Plastic Surgery

22

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Introduction

Plastic surgery is a unique medical specialty, derived from the Greek "plastikos", meaning to remodel, reshape and mold. Its origins date back to 600BC, when Shushruta, an Indian surgeon, described the first nasal reconstruction using a forehead skin flap. During the sixteenth century, the Italian surgeon Tagliacozzi also performed a nasal reconstruction, this time using a local flap derived from the arm of his patient. However, it was during the World Wars that the specialty of plastic surgery really developed due to the high prevalence of traumatic injuries to the faces of soldiers. Hospitals were created that specialized in reconstructive techniques, setting the foundations of plastic surgery as we know it today.

Plastic surgery can be broadly divided into aesthetic and reconstructive surgery. Aesthetic surgery refers to the remodeling of normal body structures, and reconstructive surgery refers to the alteration of abnormalities, including congenital and developmental defects, disease or injury in order to restore normal function and appearances. However, a substantial amount of overlap occurs between the two.

Due to its ambiguous boundaries, no sole definition of plastic surgery exists, and in many respects, is the last true form of general surgery remaining. Unlike other specialties, plastic surgery is not based on a single organ system or specific procedures, but on certain principles and operative techniques, which form its foundation.

Core Knowledge

Skin Structure

The skin is the largest and most complex organ of the body, making up approximately 15 % of total body weight. It is subdivided into three main layers – epidermis, dermis and subcutaneous tissue. The dermis in turn, can be divided into a superficial papillary and deep reticular layer (Table 22.1).

Principles of Incisions

Since scarring always occurs after an incision, the ideal outcome is a minimally conspicuous, fine-lined scar. However, as the final appearance of a scar depends on several factors, predicting the outcome is complex and for an identical incision, two individuals may develop different severities of scarring.

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Table 22.1 Structure and composition of skin – epidermis, dermis and subcutaneous layers

	Epidermis	Dermis		Subcutaneous layer
		Papillary	Reticular	
Composition	Keratinocytes Melanocytes Langerhan cells Merkel cells	Collagen Elastic fibers Fibroblasts	Collagen Elastic fibers Reticular fibers Fibroblasts Small adipocyte clusters	Predominantly adipose tissue Collagen Elastin Lymphatic vessels
Vascular supply	None	Rich in small blood vessels	Rich blood supply	Rich blood supply
Appendages	Nerve endings	Meissner's corpuscles	Hair follicle roots Sebaceous glands Sweat glands Receptors Nails	Hair follicle roots Ruffini corpuscles Pacinian corpuscles
Description	Keratinized stratified squamous epithelium	Loose, areolar layer	Dense, irregular connective tissue	Also known as hypodermis, consisting mainly of loose connective tissue

Factors of scar formation:

- Size of incision
- Location of incision
- Incision along Langer lines (Fig. 22.1)
- Skin type
- Skin tension
- Patient systemic factors (e.g. obesity, malnutrition, diabetes)
- Patient age
- Suture technique and surgeon's own ability

Fig. 22.1 Langer lines on the face

The Reconstructive Toolbox

A number of techniques form the basis of most plastic surgery, such as full-thickness or split-thickness skin grafts and local, regional, or free tissue transfers.

Traditionally, the reconstructive ladder (Fig. 22.2) was used when plastic surgeons were presented with various defects. The principle is that wound closure is first achieved by the simplest method, before 'climbing' to more complex methods if the former fails. It provides a basic framework, progressing from simple techniques such as wound healing by secondary intention to more complex ones such as the use of free flaps.

However, the reconstructive ladder is overly simplistic, and can be replaced by the reconstructive toolbox (Fig. 22.3). The use of this toolbox ensures that the technique chosen for the patient is the most appropriate to repair the injury or defect, with the best outcome initially.

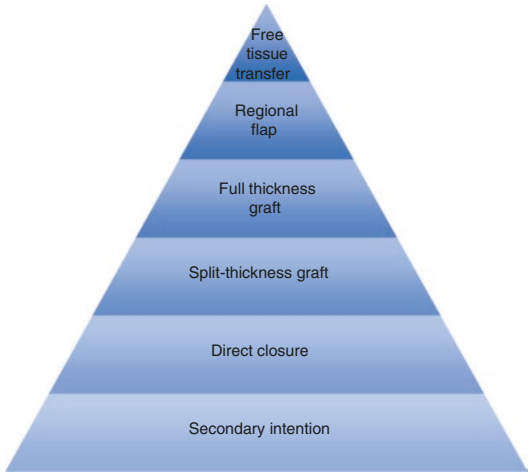


Fig. 22.2 The reconstructive ladder

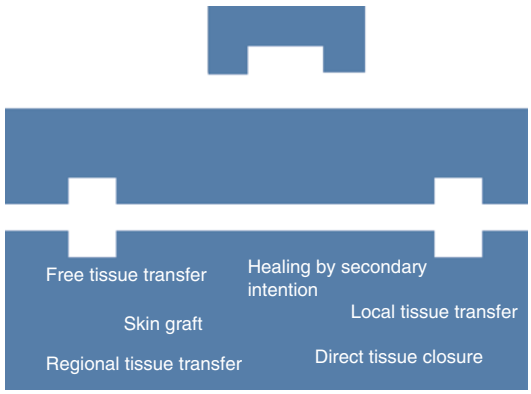


Fig. 22.3 The reconstructive toolbox

Wound Healing

Wound healing is a complex and dynamic process composed of four overlapping sequential stages: haemostasis, inflammation, proliferation and repair, and remodeling (Table 22.2).

Wound Closure

Wound closure can be achieved by primary, secondary or tertiary intention [2].

Primary Intention

Most surgical incisions heal by primary intention via use of sutures:

1. Wound edges are re-approximated
2. Epithelial regeneration occurs
3. Minimal wound contracture and scarring

Secondary Intention

1. Wound edges are not re-approximated
2. More intense inflammation compared to primary intention
3. Greater granulation of the wound occurs
4. Followed by re-epithelialization
5. More extensive wound contracture and scarring

Tertiary Intention

1. Wound edges are not re-approximated immediately, but debrided and cleaned first
2. Allowed to granulate for a few days before wound edges are re-approximated

Free Skin Grafts

Skin grafts are defined as a layer of epidermis, along with some or all of dermis, that is removed and translocated to another part of the body. They are commonly used for the treatment of burns and extensive wounds or after excision of skin cancers.

Skin grafts can be categorised as either split-thickness or full-thickness:

Split-Thickness Skin Graft

These consist of epidermis and a variable amount of dermis. They can be further classified as thin, intermediate or thick, and are harvested with a Humby knife or more commonly a power-driven dermatome. Epidermal elements (e.g. sweat glands and pilosebaceous follicles) remain at the donor site, allowing re-epithelialization and spontaneous healing. As such, larger split-thickness skin grafts can be harvested, and are selected for more extensive defects. Common donor sites include the lateral thigh and trunk. However depending on the circumstance, amount needed and type of defect, almost any part of the body could be a potential donor site; including scrotum, scalp and foot.

Full-Thickness Skin Graft

These consist of epidermis and all of the dermis, and are harvested with a scalpel. No epidermal

Table 22.2 Stages of wound healing

Haemostasis	• Occurs at time of injury, completed within hours • Initial transient vasoconstriction, platelet plug and clot formation • Platelet aggregation, activation and degranulation releases platelet-derived growth factor (PDGF) and transforming-growth factor beta (TGF-b), initiating chemotaxis and proliferation of inflammatory cells
Inflammation	• Begins right after haemostasis, completed within 24-72 hours • Neutrophils infiltrate the wound, to contain foreign microorganisms, and are the predominant cell type for a few days. Other white cells present include plasma cells, monocytes and lymphocytes • In absence of infection, neutrophil infiltration diminishes, and monocytes differentiate into macrophages • Macrophages have numerous roles, including phagocytosis of dead cells and cellular debris, cytokine release to initiate repair, matrix metalloproteinase (MMP) production, and nitric oxide release
Proliferation	• Occurs 1-3 weeks after injury • Fibroblast proliferation occurs, which are responsible for collagen production • Angiogenesis and capillary growth by endothelial cells are stimulated by growth factors
Repair	• Begins 3 weeks after injury, completed within several months or years • Collagen accumulation plateaus • Random collagen fibrils are replaced with organised, cross-linked fibrils

appendages or elements are left, and the donor area has to be closed by sutures, limiting the size of the graft. Common donor sites include the supraclavicular area and postauricular regions, as well as flexural skin (e.g. antecubital fossa, groin).

While a full-thickness graft yields better cosmetic results and is more stable against trauma, they may not take as readily as split-thickness grafts.

Survival of Skin Grafts

After the free skin graft is temporarily detached, devascularised and transferred to its new site, *take* occurs; the process by which the graft is reattached and revascularised (Fig. 22.4).

The two main factors influencing graft take are graft adherence via fibrin attachment, and re-vascularisation, which are in turn determined by the characteristics of the graft bed, the graft, and conditions under which the transfer occurs [4].

Skin Flaps

Flaps differ from skin grafts in that they contain their own vascular supply – arterial, venous and capillary. The effectiveness of the blood circulation determines the flap survival. They are generally used for covering up defects with poor vascularity, reconstructing the face (eyelids, nose, cheeks) and protecting vital structures.

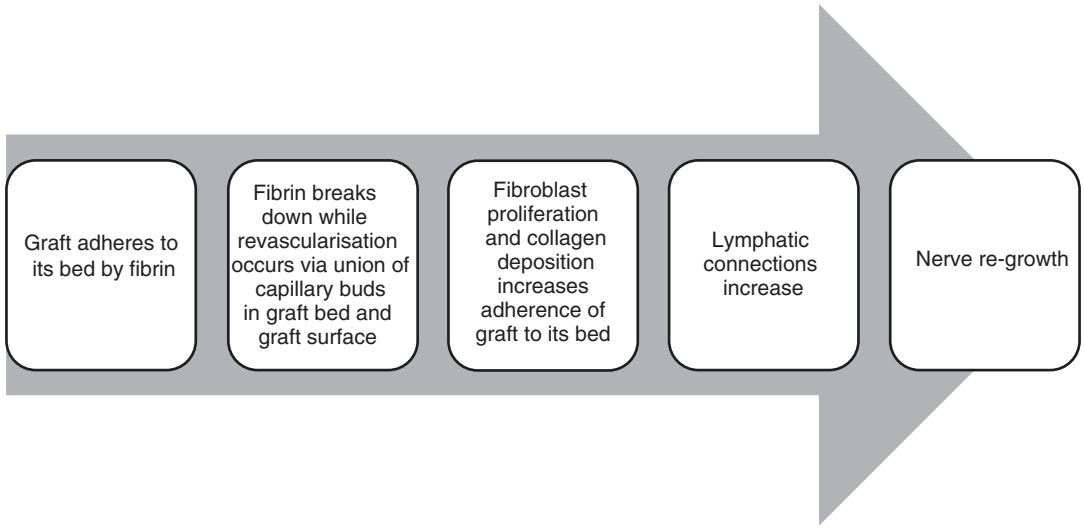


Fig. 22.4 The process of graft take

Table 22.3 Major skin flaps categorized according to composition

Flap	Composition
Cutaneous	Skin and superficial fascia
Fasciocutaneous	Skin, superficial fascia and deep fascia
Muscle	Muscle
Myocutaneous	Muscle and skin overlying muscle
Osteomyocutaneous	Muscle, skin overlying muscle and bone to which the muscle is attached

Table 22.4 Local flaps

Local flaps	
Advancement	A to T
	V to Y
	Island
	Unilateral
	Bilateral
Rotation	0 to Z
	Karapanzic
Transposition	Rhomboid Zitelli bilobe

Skin flaps can be classified in three key ways: tissue composition, donor site location or blood supply. Each of these classification systems is outlined below.

Tissue Composition (Table 22.3)

Donor Site Location

A flap may be classified based on its proximity to the site of the primary defect, and can be described as local, regional or free.

Local

Local flaps are raised from tissue in close proximity, adjacent to the primary defect, and can be further classified as advancement, rotation, or transposition flaps (Table 22.4). However, some flaps have elements of more than one technique (See Box 22.1).

Box 22.1 An Arrangement of All the Local Graft Images on One Page

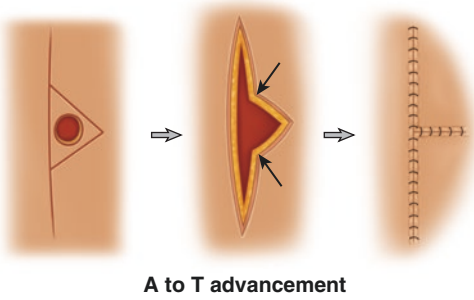


Fig. B1.1 A to T advancement

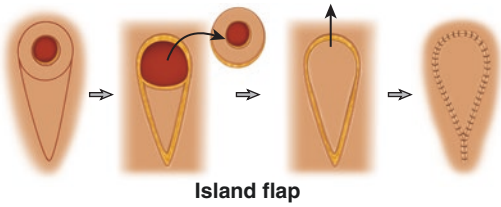


Fig. B1.2 Island flap

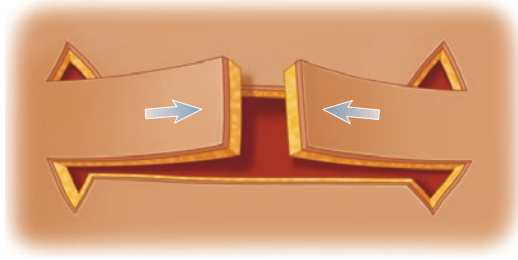


Fig. B1.3 Bilateral advancement flap

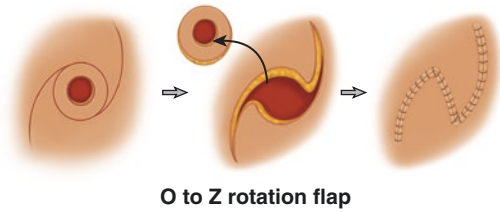


Fig. B1.4 O to z rotation flap

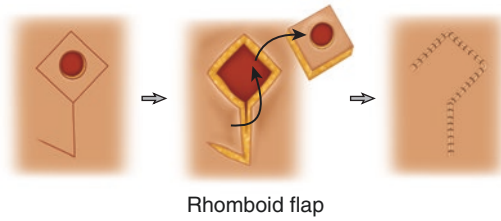
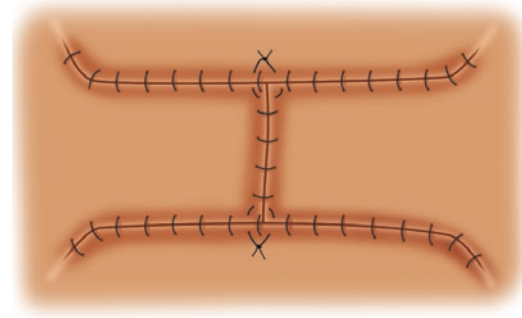


Fig. B1.5 Rhomboid flap



Regional

Regional flaps are raised from tissue in proximity, but not adjacent to the primary defect, and can be further classified as transposition or interpolation flaps (Table 22.5). Interpolation flaps include melolabial, nasofacial and paramedian forehead.

Table 22.5 Regional flaps

Regional flaps	
Transposition	Pectoralis major myocutaneous flap Deltopectoral flap Latissimus dorsi flap
Interpolation	Melolabial
	Nasofacial
	Paramedian forehead

Free

Free flaps are raised from tissue distant from the primary defect, and are thus non-pedicled. Thus, the vessels in the flap need to be re-anastamosed to an artery and vein in the recipient site; establishing a new blood supply and maintaining viability.

Blood Supply

Flaps can also be classified according to their blood supply. Within the dermis lies two vascular arcades – a superficial vascular plexus and a deeper subdermal plexus running between the reticular dermal layer and subcutaneous tissue. Additional vascular supply to the skin comes from perforator arteries off deep musculocutaneous arteries.

Random

Random flaps receive their blood supply from the subdermal plexus, and many local flaps are random.

Axial

Axial flaps receive blood supply from named perforator arteries off musculocutaneous arteries, and most muscle flaps are axial. They can also further be described as local, regional or free.

Axial muscle flaps can also be further classified into types I to V, based on the source, size, number, angiographic patterns, and the location and insertion of vascular pedicles supplying the muscle [7, 8] (Fig. 22.5):

- Type I – one vascular pedicle (e.g. Tensor fascia lata)
- Type II – one dominant vascular pedicle with minor pedicles (e.g. Gracilis)
- Type III – two dominant pedicles (e.g. Gluteus maximus)
- Type IV – segmental vascular pedicles (e.g. Sartorius)
- Type V – One dominant vascular pedicle with segmental vascular pedicles (e.g. Latissimus dorsi)

Z-plasty

The Z-plasty is a technique that is applied in numerous areas in plastic surgery, and is named after the three limbs of the flap. This technique brings about two outcomes; a gain in length and a change in direction of the main limb of the 'Z'. It is commonly applied where a scar needs to be realigned to minimize its appearance, for the treatment of contractures, as well as in the prevention of contracture development.

Procedure (Fig. 22.6)

- The Z shaped incision is created, with the central limb lying along the contracture line.
- The limbs and angles of the 'Z' are equal in length, to ensure the two flaps fit after transposition.
- The angle size can be varied; the greater the angle, the greater the amount the scar is lengthened by:
  - 30° results in 25 % increase
  - 45° results in 50 % increase
  - 60° results in 75 % increase (most commonly used)
- The length of the limbs can be varied; a longer length allows a larger Z to be incised, accommodating a larger contracture.
- Once the 'Z' is incised, two equal flaps are created, and are transposed. They are then sutured in place [4].

Core Operations

Due to the generality of plastic surgery, almost all plastic surgeons subspecialise [6]. The common subspecialties include skin, hand and upper limb, head and neck, breast and cosmetic. An overview of some of the key procedures of each specialty is reviewed below.

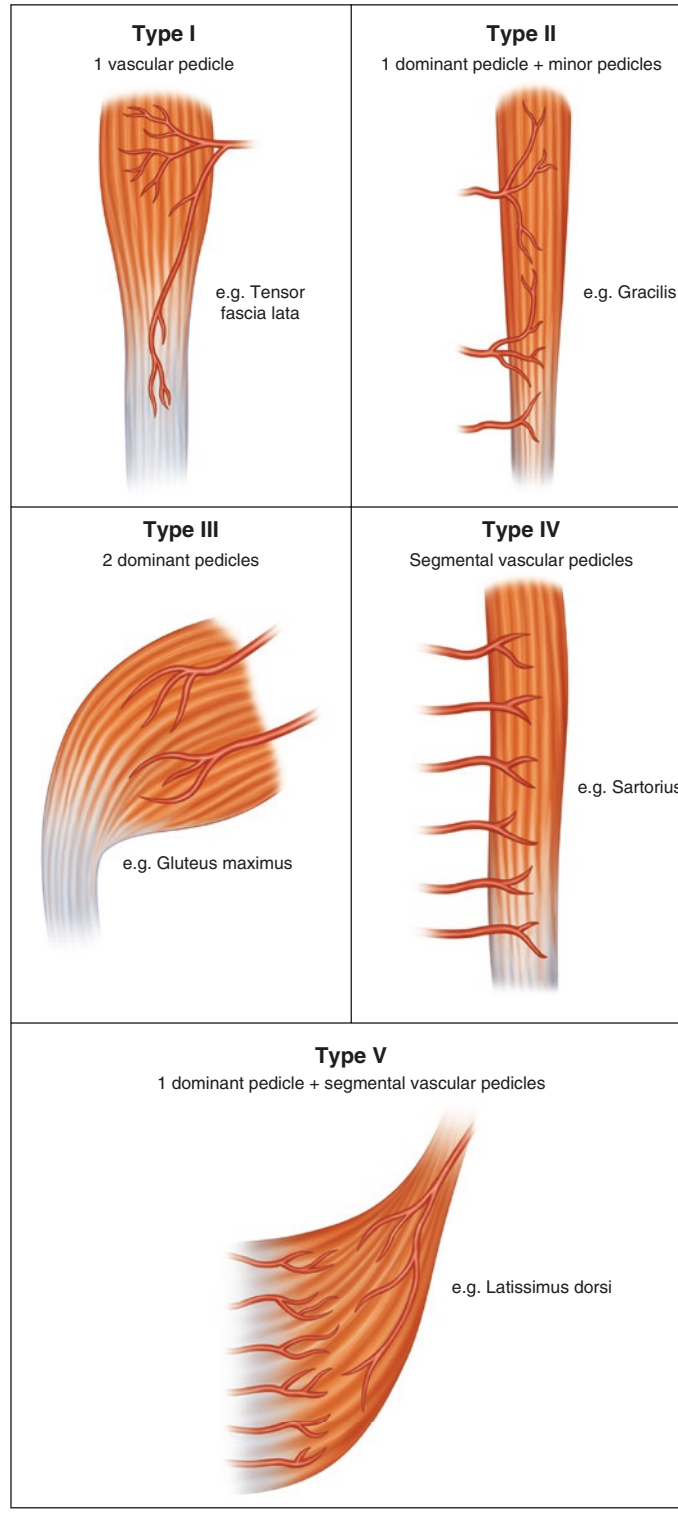


Fig. 22.5 Sub classification of axial flaps – I – V

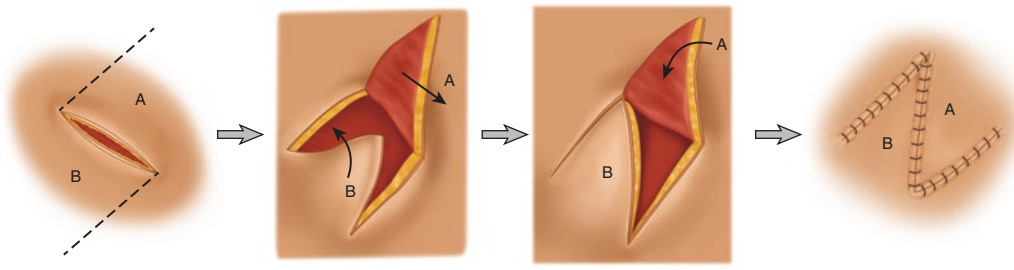


Fig. 22.6 Z-plasty

Skin

Skin surgery involves the excision of skin lesions, whether malignant or benign, as well as the removal of lymph nodes and the management of cutaneous cancer metastases. Common skin lesions removed include basal and squamous cell carcinoma and melanoma. Local flaps and grafts are often utilized in this subspecialty.

Hand and Upper Limb

This involves the correction of any congenital deformities of the hand, such as polydactyly (duplicated digits) or syndactyly (fusion of digits), treatment of degenerative hand diseases, and repairing injuries to the hand, for example by tendon grafting. One such example is flexor tendon repair.

Flexor Tendon Repair

Indications

- Tendon lacerations causing dysfunction.

Contraindications

- Extensive damage of vincula (nutrient provision to tendons).

Presentation

- Loss of flexor tendon strength.
- Limited movement of affected digits.
- Reduced range of motion.
- Deformity of digits.

Step-by-Step Summary: Flexor Tendon Repair

1. A zig-zag incision is made to avoid contracture formation.
2. Bone and joint structures are repaired first, followed by tendons and neurovasculature.
3. Tendon retraction, with minimal trauma inflicted on tendons – Intact vincula could prevent retraction of the proximal tendon.
4. The tendon is passed through the flexor sheath and secured by sutures.

Complications

- Tendon and pulley rupture.
- Infection.
- Tendon adhesions.
- Contracture of the joint.
- Trigger finger.
- Swan-neck deformity.

Follow-Up

- Rehabilitation with controlled mobilisation post-operatively is vital.
- Follow up in 4 weeks.

Breast

Breast reconstruction is carried out for several reasons, such as for patients with congenital deformities, but more commonly in patients who have undergone partial or full mastectomies for breast cancers. One common method of breast reconstruction is by using the deep inferior epigastric perforator flap, which involves free tissue transfer of skin and fat, with no involvement of the rectus abdominis.

Deep Inferior Epigastric Perforator (DIEP) Flap

Indications
- Breast reconstruction following mastectomy.
- Traumatic injury.

Contraindications
- Damaged or unsuitable deep inferior epigastric vessel.

Step-by-Step Summary: DIEP Flap
1. Main flap perforators are assessed using a handheld Doppler, and are marked. Alternatively, angiography may be used to assess blood flow.
2. Skin markings are made.
3. For the breast, the areolar complex and biopsy sites are marked. Markings are also made on the abdominal donor region.
4. The abdominal island flap is harvested by a transverse incision above the umbilicus, and a second incision similar to the Pfannenstiel incision that is used for caesarean section.
5. The flap is elevated from lateral to medial towards the main perforator(s), and this is then followed carefully through the rectus muscle to its undersurface and down to the main vessel (the deep inferior epigastric artery).
6. As the rectus abdominis is dissected, the intercostal nerves are preserved except perhaps the branch that runs with the perforator vessel.
7. Once the perforator is freed, the arterial perfusion is checked and the vessel is carefully ligated near its origin.
8. The artery (and vein which runs with it) are then anastamosed, most commonly to either the internal thoracic or thoracodorsal vessels, and the flap is inspected for adequate perfusion. The flap is then shaped, de-epithelialized and secured in position for appropriate breast reconstruction.
9. Abdominal fascia is sutured closed, as are the abdominal skin edges.

Complications
- Infection.
- Distal flap necrosis.
- Herniation of flap donor site.

Follow-Up
- Appointment with dressing clinic 1 week following discharge.
- Appointment with surgical team 4–6 weeks post-operatively.
- Routine oncology [3].

Head and Neck

An example of a procedure is mandibular reconstruction using a free fibular flap, which is useful after excision of oral cancers involving the oral mucosa and underlying mandible.

Mandible Reconstruction Using a Free Fibular Flap

Indications
- Mandibular involvement of head and neck cancer.
- Oral tumours.
- Trauma requiring reconstruction.

Contraindications
- No contraindications besides individual patient comorbidities preventing surgery.

Step-by-Step Summary: Mandibular Reconstruction
1. The lesion and tissue to be excised is marked out. The underlying mandible is exposed via a transverse incision.
2. Pre-plating is then carried out, with the plate fixed to the mandible via screws. The preplate is then removed.
3. The mandibular lesion is resected
4. A free fibula flap is designed with an overlying skin paddle to fill the soft tissue defect while the underlying fibula is osteotomised and using

the plate, remodeled to the shape required for reconstruction of the mandibular defect.
5. The flap is then transferred to the resected mandible and fixed to the definitive plate, vessels are anastamosed, and the skin sutured in place.

Complications
- Flap necrosis.
- Wound dehiscence.
- Wound infections.
- Wound contracture.
- Asymmetrical face.

Follow-Up
- Review of both donor and reconstructed mandible sites.
- Naso-gastric feeding 24 h post-operatively.
- Oral feeding 10 days post-operatively.
- Monitoring of flap vascularity using Doppler scans [5].

Cleft Deformities

This subspecialty involves the correction of cleft lip and cleft palates. There is debate about the exact timing of repair, although often the "rule of 10s" is applied, which suggests that the repair should occur at least 10 weeks after birth, when the infant is at least 10 pounds and a haemoglobin level of at least 10 g/dL.

Unilateral Cleft Lip Repair (Millard Rotation Advancement Closure Technique)

Indications
- Unilateral cleft lip deformity

Contraindications
- No contraindications besides individual patient comorbidities preventing surgery (anaemia, tolerability of general anaesthesia); Coexisting cardiac abnormalities.

Step-by-Step Summary: Cleft Lip Repair
1. Patient in supine position.
2. Skin markings are made with methylene blue dye (Box 22.2 Fig. B2.1 – in this example markings are simplified to red, blue and orange markers).
3. Incisions are made to create a rotation flap.
4. An additional incision is made to the contralateral side, creating the lateral philtral ridge, which is sutured to the rotation flap edge. This creates the advancement flap.
5. Closure of advancement-rotation flaps.
6. The flaps are approximated and sutured.

Box 22.2 Unilateral Cleft Lip Repair (Procedure Simplified from Flint et al. 2010)

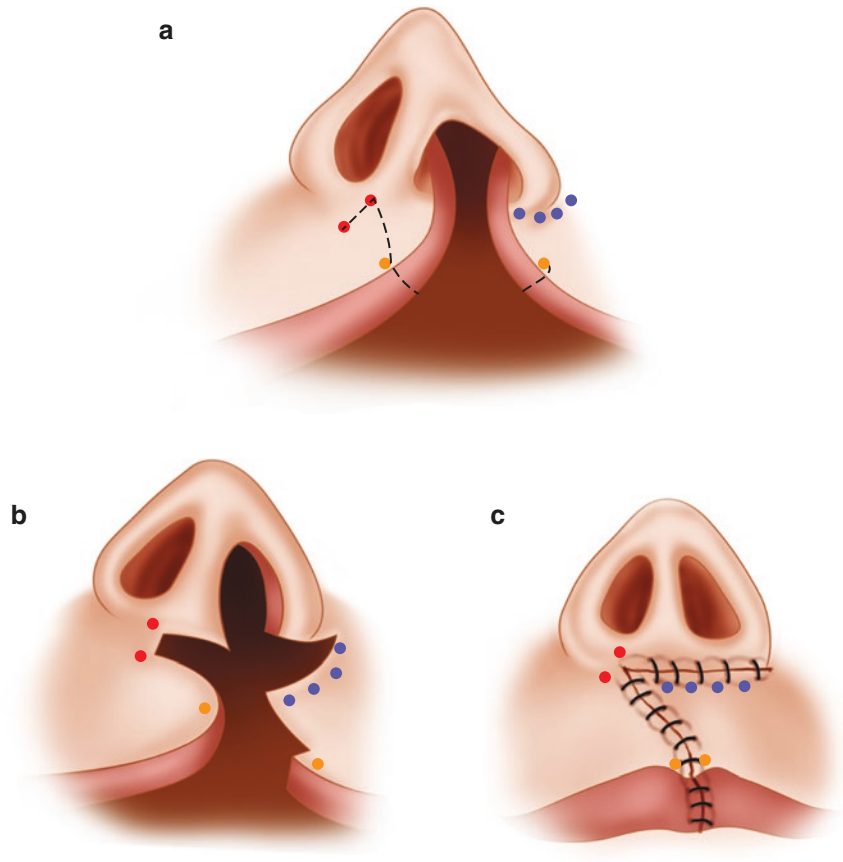


Fig. B2.1 Unilateral Cleft Lip Repair (Procedure Simplified from the Millard rotation advancement technique) (**a**) Marking the site (**b**) Incisions are made to form an advancement flap for surgical repair (**c**) Closure of advancement-rotation flaps

Complications

- Scar contracture or hypertrophy.
- Vermillion border misalignment (insufficient flap rotation).
- Wound dehiscence.

Follow-Up

- Routine wound care.
- Intraoral care of mucosal incisions.
- Revisional surgery if required.
- Assessment of hearing and speech.
- Promotion of good oral hygiene.

Burns

The goal of reconstruction of burns is the restoration of function and appearance. It involves the use of split-thickness or full-thickness skin grafts as described earlier.

Lower Limb Reconstruction

Lower limb injuries involving a fracture and skin compromise requires management by a multidisciplinary team involving orthopaedic, vascular

and plastic surgeons. The multidisciplinary approach allows for extensive injuries to be treated appropriately, thus restoring the function and appearance of the limb.

Anterolateral Thigh Free Flap (Fasciocutaneous)

Branches of the lateral circumflex femoral artery supply the ALT free flap. Its descending branch supplies 3 of the 4 quadriceps muscles: rectus femoris, vastus lateralis and intermedius.

Indications

- Open wounds of the lower limb (peripheral vascular disease, trauma, tumour resection).
- Prevention of amputation.

Contraindications

- Previous surgery to upper thigh.
- Insufficient vascular supply via circumflex femoral artery.
- Peripheral vascular disease.

Step-by-Step Summary: Lower Limb Reconstruction with Anterolateral Thigh Free Flap

1. Colour doppler is used to locate the perforators of the flap.
2. Flap dissection is carried out above muscle fascia, reducing muscle herniation risk and sensory nerve damage.
3. The flap is raised, the pedicle divided at the divisions of profunda femoris artery.
4. The arterial vessels are anastomosed at the recipient site, and venous anastomosis is achieved.

Complications

- Flap necrosis.
- Wound dehiscence.
- Lateral femoral cutaneous nerve damage.

Follow-Up

- Routine wound care.
- Monitoring of flap vascularity post-operatively using Doppler scans.

Cosmetic (Aesthetic)

Cosmetic surgery is carried out to change one's appearance, and is generally not available on the NHS. Examples of procedures include rhinoplasty, breast augmentation and breast reduction.

Breast Augmentation: Inframammary Approach, Subpectoral Placement

Indications

- Patient's personal reasons.
- Breast asymmetry.
- Post-partum involution.

Contraindications

- Pregnancy.
- Existing breast malignancy or pre-malignancy.
- Concurrent infection.

Step-by-Step Summary: Breast Augmentation

1. An incision about 2.5–3 cm in length is made at the inframmamary fold.
2. The inferior pectoralis muscular attachment is freed with cautery dissection, and is then lifted off the chest wall.
3. An implant has already been chosen based partly on the patient's wishes but more importantly on her chest wall and breast dimensions. The prosthesis is placed commonly so that most of it is covered by the overlying pectoral muscle with the lower portion covered by the overlying breast parenchyma.
4. The outcome is reviewed by sitting the patient upright, before the incisions are sutured closed.

Complications

- Wound infection.
- Haematoma formation.
- Seroma (fluid build-up).
- Reduced areolar sensation due to nerve damage.
- Displacement of implant.
- Implant rupture.
- Problems with breast-feeding.

Follow-Up

- Routine wound care.
- Follow-up appointments (3 weeks, 6 weeks, 6 months, 1 year) post-operatively.

Student Tips for Placement

Whenever on a placement, it is always important to be enthusiastic and to do your research before attending. In doing so, you will be better prepared to answer the questions the doctor you are shadowing may have for you. A great and concise resource for any plastic surgery placement is 'Fundamental Techniques of Plastic Surgery', written by Alan and Ian McGregor.

A working knowledge of the reconstructive toolbox will put you in good stead for many questions. The surgeon will often be asking himself or herself: "how can I reconstruct this defect?"

Due to the very broad range of plastics subspecialties, it would be worth checking what the surgeons' interest is before attending the list or clinic and reading up around this subject.

Surgeons' Favourite Questions for Students

1. How does a graft take?
2. What is the difference between a split and full thickness graft?
3. What is the difference between and graft and a flap?
4. How do you classify flaps?
5. What makes up the reconstructive toolbox; what options are available to us?

Careers

Training follows a similar pathway to most surgical specialties. Following foundation years, core-training schemes should include a plastics rotation to gain exposure to the fundamentals of the specialty and confirm your interest. In an ideal world, trainees would then proceed directly into specialty training, which lasts for 6 years. However it is difficult to make yourself competitive for selection. Although discouraged by some, historically, many trainees have undertaken a period of time in research, which in addition to any extra degrees and publications, also develops many other skills and may provide further opportunities for surgical experience prior to formal registrar training. The number of certain procedures you have performed, such as tendon repair, and your in depth knowledge of these procedures will be assessed at your ST interview. You should be looking to maximize your surgical exposure at every opportunity and it is common to find enthusiastic and committed medical students trying to do just this at an early stage.

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