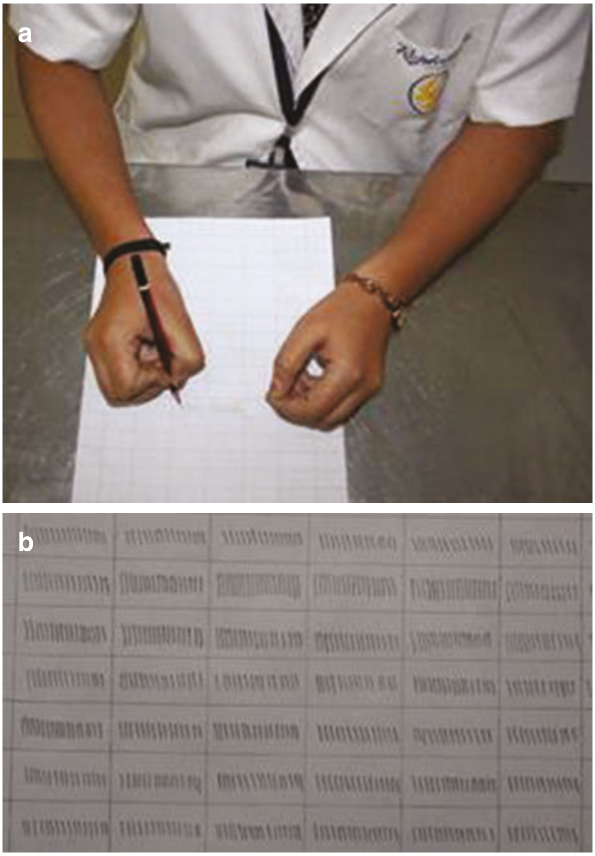

Fig. 75.2 (**a**) Making straight equidistance parallel lines. (**b**) Practice sheet

microsurgery position. Begin without magnification and then add magnification. Assistant should complete 15 sheets under magnification (Fig. 75.2).

75.4 Foam Model

75.4.1 Strip Harvesting

This model is used to learn how to hold the scalpel, how to identify which part of the blade is needed in strip harvesting and how to raise strip while dissecting in one plane of tissue (Fig. 75.3).

Material—1-inch-thick high-density foam piece 8 × 10 cm in size, wooden platform, marking pen, scalpel and toothed forceps.

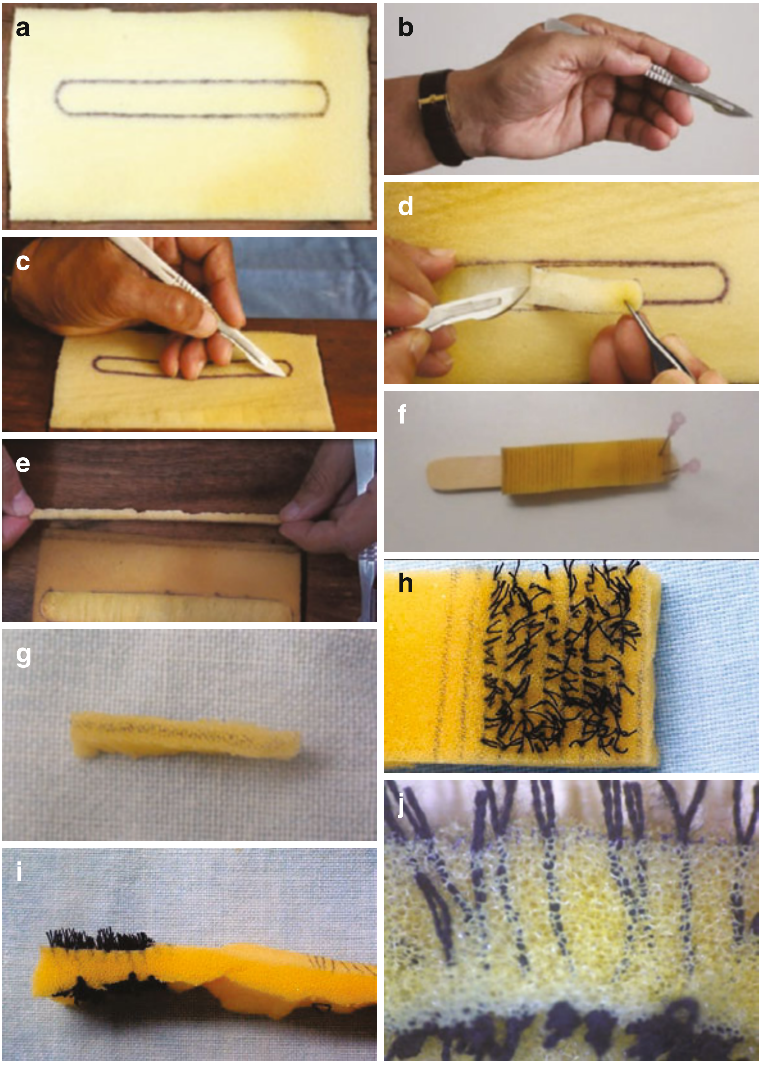

Fig. 75.3 (**a**) Foam with marking, (**b**) scalpel in pen-holding position, (**c**) incision, (**d**) strip harvesting, (**e**) harvested strip of uniform thickness and (**f**) foam strip. Markings for rows of hair (**g**) foam sliver. *Marking* indicates rows of hair, (**h**, **i**) thread woven foam strip and (**j**) foam sliver

Method—Fix foam to wooden platform or other surfaces. Mark strip area with skin marking pen. Hold scalpel in dominant hand in pen-holding position. Keeping sharp edge of scalpel almost parallel to the surface of foam, a partial thickness cut is made over the marking. The depth of incision should be the same all around; this is only possible when you apply equal pressure over the scalpel. Direction of incision is slightly oblique, as hair direction in the scalp is oblique, and we need to follow the direction of the hair follicle. Next, using toothed forceps, hold one end of strip and pull it up and cut underneath with a scalpel taking care to cut in the same plane and thus harvesting uniform thickness of foam strip. This must be practised multiple times to achieve a foam strip of uniform thickness.

Slivering—Slivering training is divided into two phases. First we learn to move the scalpel in an up and down direction while creating thin slices of foam. Next we practise slivering on a foam strip woven with thread. Black thread with a knot symbolises the graft, and during this phase, the thread should not be cut.

Material—1-inch-thick foam, black stitching thread, sewing needles and skin marker.

Method

A. Cut small pieces of foam 1 cm thick, 2 cm wide and 7–10 cm long. Using skin marker, make multiple straight parallel lines at 2–3 mm intervals on the surface of foam. The foam strip represents a sliver, and the marked lines represent rows of hair follicles. Fix this foam sliver on wooden spatula using needles. Start slivering with a fine-toothed forceps in the non-dominant hand and scalpel in the dominant hand. Toothed forceps should grab the upper edge of foam sliver, while the scalpel cuts between two lines from top surface of foam to bottom. While the scalpel is cutting, pull foam sliver outside and slightly upward, so there is increased gap between two rows. Very thin equal uniform slices of foam should be created.
B. A black stitching thread is used to represent the hair follicle, and a single knot of thread represents the hair bulb. Using a needle, multiple threads are sewn in rows on a foam strip, with a knot on the underside, leaving small free ends of threads on the other as shown in the figure.

Slivering is started as explained in A, taking care not to cut the thread or its knot.

75.5 Leaf Model (Fig. 75.4)

75.5.1 Follicle Dissection

Material—Thick plant leaf such as leaf of money plant (*Epipremnum aureum*). These are thick and have a texture similar to the skin. Marking pen, scalpel and forceps and magnification.

Method—Prepare 5 × 2 cm pieces of thick leaf. Create 10-mm-long parallel lines in the centre of leaf strip. These lines represent hair follicles. Begin follicle dissection under microscope or other magnification. The assistant cuts between lines and makes small pieces of leaf having a line in the centre of each piece. Each line represents a hair and hair bulb, and the leaf part is peri-follicle tissue. During this step, the assistant also practises coordination of scalpel and forceps. Any indentation of forceps over leaf surface warns the assistant that the grip of the forceps should be softer so as to avoid crushing the follicle. The assistant should cut at least 100 such plant slivers.

75.5.2 Implantation

Both stick place and slit method of implantation can be practised.

Material—Money plant leaf (leaf of any plant which is thick and soft), wooden spatula, slit making knife, needles, black thread and diluted adhesive solution (e.g. Fevicol solution, a synthetic resin adhesive).

Method—Create a scalp model by stacking multiple pieces of leaf of equal length and width until an 8–10-mm-thick layer of leaf bed is formed, and secure them to a wooden spatula. Now create hair follicles using black thread. Immerse black thread in a diluted adhesive solution, and then allow the thread to dry, making

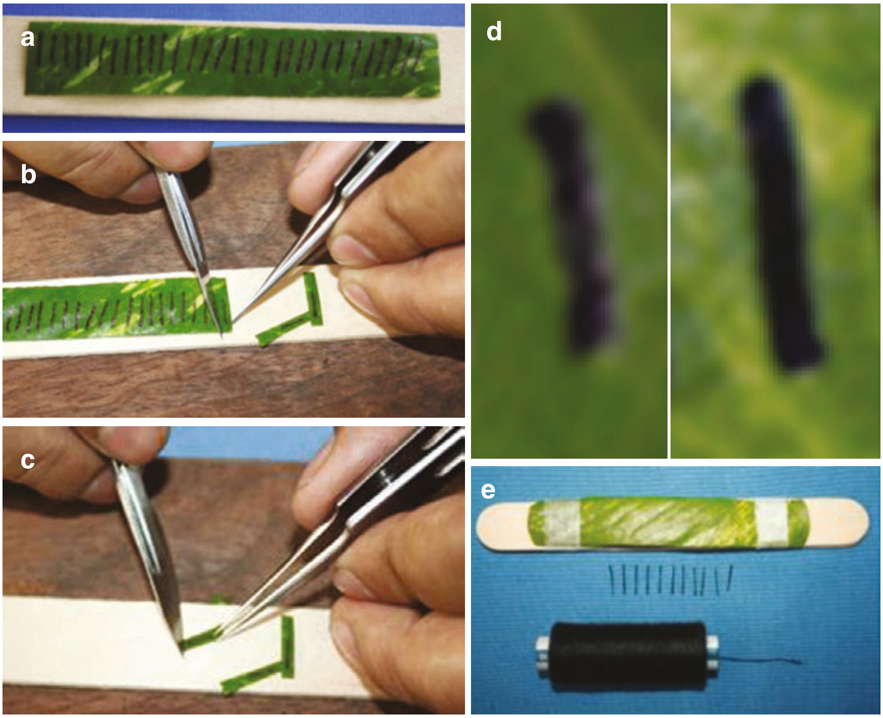

Fig. 75.4 (**a**) Plant leaf sliver, (**b**) follicle dissection, (**c**) trimming of follicle, (**d**) follicles, (**e**, **f**) preparing thread follicles and leaf scalp. Multiple leaf strips are put over each other to make it as thick as the scalp. (**g**, **h**, **i**) Stick and place technique. Implantation of thread follicles on 'leaf scalp' using needle and forceps, (**j**, **k**) premade slit and Implantation. Implantation of thread follicles in premade slits using two forceps. Slits made using needle. (**l**) Final appearance. (**m**) Final appearance

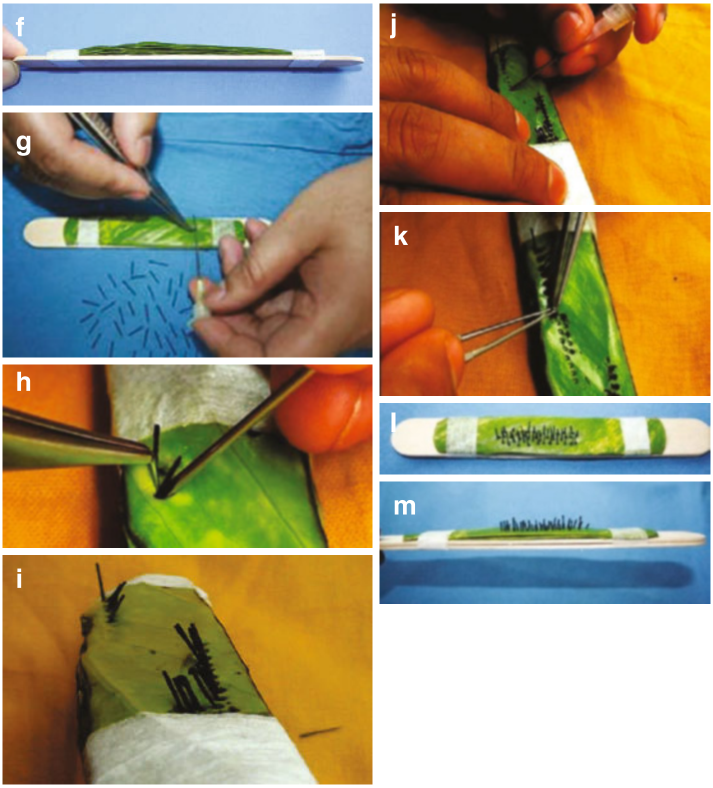

Fig. 75.4 (continued)

it stiff. Next cut thread into multiple 8-mm-long pieces. Thread follicles are now ready for implant. To teach implantation into premade slits, first make multiple slits into bed of leaf scalp model using either needle or slit knife blade, and then use preferred technique with one or two forceps and one needle. Dilate the slit using forceps and implant thread into the hole.

To teach the stick and place technique, insert needle in leaf model 3–4 mm deep and implant thread by sliding it along the bevel portion of needle.

75.6 Goat Model

Human hair follicles are precious, as they are limited and not reproducible. Damage to follicles causes permanent loss, which is bad for our patients, so practise with the goal of achieving zero transection of human follicles. Goat skin is readily available and inexpensive and is a very versatile model to practise on before starting on human skin. Goat skin gives you the feel of human skin, and although goat follicles are shorter and have higher density than human follicles, this can be an advantage when learning.

Material—Black goat fresh skin measuring 10 × 2 cm.

Method—Clean the skin with tap water, shave it, and then again clean it with tap water. This goat skin piece is ready for slivering practice.

Slivering of goat skin strip—After attaching goat skin to wooden spatula, slivering is performed under magnification as we learned on the foam model. This goat skin feels like human skin but with greater density with shorter length of follicles. Excess fat is trimmed away.

75.6.1 Follicle Dissection of Goat Sliver

Goat slivers are then dissected under the microscope or any magnification of your choice. All precautions are taken and practised as if human follicles were being dissected, including de-epithelization, trimming and irrigation. Goat follicles are now ready for implantation into the leaf scalp model (Fig. 75.5).

75.6.2 Implantation of Goat Follicles

Material—Goat follicles, leaf, adhesive tape and helmet.

Method—Mount five to six layers of leaf on the front side of a helmet or other similar models of a human head. This provides a curve and surface similar to human scalp except that it is little larger in size. Practise implanting goat follicles either by slit method or stick and place method.

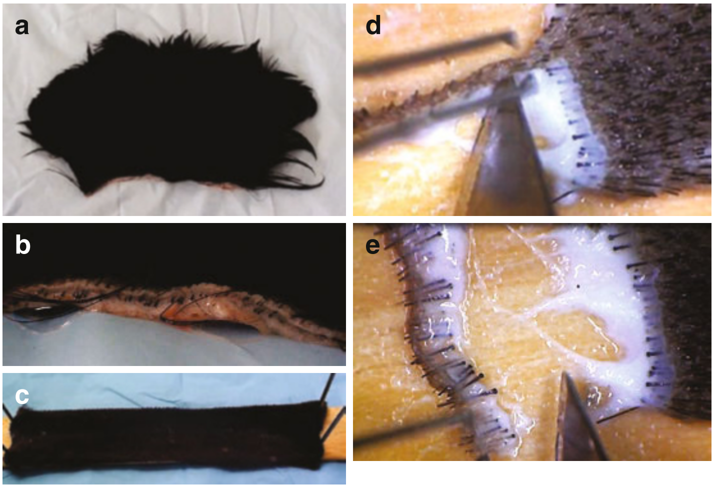

Fig. 75.5 (**a**) Fresh goat skin, (**b**) goat skin side view, (**c**) goat skin piece shaved and mounted over wooden spatula for slivering, (**d**, **e**) slivering of goat skin under stereo microscope. (**f**) Follicle dissection of goat sliver under stereo microscope. (**g**) Goat follicles over the thumb. (**h**, **i**) Leaf mounted over helmet. (**j**) Goat follicles implanted

Fig. 75.5 (continued)

75.7 Summary

The steps outlined in this training module are versatile, user-friendly and economical for learning all steps of the hair transplant [3]. The author has used this to train all his team members. Two hours per day for 3–4 weeks is enough to train a technician in basic knowledge of the hair transplant procedure, follicle care and importance of graft hydration, ischemia and temperature control. The delicacy of the hair follicle should be repeatedly explained, and we help them realise how important their job is. Hair transplantation requires teamwork, and every step should be performed with the optimum results for the patient in mind.

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This Technique is Authors Own Innovation. This Has Been Presented in Annual Congress of International Society of Hair Restoration Surgeons in 2015

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Chapter 76
Hair Prosthesis: QOL and Psychology of Patients

Masashi Nakayama

76.1 Types of Hair Prosthesis

76.1.1 Hair Restoration

This method is used to increase the volume of hair by attaching artificial hair to natural hair. Multiple artificial hairs (roughly two to ten hairs) are attached to one natural hair. This method is very effective for treating mild alopecia and thinning hair. Like natural hair, this method requires no restriction in sports, bathing, etc., and therefore it is possible to keep a normal standard of living with very little stress for patient's life.

This treatment is also good for covering the scalp, after hair transplant surgery and during the time of hair engraftment, temporal hair loss, and regrowth of natural hair.

When natural hair grows, artificial hairs can be easily detached or cut. Patients can live comfortably for several months after the hair transplant surgery.

The treatment is done by trained hairdressers or beauticians (Fig. 76.1).

Fig. 76.1 Hair by attaching artificial hair to natural hair

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76.1.2 Partial Wig

Common ways to cover the parietal region of the head are toupees, hair pieces, and partial wigs. Two types of AGA, hair loss at the parietal region of the head and receding hairline, can both be treated. They can also cover the hair loss of a large area.

For medical purposes, partial wigs are used for the hair loss due to burn, cicatrizing alopecia, accident injury, and operative scar. They can be put on not only the parietal but also temporal and occipital region of the head.

Recently they are often used for covering donor sites after hair transplant surgery. They have no bad effect on affected areas and have the advantage that they can blend in well with natural hair. Many of partial wigs for continuous use are braided into natural hair, and if they are prepared in advance, they take only 20–30 min to be attached. Of course, you can use shampoo and a hair dryer.

Partial wigs are made by implanting hair to a net. Part or hair whorl made of silicon is often added for the natural appearance, but after hair transplant surgery, products without them are used.

These few years, thinner and lighter products are preferred.

Attachment methods include one-touch pin, medical double-sided tape, hook (for continuous use), and braiding (each manufacturer has its own characteristics). The appropriate method is chosen depending on the situation (Figs. 76.2, 76.3, 76.4, 76.5, and 76.6).

76.1.3 Partial Sheet

For alopecia or AGA patient's problem with receding hairline, sheet-type wigs are most appropriate. It is possible to cover patient's bare patches by shaping the polyurethane or silicon sheets to fit the area and by attaching the product to the skin with

Fig. 76.2 Partial wig

Fig. 76.3 Partial wig

Fig. 76.4 Partial wig

Fig. 76.5 Base net

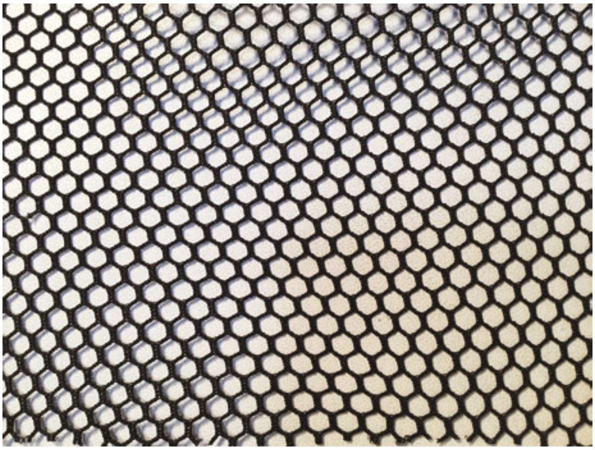

Fig. 76.6 Base net

double-sided medical tape. In this method, it is preferable to avoid keeping it on for a long time.

If the hair starts regrowing through the effect of medication, etc., it is possible to easily attach or detach the sheet without affecting the hair by using our silicon gel double-sided tape (Figs. 76.7, 76.8, and 76.9).

76.1.4 Wig for the Whole Head

This applies to patients of AGA, alopecia totalis, and alopecia universalis and those whose hair loss is occurring in the entire skull.

When the product for partial hair loss does not cover sufficiently or when the entire hair volume has reduced excessively, it is difficult to maintain hairstyle, and patients tend to be under heavy stress.

When donor sites or transplant sites are large after hair transplant surgery, whole head wigs are often used for a few months to cover the scalp. Some new products, better suited to such purpose, are now being developed. The amount of these products' hair should be as small as possible. If so, when natural hair regrows and a product is detached, the change in appearance can be relatively little.

Fig. 76.7 Sheet-type wigs

Fig. 76.8 Image of hairline

Fig. 76.9 Silicon gel double-sided tape

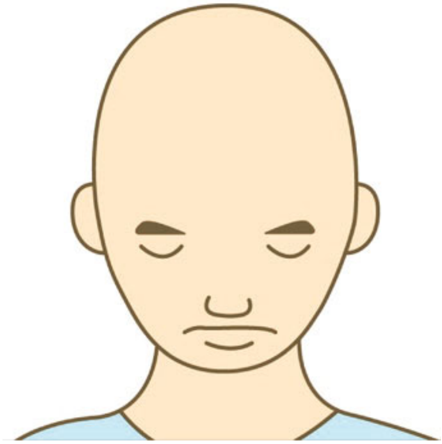

Fig. 76.10 Wig for the whole head

There are various products for whole hair, such as one with artificial skin or one with film-type skin that can be shown around the hairline. Some of them are so well made that it is difficult to know that one is wearing a wig.

Attachment method is the same as partial wigs: medical double-sided tape and one-touch pin (Figs. 76.10, 76.11, 76.12, 76.13, 76.14, and 76.15).

76.1.5 A Cover After Own Hair Transplant Surgery

Recently, this is indispensable when we consider about QOL of a cover after own hair transplant surgery.

Fig. 76.11 Base net of wig for the whole head

Fig. 76.12 Wig for the whole head

Fig. 76.13 A youth wearing a wig for the whole head

Fig. 76.14 A pin with a single touch

Fig. 76.15 Medical double-sided tape

As mentioned in Sect. 76.1.2, they have no bad effect on affected areas, and they can blend in well with own natural hair.

Because of own hair transplant surgery which is called FUE, shaving donor sites is indispensable. Therefore, the patient hesitates that surgery, but our technique of wig avoids that very nicely. After FUE many patients go back to their daily life soon, so it is good for patients having cover wigs the next day.

Process is the following:

1. At the next day when a patient is transplanted with their own natural hair, our hairdresser or beautician makes a pattern for partial wig of donor sites, at all our salons in Japan or visiting clinic.
2. Cut the partial wig according to a pattern of donor sites (Figs. 76.16 and 76.17).
3. Partial wig knits to natural hair using cotton thread; at this time, the part around the nape of the neck does not knit because of hair washing. There are many kinds of method. Therefore, our company method is small amount natural hair knits base net directly. This method is setting up time is very short and hardly detached it, so it is very popular with patients (Figs. 76.18, 76.19, and 76.20).

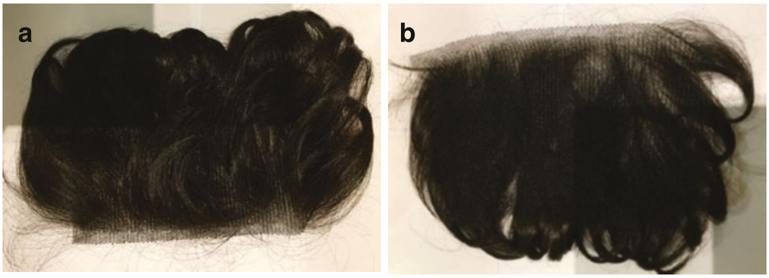

Fig. 76.16 (**a**) The partial wig of a cover after own hair transplant (hidden side). (**b**) The partial wig of a cover after own hair transplant (front side)

Fig. 76.17 The partial wig of a cover after own hair transplant

Fig. 76.18 Image of the partial wig of a cover

Fig. 76.19 A wearing appearance

Fig. 76.20 Cutting to adjust around hair

4. After 1 month, the partial wig becomes loose because of growing hair about 1 cm.

At this time, we take off the wig and repair again.

Repairing again can be done many times, but these patients use wig for about 2 months. It means after the first repairing again, they use wig for only 1 month usually.

5. Cost of cover

We accept rental system because a partial wig will be disuse by the patient.

Initial cost is 15000 yen which includes wig cost and setting up.

Repairing again costs 10000 yen.

Rental cost is 250 yen per day; this cost will be paid later.

An average of total payment is about 50000 yen without tax. It depends on each person.

This partial wig is made of high-quality artificial heat-resisting hair and base net with polyester. For the reason there is merit, this wig is used like their own natural hair.

And ore, we support clinics many kind of items such as losing of hair for shock of surgery, by toupee, extension hair and mashike named aplan touch.

76.1.6 Others

Other convenient methods that don't require products (1–4) include sprays that color the bald area or sprinkles made of fiber to put on the head directly to hide the bald area. They increase the volume of hair and hide the patches with no hair.

These are useful for covering transplant sites some time after hair transplant surgery.

Many abovementioned sprays and sprinkles are put on the market by several manufacturers.

76.2 Role of Hair Prosthesis

Hair prostheses have always functioned as medical substitute, similar to eye prostheses or limb prostheses. QOL of patients can be improved dramatically by using hair prostheses (wigs). Especially for hair loss caused by various reasons, it has always played an important role.

In today's society, much value is put on our appearance. Even success in career or love can be affected by hair in our everyday lives. Hair prostheses can protect patients against harsh scrutiny from others.

For medical purposes, wigs or hair prostheses should be light, easy to attach or detach in daily life, breathable and harmless to the scalp, and not interfering with treatment.

76.3 Conclusion

Looking back at history, from ancient Egypt and Orient, ancient Rome and Greece, and medieval Europe to modern age, hair and wigs have always been symbols of power and wealth and also been eternal themes. In Japan, wigs started being used in the ninth century. People's obsession with or yearning for hair has not changed in the past and at present.

Nowadays, various methods can cover alopecia and thinning hair, but there are also stresses caused by the fact that the patient is using a wig. Improvement of the appearance may make them feel as if they are deceiving others, and concerns of others finding out may lead to self-denial.

During an outing, one may be always checking himself reflected on a show window or a mirror if his hair is looking odd or unnatural. In the case of a person who is hiding the use of a wig, it is rare for them not to have this anxiety. Wig is widely recognized by the public, and its quality is not as bad as it used to be, but it is still far from getting a 100% positive reaction.

In conclusion, it is clear that keeping a healthy mental state in high quality is very difficult when there is a sense of discrimination against lack of hair. Even without medical issue, and a person may think that he has overcome the issue philosophically, there may still be discontentment toward the ugliness = lack of hair. If medical methods cannot fully or rapidly fix the problem, patients will always compare themselves with days prior to hair loss, so the only thing that will lessen the gap is the use of a wig, etc.

In recent years, there are good news for those who have alopecia and thinning hair regarding hair transplant surgery, medication, and regenerative medicine (which is yet off from practical use, though). I would like to support those patients in their own methods who work hard to improve their appearance and improve their quality of life.