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Cleft Lip and Palate Primary Repair

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With 441 figures, 406 of them in color

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Preface

Congenital cleft lip and palate is the most common cranio-maxillo-facial birth defect. It can markedly affect the morphology and almost all the functions in the facial area except vision. Religion, superstition, invention and charlatanism characterized the early history of cleft lip. Spartans and Romans killed cleft lip children, whom they considered harbour evil spirits, while the Greeks simply ignored them. As saner senses prevailed, Fabricius ab Aquapendente (1537-1619) was the first to suggest an embryological basis for clefts. The knowledge of cleft lip and its surgical correction expanded significantly between the Renaissance and the 19th century. During this period, Pierre Franco's Petit Traité and Traité des Hernies described the cleft condition as "lievré fendu de nativité" (cleft lip present from birth). The first ever documented cleft lip surgery is from China, in 390 BC, performed on an 18 year old patient named Wey Young-Chi, who wanted to be a soldier. Albucasis of Arabia and his fellow surgeons used cautery instead of the scalpel, and Yperman in 1854 recommended dissecting the cleft margins with a scalpel before suturing them with a triangular needle dipped in wax. The repair was reinforced by passing a long needle through the two sides of the lip and fixing the shaft of the needle with a figure-of-eight thread over the lip. Germanicus Mirault was the originator of the triangular flap, which was later modified by C.W. Tennison in 1952 and Peter Randall in 1959. In the late 1950s, Ralph Millard presented his "cut as you go" technique. Similarly, the protruding premaxilla of a bilateral cleft lip has also been dealt with in several ways throughout the ages—from being totally discarded, to being pushed back by a wedge resection of the vomer, to finally being left to the orthodontists.

Though Tennison and Millard, who established the foundations of modern cleft lip repair, significantly improved the previous technique of cheiloplasty and achieved more stable, long-term outcomes, there remained a remarkable amount of secondary deformities after the application of their techniques. Furthermore, it is especially difficult for junior surgeons to expertly practice their methods and obtain consistently favorable results. In order to resolve these problems, other researchers have carried out much methodological work characterizing cleft lip deformities in the last twenty years. They partially improved previous methods, especially the rotation advancement method, and created several distinct methods to repair cleft lip. These improvements have made the operations easier to perform and the postoperative results more consistent. These technical improvements in surgery prompted a number of questions, however. What is the soul of cheiloplasty design? In other words, how to harmonize the incision design and the surgical purpose? How can the labial peak on the cleft side be precisely rotated downward, no matter who the surgeon is? What is the value of the horizontal incision at the alar base on the cleft side and how to apply it? What causes the deficiency of columella height and how to correct it? How to design and rebuild the labial tubercle? Cleft lip repair has developed from a purely morphological rebuilding to a procedure which restores the labial form based on functional reconstruction, and aims to lead to normal growth of the upper lip – hence, the academic debate as to whether the surgical method or the surgeon's experience is the more important.

We believe that clinicians can further understand the methods and the underlying principles of different researchers through studying their theories in depth. They can then compare and choose to apply the optimal theories in their daily practice to improve final outcomes.

Primary cleft lip repair is the most important part in the whole therapeutic sequence. Its influence is the widest and lasts the longest. Therefore, it is always meaningful to emphasize the importance of primary lip repair and pursue related research to improve its outcome. This is also the reason why this book mainly focuses on primary repair.

With regard to surgery of the palate, this was virtually nonexistent in the 16th and 17th centuries in Europe. Cleft palate was first repaired in 1556 by Franco. Though the understanding of the velar function and cleft repair was still quite primitive, the first doctor who really succeeded in repairing cleft palate was the French dentist, Le Monnier, who operated on a child with a palatal cleft "from the velum to the incisor teeth", as described in 1766 by Robert. The preliminary procedures to repair soft palate cleft were based on the continuous endeavors of Von Graefe and Roux. Dieffenbach and von Langenbeck further established the method of repairing complete cleft palate, which is also most commonly used by plastic surgeons today. Sir William Fergusson first described the function of palatal muscles in 1844 in a presentation to the Royal Medical and Chirurgical Society of London. Philip Gustav Passavant of Frankfurt made significant contributions to the understanding of palatal function in speech. In one of his monographs on "closure of the palate in speech", written in 1863, he stressed the movement of the soft palate and noted a "forward swelling (of the posterior pharyngeal wall) at the level of the base of the uvula". This later became known as Passavant's ridge. Passavant was also one of the first to attempt to surgically improve velopharyngeal dysfunction. At the same time, some other phenomena correlated with cleft palate repair were discovered. In the early 1800s, it was noted that a cleft palate was rather a separation of parts of normal size and potential than an underdevelopment or absence of normal parts. External pressure on the cheeks followed by palatal closure was described by Montin in Paris in 1836. When the borders of the cleft were approximated, they were "denuded with a red iron which was dipped in boiling water", and it was noted that "this pressure may result in fracturing of the maxillary bones".

In order to improve the postoperative velopharyngeal function, the pushback procedure invented by Harold Gilles and Kelsey Fry was once regarded as a logical method in theory and widely applied. The V-Y palatal lengthening invented by Ganzer was also widely used.

A most important improvement in palatoplasty is intravelar veloplasty, which originated from the discoveries of the autopsy by Otto Kriens on an autopsy patient with cleft palate. He made the point that the dislocated levator palatini muscles along the fissure should be restored to their normal horizontal position in palatoplasty. It also accords with the principle of "normal to normal", expressed by Millard. Based on this opinion, Leonard Furlow created the double opposing Z-plasty for cleft palate closure.

Modern palatoplasty is no longer the simple matter of closing the cleft only. Account should be taken of how to repair the cleft with less out releasing incisions and on how to recover maximum velar function through the levator reconstruction. It involves several aspects, such as the patient's age, surgical principles and ideas, and the arrangement of sequential therapy.

In a word, the concepts and techniques of modern cleft surgery are almost unrecognizable compared with those of earlier times. The global efforts of clinicians have taken the treatment of cleft lip and palate on to a completely new level. In order to promote continued patient management and development of technique and procedure, a number of experts in the field of craniofacial cleft have contributed their theories and techniques in this book.

The satisfaction for the clinician in treating cleft lip and palate lies in the potential to achieve a successful outcome, although in reality it can be extremely difficult to regain normal morphology and function compared with the ideal results one can imagine and hope for. Therefore, many experts attribute different outcomes to the competence or experience of different surgeons rather than different surgical techniques. The innovation of cleft surgery is increasingly focused on scientific theory rather than on formal surgical technique. We are aware that mere technical advances can bring improvements of a minor nature, while theoretical developments can bring about revolutionary changes. Furthermore, some earlier surgical procedures which originally seemed logical and understandable nevertheless came under scrutiny: naturally, only those of proven worth can be widely accepted and advocated, and this applies even to those that previously might have been regarded as incomprehensible by the majority of investigators.

Cleft lip and palate is a globally significant birth defect and people can compare the effectiveness of treatment in different countries or areas. The sheer frequency of this condition and the significance of successful treatment for the patient challenge plastic surgeons to develop optimal and effective treatment plans. We all know that primary repair is the most important procedure for patients with cleft lip and palate, which emphasizes not only improved appearance and simplified follow-up treatments, but also the beneficial effects on normal mental development. Therefore, one should never over-estimate the importance of primary repair.

The long history over 150 years of cleft repair has proved and is still proving that the treatment of clefts is not easy. Therefore, I have invited some of the leading world experts who have developed new ideas in primary cleft repair to collaborate in this book, to introduce their theories, techniques and experience in primary cleft repair. The purpose of this book is to help the reader to rapidly acquire experience from worldwide medical institutions, to help them modify their treatment strategy where appropriate and finally improve overall treatment. Much to my delight, I received generous support from a significant number of specialists in this field and I would like to gratefully acknowledge their contributions and thank them.

In order to realize the ideas mentioned above, we have tried to explain primary cleft treatment from theory to technique. I hope this combined approach will enable the reader not only to understand the result but also the reasoning behind the practice.

Bing Shi
Chengdu, China
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Contents

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Part I

Pre-Surgical Treatment of Cleft Lip and Palate

1

The Role of Nasoalveolar Molding in the Presurgical Management of Infants Born with Cleft Lip and Palate

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1.1 Introduction

While the conventional nomenclature of cleft deformity would suggest that only the "lip and palate" are affected, recognition and management of the potentially substantial nasal deformity is necessary in order to achieve an esthetic and functional treatment outcome. In most cleft treatment protocols, the nasal deformity is addressed surgically and requires a number of secondary surgical revisions as the affected individual grows to maturity.

Although surgical techniques to repair cleft lip and palate have improved over the years, arguably the most significant advance in surgical cleft rehabilitation has been the presurgical management of the cleft alveolar and nasal deformity with nasoalveolar molding (NAM) and the subsequent primary nasal reconstruction.

This chapter will describe the clinical indications, clinical management, and how to avoid or manage the potential complications of NAM.

1.2 Treatment Objectives and Clinical Indications of NAM

NAM is the only presurgical infant orthopedic technique that directly addresses both the cleft nasal and alveolar deformity [1]. The rationale for performing NAM is to reduce the severity of both the hard and soft tissue deformities, thereby facilitating optimal results from the primary surgical correction. Enhanced esthetic outcome of the primary repair should lead to improved early social integration of children with clefts and a reduction in the need for repeated surgical revisions.

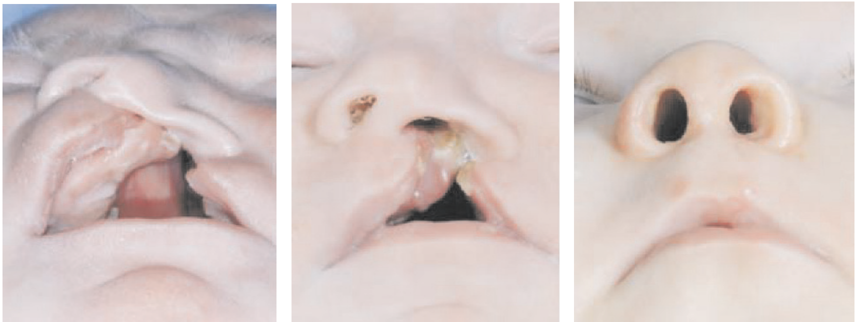
NAM uses an intraoral molding plate to gradually approximate the displaced alveolar segments, which results in approximation of the cleft lip segments as well as the medial and lateral aspects of the nose. Once the underlying alveolar segments are approximated, the overlying lip and nasal soft tissues attain a degree of laxity that permits reshaping and alignment with the introduction of the nasal stent. In addition, owing to the plasticity of the alar cartilage during infancy, the achieved changes can become permanent [2].

The nasal stent reshapes and projects the nasal tip while correcting the corresponding deformity of the lower lateral alar cartilage. As the immature nasal cartilage is maintained in the correct shape and position, these positive changes become permanent. In cases with a bilateral cleft deformity where the columella is notably deficient, nonsurgical columella elongation can be performed with the nasal stent, providing the surgeon with adequate columella tissue to achieve the primary surgical repair of the nose.

While not every infant that is born with a cleft lip and/or palate is a candidate for NAM, specific clinical findings may be used to determine which infants are good candidates for this treatment. Nearly every infant with complete unilateral cleft lip and palate (UCLP) and the associated nasal deformity is a candidate for NAM. In complete UCLP, the nasal floor is absent on the cleft side and the greater alveolar segment is often found to be protruding anteriorly, lacking its normal dental arch curvature. The cleft side lower lateral alar cartilage is subsequently prolapsed with deviation of the nasal tip and columella towards the non-cleft side. Asymmetry is the hallmark of complete UCLP as evidenced by comparing the nasal apertures, nasal apices, and columellar heights between the cleft and non-cleft sides (Fig. 1.1a). NAM has demonstrated the ability to improve nasal symmetry in complete UCLP up to the age of 9 years [3, 4] (Figs. 1.1b – 1.1c).

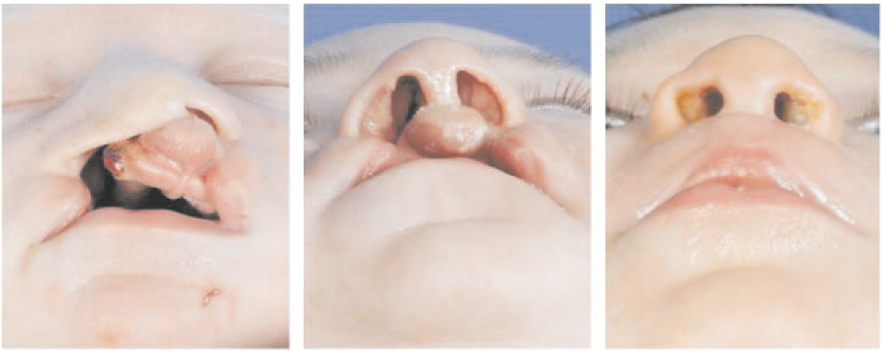
Infants born with complete bilateral cleft lip and palate (BCLP) often present with the premaxillary segment positioned outside the oral cavity, a wide nasal tip and alar base, and a severely deficient columella. The prolabium appears to extend directly from the tip of the nose (Fig. 1.2a). NAM has been shown to obviate or reduce the need for surgical construction of the columella and reduce the number of surgical revisions in complete BCLP cases up to the age of 8 years [5]. Further, it has been demonstrated that NAM can lead to a normalized columella length, nasal tip protrusion, and alar base width at the age of 12.5 years following only the primary nasal reconstruction [6] (Figs. 1.2b – 1.2c).

While the cleft lip and palate deformity has variable expression, the majority of the patients with them could benefit from NAM. For patients with unilateral clefts, the lower lateral alar cartilage deformity, reduced nasal tip projection, and a wide lip and/or alveolar cleft are often improved with NAM. In bilateral cleft



(a) (b) (c)

Fig. 1.1 UCLP: (a) Initial presentation: Note deviation of the columella and greater alveolar segment to the non-cleft side, asymmetrical nostrils, and significant lip and alveolar clefts; (b) Post NAM treatment: Note reduction in severity of the nasolabial and alveolar deformities; (c) Post primary surgery: Note symmetry in alar wings, up righting of the deviated columella, and overall lip symmetry



(a) (b) (c)

Fig. 1.2 BCLP: (a) Initial presentation: Note protrusive and deviated premaxilla, deficient columella and wide nasal tip and alar base; (b) Post NAM treatment: Note presurgical elongation of the columella, increased nasal tip projection, and approximation of the lip and alveolar segments at rest; (c) Post primary surgery

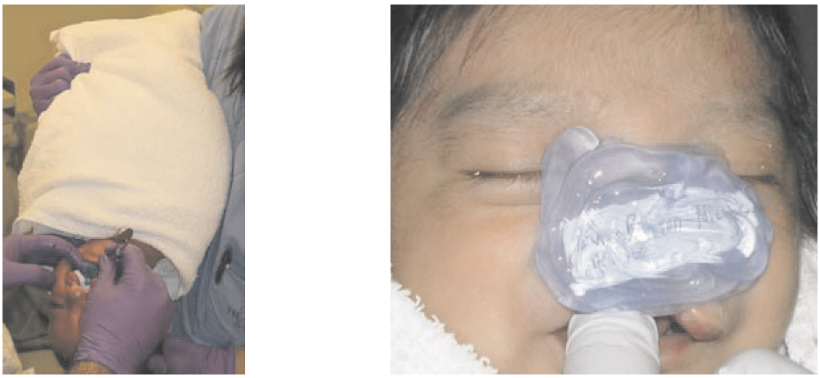
cases, an ectopically positioned premaxilla, deficient columella length, and wide lip and/or alveolar clefts are indications to perform NAM.

The primary reason to perform NAM is to improve the quality of the primary nasal and labial surgical repair. Gentle alveolar molding is performed in order to facilitate nasal molding and columella elongation. Traditional alveolar molding alone, whether performed with lip taping [7], a pin-retained Latham appliance [8], or with a McNeil type plate [9], offer little or no benefit to the surgical repair of the cleft nose. The combined effect of correcting both the alveolar and nasal deformity serves to reduce the severity of the cleft and provides the surgeon with an enhanced clinical condition to achieve the optimal surgical outcome.

1.3 NAM Plate Fabrication

1.3.1 Maxillary and Nasal Impression

Obtaining an accurate intraoral maxillary impression is the important first step in fabrication of the molding plate. This is accomplished by using an appropriately sized infant impression tray loaded with a heavy body Polysiloxane impression material (Coltene Rapid Soft Putty, Switzerland). The clinician who performs the impression must remain constantly attendant to the infant's airway. A small dental instrument (e.g. intraoral mirror handle) is used to prevent the tongue from occluding the airway during the impression procedure. Good intraoral illumination facilitating direct visualization of the tongue position and the posterior aspect of the pharynx is essential to prevent airway obstruction by excess impression material or the tongue. A clinical assistant should be present to mix the impression material, load the impression tray, and then help where needed. The surgeon or a physician, qualified to take appropriate action in case of an airway emergency, holds the swaddled infant upside down during the maxillary impression (Fig. 1.3a). After the impression material is set, the impression tray is removed and the oral cavity is examined to ensure that there is no debris from the impression remaining in the mouth. One advantage of using a thick putty impression material is that it does not tear as readily as the more common intraoral impression material, alginate. An impression of the nose including the left and right medial canthi is performed with a light bodied material (Memosil 2, vinyl Polysiloxane, Heraeus Kulzer, Germany) (Fig. 1.3b). Photographic records are taken, including complete intraoral and extraoral views. Ideally, a 3D photographic image would be captured as well.



(a) (b)

Fig. 1.3 (a) Maxillary impression: Initial impression with infant swaddled and held upside down. Note clinician elevating tongue with mirror handle to maintain patent oral airway; (b) Nasal impression: Following the application of impression material to the nose to provide an initial record of the nasal deformity

1.3.2 Construction of Molding Plate

The maxillary impression is poured up with dental stone and allowed adequate time to set. The intraoral portion of the NAM appliance, the alveolar molding plate, can either be made from a self-curing acrylic or a 2 mm thick sheet of Biocryl which will accept the subsequent additions of acrylic readily. Undercuts and the nasal septum should be blocked out and separating material applied as needed. Ensure that there is full thickness of the plate across the alveolar gap space; otherwise, this will need to be added during the alveolar molding process as the cleft is reduced. The cast is trimmed, leaving the full height of the vestibule intact. Vestibular extensions of the plate should be reduced at least 2 mm from the vestibular fold as well as around all frenal attachments (Fig. 1.4). The NAM molding plate should then be polished.

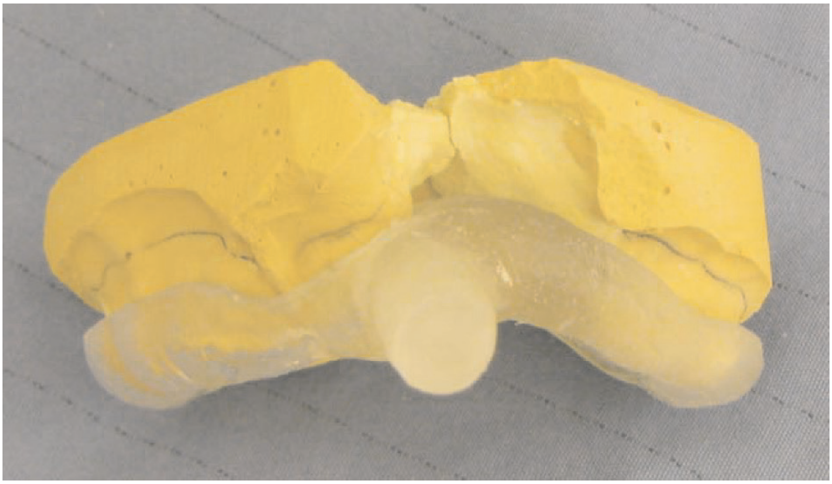


Fig. 1.4 Note the distance (approximately 2 mm) from the height of the vestibule to where the NAM appliance extends

The molding plate is carefully placed in the infant's mouth for the first time and held in position with gentle, superiorly directed pressure. A marking pencil can be used to indicate the location and extent of adjustment required in the vestibular extensions of the molding plate. A pear-shaped acrylic bur on a slow speed hand piece is ideal for removing the excess acrylic.

A hole 5 – 10 mm in diameter is created at the height of the palate to provide for the passage of air should the posterior aspect of the plate flip down towards the tongue.

Recently, a computer-aided system for NAM appliance fabrication and adjustment has been described, and appears promising [10].

1.3.3 Retention Button Addition

With the plate held gently in the mouth, the position of the retention button(s) is indicated with a marking pencil. One button is added for cases treating UCLP and two for BCLP. In UCLP, considering the greater alveolar segment will be molded transversely towards the lesser segment, the button should be positioned slightly towards the non-cleft side from the midline to minimize the need for moving the button as it will approach the cleft side lip segment as the alveolar gap is reduced. In BCLP, one button is placed on each side of the premaxilla towards the lateral aspect, extending anteriorly. Buttons should be positioned approximately 30 degrees to the occlusal place and between the respective lip segments. They can either be prefabricated and attached with acrylic or built *de novo* from hard acrylic and custom shaped. A measurement from the front edge of the plate while in the mouth to just in front of the lips will provide an estimate for the initial length of the button. The body of the button should be 3 – 5 mm wide, and can be reduced a little to accommodate the approximation of the lips as treatment progresses. An undercut at the tip is necessary to provide a point of attachment for the orthodontic elastics. The retention button(s) will likely need to be increased in length as the infant grows and the plate translates posteriorly. (See below for explanation of biomechanics and complications)

1.3.4 Alveolar Molding Plate Retention

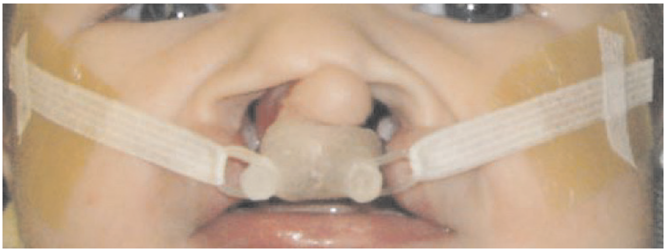
Retention of the plate on the alveolar ridges and palate is accomplished via a pair of extraoral tapes and elastics. If necessary, a very small amount of denture adhesive paste may be temporarily used to augment retention.

The first layer of tape applied to the cheeks (base tape) is a hydrocolloid bandage. DuoDerm can serve as the base tape in addition to more easily obtained and economic options readily available in most grocery stores or pharmacies (e.g., hydrocolloid bandage). The base tape serves as a barrier between the skin and the retention tapes. The base tapes are optimally positioned just inferior to the lateral canthi of the eyes, with the medial aspect of the tape angled inferiorly towards the upper lip (Fig. 1.5a). This is in contrast to a more inferior and horizontal position of base tapes when performing lip taping alone (Fig. 1.5b). The exact position of the base tape is ultimately dictated by the necessary position of the retention tapes to create optimal retention of the plate. The base tapes can remain in place for up to a week. When it is time to change them, they should be carefully removed by moistening them with water or adhesive tape remover. Then the cheeks should be cleaned and moisturized. It is appropriate to give the cheeks a rest period of 1 – 2 h each time the base tapes are changed. The NAM appliance can be out of the mouth during this time as well.

The retention tapes are positioned on the base tapes and are made of ¼" 3M steri strips with an orthodontic elastic engaged at the medial end for attachment to the retention button(s) (Fig. 1.5c). The orthodontic elastics should provide 1.11 – 1.67 Newton of force. The retention tapes should be replaced daily as the elastic fatigues and adhesion of the tape begins to fail, resulting in progressively insufficient force levels.

(a)

(b)



(c)

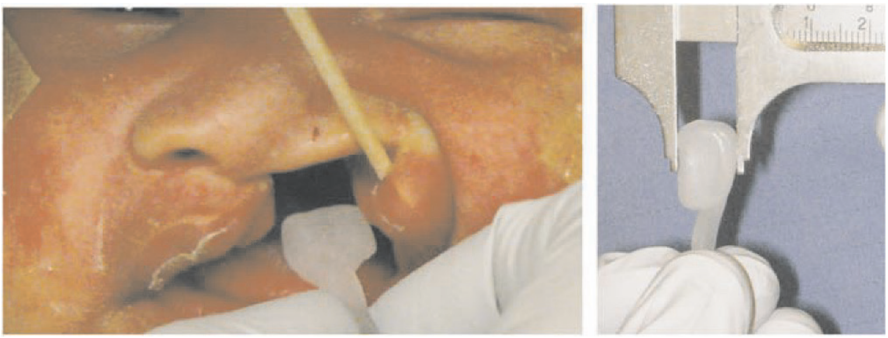
Fig. 1.5 (a) Base tapes positioned for NAM: Note placement inferior to the lateral aspect of the eye and angled downward towards the mouth; (b) Base tapes positioned for lip taping: Note parallel placement of tapes placed at the level of the lips; (c) Retention tapes: Note placement on with base tapes to reduce skin irritation

1.3.5 Delivery Appointment

Providing a set of printed instructions along with the verbal instructions on the wear and care of the molding appliance will make the family feel more comfortable and reduce unnecessary emergency calls. Educating the care providers about the cleft-specific anatomy of their child will allow them to better appreciate the rationale of the treatment, monitor treatment progress, and better communicate their observations regarding potential treatment complications via the phone or internet.

1.4 Alveolar Molding

Adjustment to the molding plate should be performed at 1 – 2 week intervals. The infant should be placed facing up on a stable and softly padded surface. The care provider stands at the head of the infant, holding its hands at its ears, thus preventing the baby's hands and head from moving. The infant should be examined with the plate in the mouth. Among the first observations is how the care provider is taping and activating the appliance. Feedback is given to the care provider regarding this very important part of the molding process. Next, the position of the retention button and elastics relative to the lips is assessed. The retention button should exit the mouth at the point where the upper lip segments come together with the lower lip. The elastics should connect to the retention button just slightly above the plane of the skin, not pressing down into the lips. The plate is removed and a cotton tipped applicator and an external light source are used to perform an intraoral examination looking for changes in response to prior adjustment and mucosal irritation or sores (see Potential Complications section below). If a sore is present, observe its direct relationship with the corresponding surface of the molding plate. The point of irritation can be marked on the plate while it is still in the infant's mouth. The plate is removed and then the offending aspect of the plate is carefully adjusted. The width of the alveolar gap should be measured periodically to assess progress. This can be done with a piece of soft utility wax formed to passively fit into the alveolar cleft space (Fig. 1.6a). The wax form can then be measured with a boley gauge or ruler (Fig. 1.6b).



(a) (b)

Fig. 1.6 (a) Using utility wax to fill the alveolar cleft; (b) Measuring the width of the wax with a boley gauge to indirectly determine the distance between the alveolar segments

1.4.1 Biomechanics

There are three mechanisms by which alveolar molding occurs, two of which are active and one is passive. The protrusive alveolar segments that are in contact with the appliance will actively be retracted by the posteriorly directed force delivered by the elastics and tapes (elastic force). The second active force is generated by reciprocal additions and subtractions of hard and soft acrylic that comprise the internal- or tissue-facing surface of the molding plate (plate force). These adjustments apply a gentle but active force that is intended to move the alveolar ridges through the application of light intermittent force. All such adjustments (additions and removals of acrylic) made to the molding plate are approximately 0.5 – 1.0 mm in thickness. For this reason the molding plate adjustment appointments are scheduled at 1 – 2 week intervals. Care should be taken to maintain a uniform plate thickness of approximately 2 mm to ensure adequate strength and resistance to breakage.

The molding plate has a passive mechanism that contributes the correction of the alveolar and palatal cleft deformities. The plate prevents the tongue, nipple, fingers, and pacifier from residing in the alveolar and palatal cleft space, thus passively allowing these structures to freely grow towards one another.

By performing the appropriate series of adjustments to the unilateral and bilateral molding plates, the alveolar ridges as well as the plates themselves gradually attain a symmetrical and "normal" arch form (Figs. 1.7a – 1.7f).

Adjustments are made to the molding plate to keep up with the expected increase in size of the alveolar ridges and maxillary arch during treatment. These adjustments are intended to increase the transverse dimension of the alveolar molding plate by approximately 1 mm per month in order to keep up with growth. If reduction of the alveolar gap is presenting a challenge, these adjustments can be limited to use the relative constriction of the transverse dimension to aid in alveolar gap approximation. The active biomechanics and appliance adjustments differ for UCLP and BCLP, which will be addressed below.

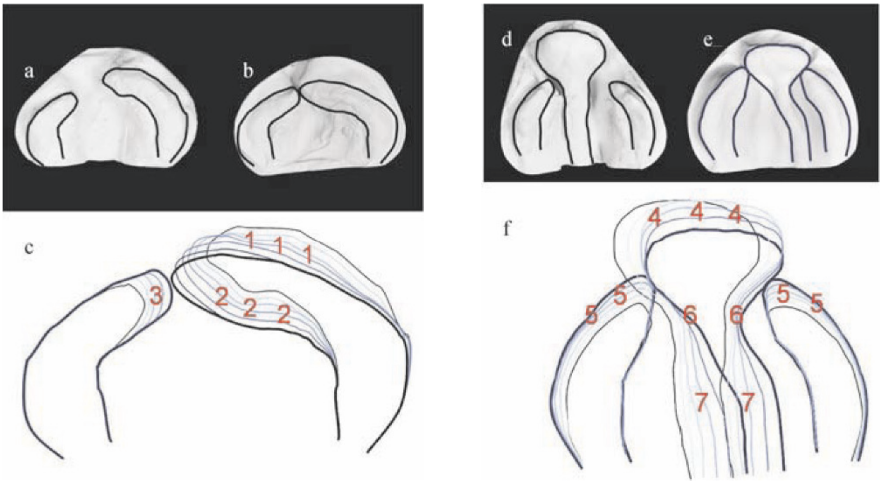


Fig. 1.7 (a) Initial cast with outline highlighting unilateral alveolar deformity; (b) Post NAM cast showing closure of the alveolar gap and correction of alveolar deformity; (c) Diagram showing progressive changes in shape, size, and position of the alveolar ridges during the process of alveolar molding. These changes were obtained by gradual additions of soft acrylic to the molding plate on the buccal surface of the alveolar ridge (1) and by equivalent reduction made on the palatal aspect of the alveolar ridge (2). Note that acrylic is removed in progressive steps along the medial aspect of the lesser alveolar segment (3) to allow for growth of the alveolus and rotation of the plate; (d) Initial cast with outline highlighting bilateral alveolar deformity; (e) Post NAM cast showing closure of the alveolar gaps, repositioning of the premaxilla between the lateral alveolar segments, and consequent deviation of the nasal septum; (f) Diagram showing progressive changes in shape, size, and position of the alveolar ridges, premaxilla, and nasal septum during the process of alveolar molding. These changes were obtained by gradual additions of soft acrylic to the molding plate on the labial surface of premaxilla (4) and by equivalent reduction made on the anterior and lateral aspects of the lateral alveolar segments (5) and posterior to the premaxilla (6). Note that acrylic is removed to allow for gradual deviation of the septum as the premaxilla is retracted (7) (for a more detailed description, see Biomechanics section)

1.4.2 Biomechanics of Complete UCLP Molding Plate Adjustment

The aim of alveolar molding in complete UCLP is to provide the normal anterior arch form to the protrusive greater alveolar segment while allowing the lesser alveolar segment to increase in size as a result of growth and to remain in its place. This is achieved through the combination of very small molding plate adjustments and the gentle application of extraoral elastic force. Hard acrylic is removed around the labial, buccal, and medial aspects of the lesser segment so the plate in combination with the elastic force is able to cause slow retraction of the projecting premaxillary portion of the greater alveolar segment. In this way, the extraoral elastic force is delivered directly to the labial side of the greater alveolar segment. This causes the greater alveolar segment to gradually be molded toward the anterior edge of the lesser alveolar segment while no force is delivered directly to the lesser alveolar segment. Greater elastic tension should be placed on the cleft side to achieve rotation of the molding plate toward the cleft side during the period of active molding. Hard acrylic should be periodically removed from the posterior border of the molding plate on the cleft side as this aspect of the plate is gradually projected posteriorly into the surrounding soft tissues.

Molding plate force is created by adding 0.5 – 1 mm increments of soft acrylic labial to the greater segment while removing an equal amount of hard acrylic from the palatal aspect of the greater segment. In this way, the protrusive greater alveolar segment is molded to achieve normal maxillary anterior arch form. It is important to remove and add equal amounts of soft and hard acrylic to the facing alveolar walls within the molding plate in order to maintain constant diameter of the space containing the alveolar process. Failure to do so could result in less available space and consequent pinching or deformation of the alveolar ridge. On the other hand, a net increase in volume of the alveolar ridge is expected to occur as the infant grows. Thus, when adding and removing acrylic to the inside of the molding plate, one must take care to maintain or slowly increase the internal dimensions of the space for the alveolar processes (Fig. 1.8).

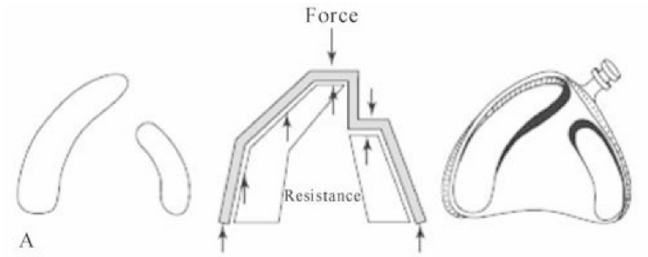


Fig. 1.8 UCLP biomechanics of alveolar molding: There are three primary ways that molding forces are generated. First, application of the elastic retention tapes results in a posteriorly directed force to tissue surfaces contacting the inside of the NAM appliance. Second, when reciprocal additions and subtractions of acrylic are made to theNAM appliance. Third, the reaction to pushing forward on the nasal tip is pushing back on the projecting alveolar process. Note the black areas indicate hard acrylic relief, the lined areas indicate soft acrylic additions, and the dotted areas indicate hard acrylic additions

1.4.3 Biomechanics of Complete BCLP Molding Plate Adjustment

The first objective of alveolar molding in patients with complete BCLP is to center the premaxilla, which is often deviated away from the midline. This can be accomplished in one of two ways. First, the premaxillary segment can be gently manipulated towards the midline at the time of the initial impression so that it appears in an improved position on the plaster cast. The molding plate that is fabricated from the cast will hold the premaxilla in the improved position that was achieved at the time of the impression (Figs. 1.9a – 1.9c). Further improvement in premaxillary position can then be achieved by making gradual changes in the molding plate. A second method to attain correction of the premaxilla towards the midline is to modify the alveolar cast itself prior to making the molding plate. In this case, the laboratory technician removes the premaxillary portion of the cast and the clinician carefully repositions it several millimeters towards the midline on the laboratory cast prior to fabricating the alveolar molding plate. In this way, the plate that is fabricated on the altered study cast will be active upon delivery and will initiate correction in the desired direction. Caution must be exercised when moving the premaxilla acutely to respect the inherent mobility of this anatomical structure. This will vary from patient to patient, ranging from 1 – 5 mm on average.

(a)

(b)

(c)

Fig. 1.9 (a) Note severe deviation of premaxilla to the right in this infant with bilateral cleft lip and palate; (b) Premaxilla was manually positioned towards the midline at the time the impression was performed that generated this maxillary cast; (c) Molding plate in position showing premaxilla repositioned towards the midline

Modifications of the molding plate and control of elastic forces are used to center the premaxilla. In the former, serial increments of soft acrylic are added to make contact with the lateral aspect of the premaxilla on the side that is further from the midsagittal plane. A similar volume of material is removed from the interior of the molding plate on the contralateral aspect of the premaxilla. Coordinated addition and removal of acrylic surrounding the premaxilla will gently and gradually move it towards the midline. In addition, adjustment of the elastic force that is applied to the molding plate by the external tape and elastic modules can contribute to this goal. Greater elastic force can be applied on the side towards which the movement is desired. The asymmetrical application of elastic force and gradual adjustment of the molding plate shape are both ways to control molding of the premaxilla in to the anatomically correct position.

Once the premaxilla is centered, attention is turned towards its retraction. The premaxilla belongs between the anterior borders of the lateral alveolar segments. Retraction of the premaxilla is also performed through a combination of alveolar plate modifications and the application of elastic forces. As the tape and elastics modules are connected to the retention buttons, a gentle and posteriorly directed force is delivered to the premaxilla. Relief of hard acrylic needs to be made on the inside of the molding plate, along the anterior face of both lateral alveolar segments. Relief of these two areas is essential in order to allow the plate to drift posteriorly as the premaxilla is retracted.

There are several molding plate modifications or “activations” that should be performed in a coordinated fashion: 1) Incremental addition of soft acrylic on the internal aspect of the plate labial to the anterior facing aspect of the premaxilla and reduction of hard acrylic behind the premaxilla, 2) Reduction in the width of hard acrylic found between the lateral alveolar segments and the premaxilla, 3) Relief of hard acrylic from the molding plate on the tissue side of the buccal aspect along the lateral alveolar segments (to permit posterior drift of the molding plate and expansion) while adding acrylic on the corresponding outer surface to maintain adequate plate thickness, and 4) Periodic removal off the posterior border so the plate does not impinge on the maxillary tuberosity area or induce gagging (Fig 1.10).

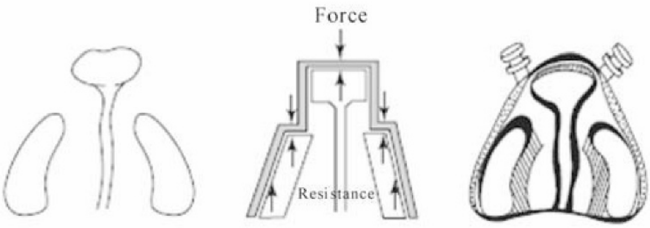


Fig. 1.10 CLP biomechanics of alveolar molding: There are three primary ways that molding forces are generated. First, application of the elastic retention tapes results in a posteriorly directed force to tissue surfaces contacting the inside of the NAM appliance. Second, when reciprocal additions and subtractions of acrylic are made to the NAM appliance. Third, the reaction to pushing forward on the nasal tip is pushing back on the projecting premaxilla. Note the black areas indicate hard acrylic relief, the lined areas indicate soft acrylic additions, and the dotted areas indicate hard acrylic additions

It will often be necessary to first increase the thickness of the hard acrylic plate by adding to the external surface before relieving from the internal aspect, so as to maintain the structural integrity and minimal acrylic wall thickness of 1 – 2 mm.

There is also the potential need for expansion of the lateral alveolar segments if they have collapsed medially. This would be achieved by reciprocally adding soft acrylic to the palatal aspect of the plate and removing an equal amount of hard acrylic from the internal aspect of the buccal portion of the plate. In this way, the full buccopalatal dimension of the alveolar ridges can be maintained.

1.5 Nasal Molding

Presurgical molding of the cleft nasal deformity is what separates NAM from all other presurgical infant orthopedic treatment techniques.

However, prior to initiating nasal molding, a period of alveolar molding alone is often indicated to reduce tension in the nasal soft tissue. The lower half of the soft tissue nose is often broadly stretched over the boney cleft. An attempt to elevate the nasal tip under these circumstances could easily result in stretching of the soft tissue. By first molding and reducing the alveolar gap width to approximately 5 mm, there should be adequate laxity of the lower lateral alar cartilage and soft tissue nose to achieve the desired nasal molding without excessive tissue expansion. In BCLP cases, alignment of the premaxilla to the midline and vertically approximating the columella/prolabial junction relative to the lateral lip segments and the lateral aspect of each lower lateral alar cartilage greatly facilitates the nasal cartilage molding and the nonsurgical columella elongation process. There are circumstances in which nasal molding can be initiated sooner, such as when the cleft is limited to the lip and alveolus or when there is significant soft tissue band (e.g. Simon Art’s band) that serves to minimize the width of the alveolar cleft. Even in these cases, it is recommended to deliver the alveolar molding plate without the nasal stent, so that the care provider and infant have some time to functionally adapt to the use of a molding plate. The nasal stent can be added one week or two later.

1.5.1 Addition and Adjustment of the Nasal Stent

In patients with UCLP, a single nasal stent attached to the molding plate enters the nostril aperture to provide support and shape for the prolapsed lower lateral alar cartilage and nasal tip. In patients with BCLP, two nasal stents are employed to achieve forward projection of the nasal tip and, most importantly, nonsurgical columella elongation.

A template for construction of the nasal stent can be made from a short span of soft utility wax. With the molding plate seated in position, the wax strip is attached to the side of the retention button(s). It is given the characteristic "swan neck shape", as it travels from the retention button into the nostril aperture. This wax template will serve as a guide for bending the wire that will become the nasal stent (Fig. 1.11a).

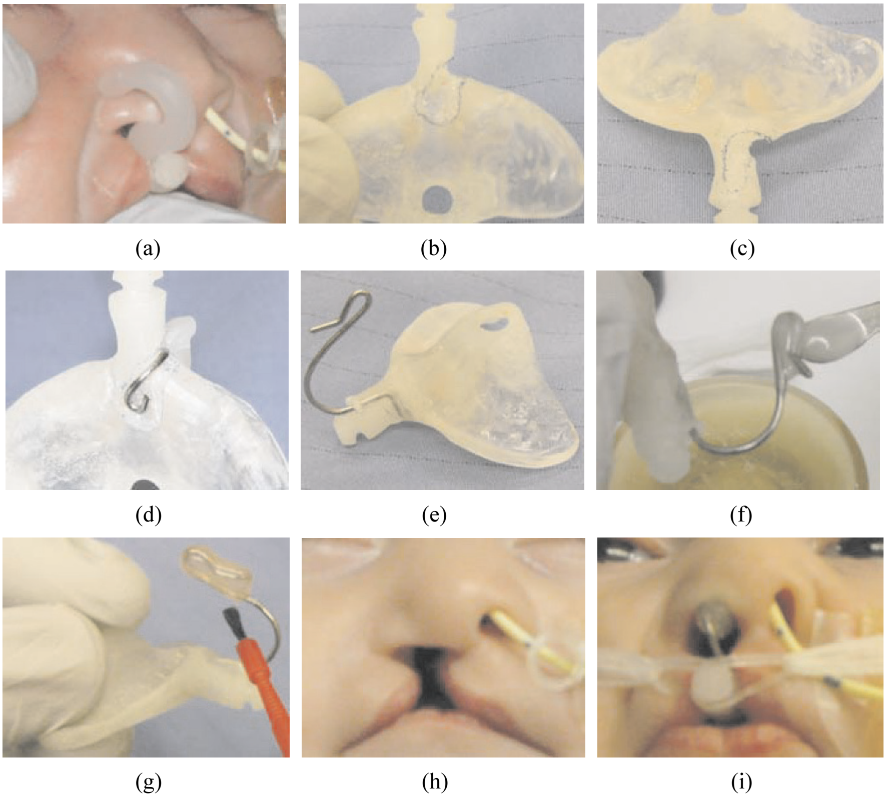


Fig. 1.11 (a) Utility wax that serves as a template for bending the wire that will become the nasal stent; (b) View of the inferior aspect of the molding plate showing relief channel in which the nasal stent wire will be embedded; (c) View of relief channel extending from the inferior surface around the lateral aspect to the superior surface of the retention button; (d) View of nasal stent wire seated in the relief channel; (e) Nasal stent wire embedded in the acrylic of the molding plate; (f) Addition of hard acrylic foundation to the intranasal portion of the nasal stent; (g) Addition of soft acrylic to the intranasal portion of the nasal stent; (h) Infant with UCLP prior to insertion of NAM appliance; (i) After insertion of NAM appliance. Note position of nasal stent with mild blanching on the rim of the nostril aperture

The next step is to create a relief channel in which the nasal stent wire will be embedded. Hard acrylic is removed from the undersurface of the plate starting just behind the attachment point of the retention button, curving around the base of the retention button laterally and superiorly, and extending along the superior surface of the retention button (Figs. 1.11b – 1.11c). For BCLP cases, this is performed bilaterally. Next, a segment of 0.036" stainless steel wire is custom bent to lie passively in the created groove(s). For UCLP cases, the wire begins with a small half circle on the undersurface to increase wire retention in the acrylic. After extending through the groove on the superior surface of the retention button, the wire should gradually curve back towards the nose (similar to the wax template), then terminate in an "R" shaped series of bends serving as the intranasal portion of the stent (Fig. 1.11d). In BCLP cases, one wire can be used to fabricate both nasal stents. In the midline on the undersurface of the molding plate, a small dimple or "U" is bent to increase retention of the wire. The wire is bent passively to lie in the created grooves around both retention buttons and to terminate in symmetric "R" shaped series of bends similar to the nasal stent in UCLP cases.

Self-curing hard acrylic is used to fasten the nasal stent wire in place. All excess acrylic is removed so that the addition of the nasal stent to the alveolar molding plate provides a seamless surface for the tongue and lips (Fig. 1.11e). Hard acrylic is applied to the "R" shaped series of bends found at the terminal end of the wire to create the "kidney bean" shaped nasal stent (Fig. 1.11f). A thin coating of soft acrylic is applied to the hard acrylic portion of the nasal stent prior to its being placed in the nose (Fig. 1.11g). The nasal stent is approximately 3 – 4 mm wide and 7 – 10 mm long, but is altered depending on the size of the infant's nose. If the stent is too narrow, it may produce tissue ulceration at the nostril apex as the molding forces will be more concentrated, and if made too wide, the stent may fail to define a discrete nostril apex and increase the circumference of the nostril aperture.

Next, the NAM appliance is placed back in the mouth and the position of the nasal stent(s) is adjusted with bird-beak and three-prong pliers. The nasal stent should be positioned to lift the nostril apex in either a symmetric location to the non-cleft side in UCLP cases or just lateral to the columella in patients with BCLP (Figs. 1.11h – 1.11i).

1.5.2 The Biomechanics of Nasal Molding and Nonsurgical Columella Elongation

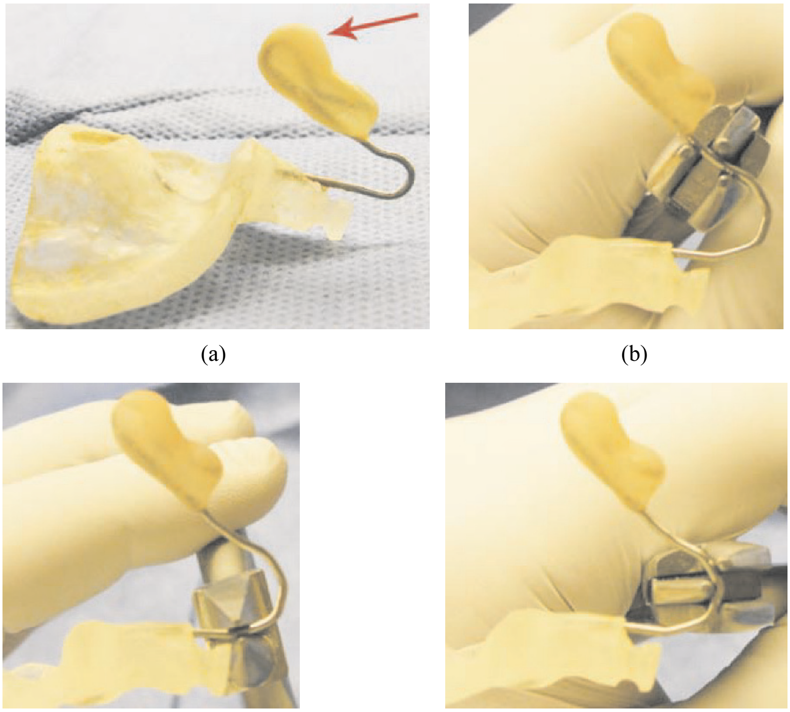
The form of the nasal stent is determined by the function that it provides. The nasal stent consists of two parts, the intranasal stent and the wire armature that supports it. The intranasal portion of the nasal stent is shaped like a kidney bean, containing two lobes. The superior lobe provides support and forward projection to the nasal tip. The saddle between the superior and inferior lobes of the nasal stent defines the nostril apex (Fig. 1.12).

The nasal stent can be activated by adding 0.5 – 1 mm increments of soft acrylic and/or by bending the nasal stent wire to achieve the desired activation. Observation of how the nasal stent affects change in the form and position of the nose dictates the magnitude and direction of each activation.

Fig. 1.12 Note position of nasal stent. The superior lobe defines the nasal tip and the saddle between the lobes defines the nostril apex. The inferior lobe should remain in an extranasal position

If greater support and forward projection at the nasal tip is desired, soft acrylic may be added to the superior lobe of the nasal stent (Fig. 1.13a). Alternatively, bending the nasal stent wire with three-prong pliers near the base of the intranasal stent will elevate the superior lobe differentially to the inferior lobe, resulting in greater nasal tip support and projection (Fig. 1.13b). Bending the nasal stent wire closer to its point of origin from the molding plate will move the entire nasal stent primarily in the anteroposterior dimension, and secondarily produce some vertical change (Fig. 1.13c). Alternatively, placing a bend in the nasal stent wire at the point of maximum curvature will primarily displace the nasal stent vertically with minimal sagittal change (Fig. 1.13d). Often it is through a combination of wire bending and soft acrylic modifications that the optimal nasal molding force is provided at each visit. It is acceptable to see some tissue blanching at the points of activation in the nose, but this should quickly dissipate.

In patients with BCLP two nasal stents are employed (Fig. 1.14a). After a few weeks of the individual nasal stents' being in place, there should be approximately 1 – 2 mm of columella evident. At this point, the two nasal stents are connected with a horizontal band of soft acrylic called the "columella band". The columella band connects the nasal stents from the medial portion of each stent, across the surface of the columella. Weekly additions of soft acrylic in 0.5 – 1 mm increments are made to the horizontal columella band. Through this process, tissue expansion forces are generated, and nonsurgical columella elongation is achieved prior to the primary surgical repair. Prolabial taping can aid the process of nonsurgical columella elongation. This is attained by applying tape to the prolabium and gently pulling downwards. This force is resisted by the upper portion of the columella band and by the intranasal stent as it seats against the inside of the nasal dome (Fig. 1.14b). Adjustments to the superior lobe and to the wire armature as described above can also be performed to enhance the forces that elongate the columella.



(a) (b)

(c) (d)

Fig. 1.13 (a) Red arrow pointing to addition of soft acrylic to the superior lobe of the nasalstent. This will increase nasal tip projection; (b) Note placement of plier at the base of the nasal stent which will result in an increase in nasal tip projection; (c) Bending the wire at the point it originates from the molding plate will provide a different ratio of sagittal to vertical change in the position of the nasal stent versus; (d) Bending it at the point of maximum curvature

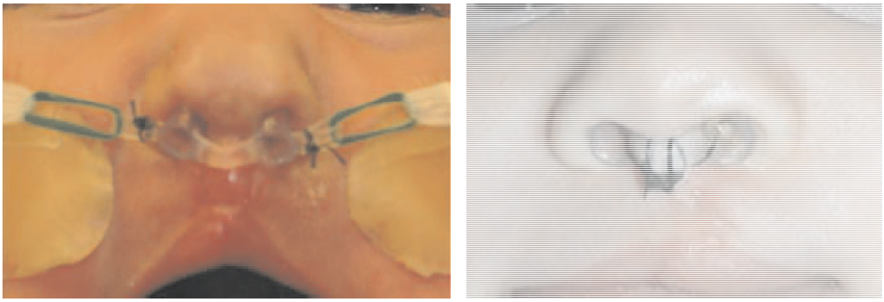
(a) (b)

Fig. 1.14 (a) Infant with BCLP showing two separate nasal stents; (b) The nasal stents have been connected with a horizontal band of soft acrylic, the "columella band". Note the application of a vertically oriented tape on the prolabium ("prolobial tape") attached with elastics to the retention buttons on the molding plate

Nasal molding proceeds for approximately 2 – 3 months. The goals of nasal molding in patients with UCLP are to achieve improved symmetry of the lower lateral alar cartilages, nasal tip projection, and increase the nasal mucosal surface area. The presurgical increase in surface area of the nasal mucosa enables the surgeon to attain a more lasting correction of the slumped nasal tip.

In patients with BCLP, the goals of nasal molding are to create approximately 4 – 5 mm of columella length, approximate the nasal tip cartilage, and improve nasal tip projection.

Postsurgical relapse of the positive nasal changes achieved from NAM have been reported [11, 12]. This phenomenon is in response to the known mechanisms of wound-healing and scarring. While many of the beneficial changes of NAM endure the period of wound-healing, there is reason to consider the employment of postsurgical retention stents. Ideally, a Porex or Koken stent is delivered after the majority of nasal swelling subsides and primary wound-healing has occurred at 3 – 4 weeks post surgery. These prefabricated silicone nasal stents are available in a wide range of sizes. The largest, well fitting stent is selected and inserted into the nose. The stents are retained using a cheek tape and elastic system just as in the NAM appliance (Fig. 1.15a). The stent size is increased each month as the infant grows. Postsurgical nasal stent treatment continues for approximately 4 – 6 months, at which point the infant's ability to remove the appliance begins to exceed the care provider's ability to maintain it in place. Alternatively, some surgeons elect to suture the postsurgical nasal stent in place at the completion of the primary surgical repair and to leave it for 2 – 4 weeks (Fig. 1.15b).



(a) (b)

Fig. 1.15 (a) Following the primary surgery, silicone nasal stents are held in position with tapes similar to those used with NAM; (b) Alternatively, the silicone stents can be retained with sutures

1.5.3 Armamentarium

The following materials are made available to the clinician when adjusting the NAM appliance (Fig. 1.16):

* Slow-speed hand-piece or dremmel drill and acrylic burs to remove and reshape the acrylic appliance
* Self-curing, hard acrylic – polymer (powder) and monomer (liquid), to fabricate the appliance and make periodic additions
* Soft acrylic – PermaSoft soft denture liner (Dentsply, York, PA), to activate the appliance
* Hot water bath to accelerate acrylic setting
* Boley gauge to measure thickness of NAM plate and to prevent inadvertent and hazardous thinning of the appliance walls
* Beaver tail spatula (# 8), to mix, manipulate, and deliver the acrylic
* Disposable brushes to collect, deliver, and position PermaSoft
* Rubber dappin dish to mix the acrylic
* 2×2 gauze
* Utility wax to measure the alveolar gap width and to serve as a template for nasal stent fabrication
* Bacitracin Zinc ointment to serve as a lubricant for the nasal stent
* Three-prong and bird-beak pliers to adjust the wire armature of the nasal stent
* Scissors to cut the tapes
* College pliers
* Pencil to mark the location of needed adjustments directly on the plate
* Scalpel to remove allotments of soft acrylic if necessary

Fig. 1.16 Recommended armamentarium for the clinical visit and adjustment of the NAM appliance

1.6 Potential Complications and Clinical Pearls

The most common complications that are associated with NAM can be broken down into three categories: soft tissue complications, hard tissue complications, and compliance issues [13].

1.6.1 Soft Tissue Complications

The majority of soft tissue complications arise from either over-extension or over-activation of the NAM appliance. Over-extension of the vestibular flange is likely to cause ulceration at the height of the vestibule, above the mucogingival junction (Figs. 1.17 a – 1.17b). While sores can develop on the attached gingiva, they are more likely to occur on the movable mucosa. Careful attention to adequate relief (approximately 2 mm) of the hard acrylic vestibular extensions, including the surface directly under the central and buccal frenal attachments, will minimize the risk of intraoral ulcerations. Over-extension of the intraoral plate up to and around the nasal septum can cause ulceration of the friable septal tissue. This is most easily to avoided by blocking out the nasal septum directly on the maxillary cast during the fabrication process. Hard acrylic must be added to the tongue side of the palatal portion of the plate while hard acrylic contacting the nasal septum is removed to ensure adequate plate thickness and strength.

(a) (b)

Fig. 1.17 (a) Infant with unilateral alveolar molding plate; (b) Intraoral sores located at the vestibular fold on both the greater and lesser alveolar segments

Over-activation of the nasal stent can result in a pressure ulcer of the nasal mucosal lining. This can easily to be detected by intranasal examination with a light and cotton swab to elevate the nostril rim. An intranasal pressure sore may also present with redness on the external nasal surface. Sometimes, a small amount of blood can be observed as a deposit on the nasal stent. If the columella elongation forces are excessive, soft tissue breakdown can occur at the points of resistance (e.g. collumela-philtral junction, nostril apex, nasal dome). If these complications occur, simply reducing the force at the point of irritation will allow the tissue to heal, usually within 2 – 3 days. Active molding may continue with evidence of healing of the soft tissue wounds. Soft acrylic can be effectively removed from the appliance surfaces and the nasal stent with a sharp scalpel. This technique for carving away soft acrylic results in a faceted and irritating appliance surface. The facets and fine edges created by the scalpel blade may be eliminated by application of a thin wash of soft acrylic over the modified appliance surface.

The nasal stent can become displaced and present external to and on top of the nostril. This could occur from over-activation of the nasal stent or from the infant dislodging the appliance (Fig. 1.18). This should be corrected upon observation, as the consequent forces are counter-productive to the objectives of nasal molding.

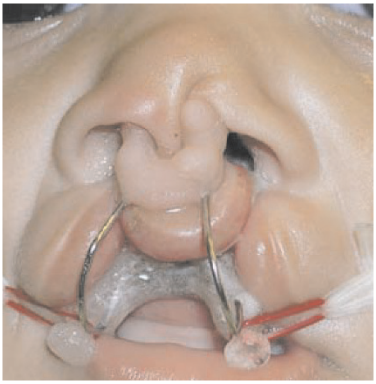


Fig. 1.18 Nasal stent is dislodged and resting externally on the nose. This should be corrected upon observation

As alveolar molding proceeds and the size of the alveolar cleft gap is reduced, the NAM appliance translates and rotates posteriorly, necessitating not only serial reduction of hard acrylic along the posterior border of the molding plate, but may call for lengthening of the retention button. If the button is not long enough, then the stretched orthodontic elastics may impinge on the lips, resulting in irritation or ulceration. In patients with UCLP, there is also an expected plate rotation that occurs as a consequence of alveolar segment approximation. This rotation is towards the side with the cleft and may necessitate differential reduction from the posterior border in the tuberosity region on the cleft side. To prevent soft tissue entrapment in the spaces that are created between the molding plate and the alveolar processes, activations should not exceed 1 mm in dimension.

While the combination of the base tapes and steri strips produce excellent appliance retention, they can result in irritation to the cheek surface (Fig. 1.19). While mild cheek irritation is fairly common and does not result in disruption to NAM treatment, more severe reactions are possible. Some predisposing factors to severe cheek irritation are infants whose cheeks are constantly wet from the flow of excess saliva or regurgitation, frequent and/or hasty removal of the base tapes, inadequate use of the base tapes, insufficient cleaning and moisturizing of the cheeks, and other infant specific intrinsic characteristics. In the most severe reactions, referral to the pediatrician or to a dermatologist may be indicated. If irritation persists and threatens treatment progress, altering the position of the base tapes on subsequent application can provide an opportunity for the cheek tissue to heal.

There is potential for gingival or mucosal infection as reported by Levy-Bercowski et al. [13] although the authors of this chapter have never observed this. Regular cleaning of the appliance with warm water should alleviate this potential soft tissue complication.

Fig. 1.19 Note irritation of the cheek around the base tape. Application of emollient cream, repositioning of the base tape, and protecting the cheeks from exposure to excessive moisture, could prevent this skin reaction

Trauma and/or bleeding can occur to intraoral, intranasal, and facial tissues from unpredictable movements of the infant's hands and/or face. Care should also be taken when holding the infant over one's shoulder or positioning the infant for "tummy time" to prevent the head from suddenly dropping and impacting the retention button against a hard surface. This can cause soft and hard tissue trauma, requiring a period of healing.

1.6.2 Hard Tissue Complications

Compression and severe reduction in the width of an alveolar segment in the labiopalatal dimension can occur if the reciprocal additions and subtractions of acrylic material employed during active alveolar molding are not made appropriately. This complication most often occurs at the leading edge of the greater alveolar segment in UCLP cases and on to the premaxilla in BCLP. A consequence of severe reduction in alveolar thickness may be ectopic or premature eruption of the underlying primary teeth. Thus, it is important continually to monitor the shape of the "negative space" that is created as acrylic adjustments are made on the inner surfaces of the molding plate (Figs. 1.20a – 1.20b). Should the inadvertent reduction in alveolar buccopalatal or labiopalatal thickness be observed, adjustment of the molding plate is made immediately to provide room for regeneration of full alveolar dimension. This will usually occurs in the immature and actively growing alveolar ridge.

Compression or thinning of the anterior labial aspect of the maxillary alveolar segment can result in premature exposure or "eruption" of primary teeth. If this occurs, the molding plate surface that contacts the exposed crown can be relieved to eliminate direct pressure upon it.

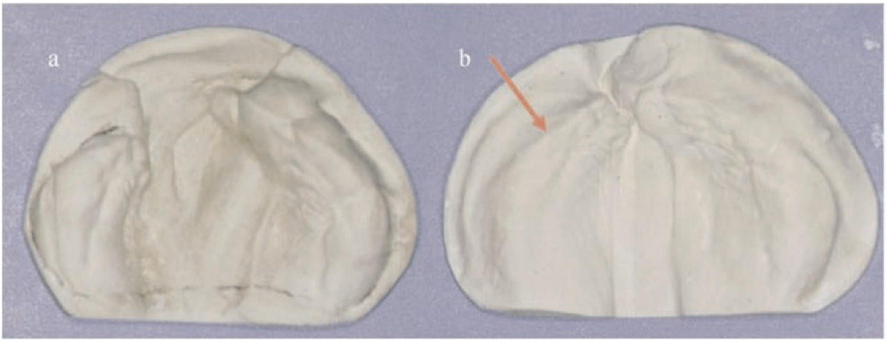


Fig. 1.20 (a) Stone cast exhibiting normal alveolar ridge anatomy on an infant with unilateral cleft lip and palate; (b) Red arrow points to a region of compressed alveolar ridge in the labiopalatal dimension ("knife-edge") resulting from adding too much soft acrylic on the labial aspect and not relieving enough hard acrylic on the palatal aspect of the internal walls of the molding plate

Sometimes a neonatal tooth is present on the cleft edge of the alveolar process. These "teeth" are ectopically located in a soft tissue sack that covers the bone on the alveolar gap and often must be surgically removed prior to the initiation of NAM therapy. The surgical removal of these ectopic teeth is necessary in order to enable adjustments to the molding plate and allow NAM treatment to proceed (Fig. 1.21). Since these ectopic teeth are not developing in alveolar bone, it is not expected that they will ever be functional. In addition, failure to remove the soft tissue sack and its contents can prevent molding, approximation of the alveolar segments, and should the sack rupture, the partially calcified immature tooth could be released into the oral cavity, putting the infant at risk of aspiration of the tissue. The extraction can be performed before or after the initial maxillary impression. If the extraction occurs after the impression, modification to either the maxillary cast prior to plate fabrication or to the plate at the time of delivery should be performed to optimize the fit of the plate.

The nasal septum must reach out to connect to the protrusive premaxilla (BCLP) or everted greater alveolar segment (UCLP). As these alveolar segments are molded back to their normal position inside the oral cavity, the elongated nasal septum is observed to deviate. Sometimes, significant deviation of the nasal septum occurs resulting in its premature contact with the inferior nasal turbinate. When this occurs, further molding of the alveolar or premaxillary segments may become difficult if not impossible.

Other causes of insufficient alveolar cleft reduction are improper alveolar molding technique or perhaps a more extensive alveolar cleft tissue deficiency. On average, the cleft gap can be reduced at the rate of 1 mm per week. To augment the alveolar molding biomechanics, a steri strip can be placed under tension and anchored on base tapes positioned on each cheek (Fig. 1.22).

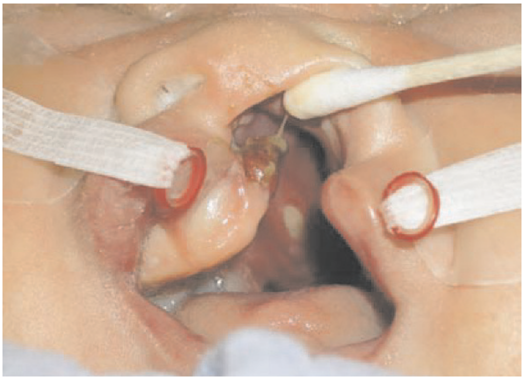


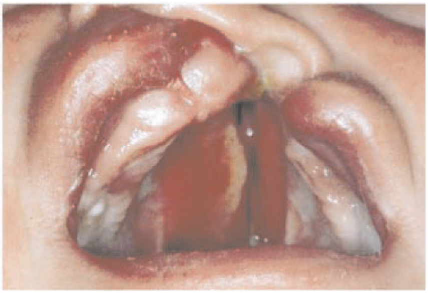
Fig. 1.21 At the end of the greater alveolar segment is a soft tissue sack containing a neonatal tooth bud. The soft tissue sack and its contents are removed to eliminate the risk of aspiration by the infant and to allow for approximation of the alveolar segments. Also seen in this figure is a sore on the nasal septum

Fig. 1.22 Note the horizontal tape with elastic module that is being used to help approximate the lip segments. This is used in addition to the retention tapes that are connected directly to the retention button of the NAM appliance

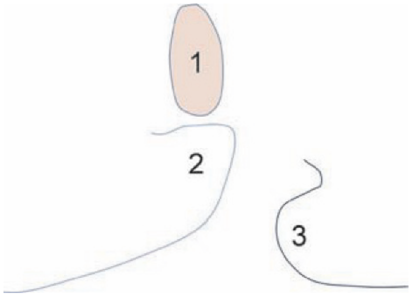
In UCLP cases, the proximal end of the greater alveolar segment can be displaced superiorly into the nasal cavity (Figs. 1.23a – 1.23b). When this is the case, it can be repositioned inferiorly by the gradual addition of soft acrylic to the inferior aspect of the nasal stent (Figs. 1.23c – 1.23d). In order to prevent a focal area of pressure and irritation, the nasal stent is broadened as it presses down upon the upturned alveolar process. This will gradually push the displaced edge of the alveolar segment inferiorly to achieve leveling of the alveolar occlusal plane in the region of the cleft gap. Adequate space should be made available in the alveolar molding plate to allow the alveolar segment to accept its corrected and more horizontal position (Fig. 1.23e).

Retraction of the greater alveolar segment and premaxilla in UCLP and BCLP respectively can occasionally result in an anterior crossbite relationship of the anterior maxillary and mandibular alveolar ridges. This can be seen in patients who show a more severe initial tissue deficiency and may be an early sign of a developing skeletal Class III relationship.

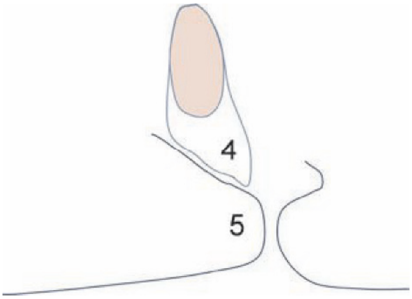
A hard tissue complication which is not seen by the authors of this chapter but reported by Levy-Bercowski, et al. [13] is when the lesser alveolar segment becomes displaced palatally to the approximated greater alveolar segment. This was referred to as a "T-shaped" maxillary arch configuration. They propose presurgical expansion of the lesser alveolar segment to address this situation.



(a)



(b)



(c)

(d)

(e)

Fig. 1.23 (a) Infant with left complete cleft lip and palate with greater alveolar ridge displaced superiorly; (b) Diagram of Fig 1.23a showing (1) cross section of nasal stent, (2) vertically displaced greater alveolar ridge, and (3) lesser alveolar ridge; (c) Diagram showing (4) foot progressively added to inferior surface of nasal stent, and (5) greater alveolar segment molded to proper vertical position; (d) Infant shown in Fig. 1.23a following vertical leveling of the greater alveolar segment; (e) Example of vertical footplate constructed out of soft acrylic on the inferior aspect of the nasal stent

1.6.3 Compliance

The vast majority of families who begin NAM treatment complete it successfully. This is because of the intense dedication of new parents to their infant and to a comprehensive informed consent process that provides families with a complete understanding of what will be required of them during NAM treatment. On occasion, a family will drop out of the NAM treatment program owing to an inability to follow through with appointments, but this is the exception, not the rule. It is important to note that the socio-economic status of our patients shows no correlation with their ability to successfully complete the NAM treatment program if the cost of treatment can be adjusted to the family's ability to pay.

If the NAM appliance is not properly retained in the mouth, clinical progress will be limited. Once it is determined that care provider cooperation is not the obstacle, the following strategies can be used to improve retention of the NAM appliance: 1) Alter the length and/or angle of the retention button, 2) Change the angle and/or tension of the retention tapes, and 3) Consider applying a very small amount of denture adhesive (e.g. Fixodent) to the tissue surface of the molding plate.

The baby may eventually be able to unseat the molding plate with their tongue as a result of the gradual reduction of the anteroposterior dimension of the plate and of improved fine motor control of the tongue. Adding an extension of hard acrylic on to the posterior border of the plate can help to prevent dislodgement of the appliance. This extension can take the shape of a bell curve centered in the midline along the posterior border of the plate. Care should be taken so that this extension does not elicit the gag reflex. An extension of approximately 5 mm in the midline is usually effective (Fig. 1.24).

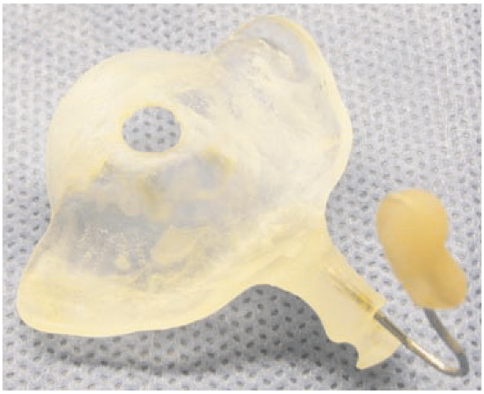


Fig. 1.24 Note the posterior border of the NAM appliance has been extended to prevent the infant from dislodging the appliance with its tongue

As the infant matures, it becomes increasingly possible for them to remove the NAM appliance with their hands. The following strategies can be employed to prevent this: 1) Place baby mittens or socks on the hands (Fig. 1.25a), 2) Using baby safety pins, close off the sleeve opening of a slightly oversized garment, confining the hands inside the sleeves, 3) Wrap small towels (face cloth) around the elbows to reduce flexion of the arms, 4) Conventional arm restraints, and 5) Other creative ways that parents may come up with to help keep the appliance in place (Fig. 1.25b).

If the NAM appliance needs to be removed owing to the development of a severe sore or cheek irritation, or if it is lost and will therefore be out of the mouth for an extended period of time, the care providers should be instructed to maintain a tight cross-cheek tape in place until the NAM appliance can be re-inserted. This will prevent relapse of the alveolar molding and overall treatment progress.

(a) (b)

Fig. 1.25 Various restraints can be employed to prevent the child from removing the NAM appliance from its mouth. (a) Mittens can be seen covering the hands; (b) This restraint was constructed by the family, out of soft cotton, wrapping around the babies midsection, and fitting over the wrists. This prevents the hands from elevating up to reach the mouth

1.7 Controversy to Conclusion

It is clear that when alveolar molding is used to attain the objectives of nasal cartilage molding and non-surgical columella elongation, there are documented benefits supporting its use [3-6, 11, 12, 14-21]. Nevertheless, some clinicians still doubt the treatment benefits of NAM. This doubt is largely based upon the mixed outcomes reported on other presurgical infant orthopedic techniques, the goals of which include improved feeding/nutrition [22], speech [23], dental arch relationships [24], nasolabial esthetics [25], and maxillary growth [26]. The key difference between

NAM and these other forms of presurgical infant orthopedics is that prior to NAM, no other infant orthopedic technique directly addressed the nasal deformity. As the goals of NAM do not include improved feeding, speech, dental arch relationship, or maxillary growth, it should not be judged by those criteria. In addition, we have seen the inappropriate association of primary gingivoperiosteoplasty (GPP) with that of NAM. Primary GPP is a surgical technique whose objective is to repair the alveolar cleft at the time of the primary lip and nose surgery. The performance of NAM may or may not be followed by GPP. In both cases, NAM is a variable that is independent of GPP and should be judged that way.

The principal benefits of NAM are to reduce the severity of the cleft deformity prior to the primary lip, nose, and in some cases, the alveolar repair. The benefits of NAM can be measured in terms of its effect on the lip and nose repair. For those clinicians who choose to include GPP in the primary repair, they may attribute the ability to perform a conservative GPP to the presurgical alveolar molding which results in the reduction of alveolar cleft width. This objective is separate from the NAM specific goal of improving the outcome of the primary nasolabial surgical repair.

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Part II

Primary Repair of Unilateral Cleft Lip

2

Features of Complete Unilateral Cleft Lip

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The face is the most changeable part of human body. Even among normal people, individual facial features vary considerably [1]. Precise measurement of the individual face, especially of the nasolabial area of patients with cleft lip, is fundamental for effective surgical operation [2]: it not only helps in the precise detection of deformity and in cheiloplasty design, but also provides comparative quantitative data to evaluate surgical results [2, 3]. The morphology and severity of individual congenital cleft lip deformities vary considerably, since patients are exposed to different risk factors, to different degrees, on different occasions [4]. Li Sheng and Shi Bing adopted three-dimensional morphometrics on facial and dental arch casts in 79 unilateral complete cleft lip and palate (UCLP) patients with an average age of 6 months [5]. The results of the facial casts were compared with those in 42 patients with cleft palate only (CPO), while the results of dental arch casts were compared with those of 34 incomplete UCL patients, all of them age-matched [5].

No significant statistical difference was found between the CLP group and the CPO group for either the distance between the medial canthi or the mouth width (Fig. 2.1). However, measurements on the CLP group tended to be smaller than that of the CPO group. In the CLP group, the difference between nasal width on cleft and on non-cleft sides was the most significant: nasal width on the cleft side could sometimes be more than three times that on the non-cleft side. Nasal height also showed a significant difference between cleft and non-cleft sides, even though the difference was not as significant as nasal width. Between the CLP and CPO groups, nasal height comparison demonstrated a significant difference only on the cleft side. In the CLP group, there was an evident asymmetry of the alar bases between cleft and non-cleft sides. Compared with the non-cleft side, the alar base on the cleft side located more laterally, inferiorly and posteriorly. In this study, the authors defined the anteroposterior plane as the one vertically crossing through the middle point of the line connecting both of the medial canthi. The coronal plane was defined as that passing though the medial canthus and the labial commissures on both sides. The horizontal plane was defined as that vertical to both the anteroposterior plane and the coronal plane and passing through the line connecting both of the medial canthi.

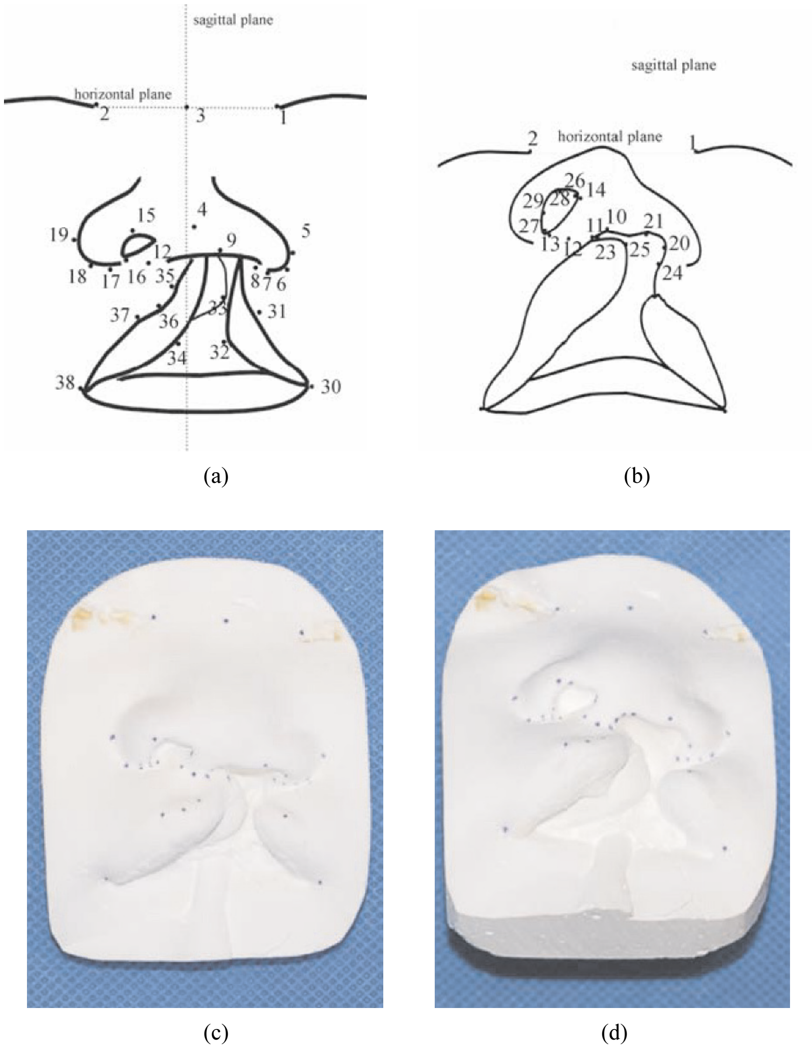

Fig. 2.1 (a) Sketch map of frontal nasolabial view before surgery and spotting; (b) Sketch map of supine nasolabial view before surgery and spotting; (c) Frontal view of patient's nasolabial model before surgery and spotting; (d) Supine view of patient's nasolabial model before surgery and spotting

The distance from the alar base on the cleft side to the coronal plane was 2.49±1.49 mm while this parameter was 5.46±1.09 mm on the non-cleft side. The columellar base was positioned 6.45±1.34 mm (3.5 – 8.76 mm) from the very middle to the non-cleft side. Moreover, the alar base on the cleft side located in a lateral, inferior and posterior direction. This led to the deflection of the columella and made the asymmetry of the columellar lengths on both sides even more pronounced. The columella length was 1.60±0.59 mm (0.24 – 2.89 mm) on the cleft side, and 3.76±0.79 mm (1.9±5.24 mm) on the other side. As the columella was almost horizontal in some cases, it was difficult to identify the columella and the nasal dome. All the parameters with smaller values in the CLP group indicated retarded facial development [6].

In the CLP group, the distance from the middle point of the nasal rim to the line connecting the medial canthi showed no significant difference from that of the CPO group. However, the distance from the alar base to the line connecting the medial canthi showed a significant difference between the two groups. The data indicated that the nasal rim on the cleft side skewed inferiorly. The CLP group showed no significant difference in nostril width of the non-cleft side from the CPO group. However, the nostril height of the CLP group was significantly less compared with the CPO group [7]. More significant differences were found between the cleft side and the non-cleft side in the CLP group. The labial height, the labial width and the distance from the alar base to the labial commissure also suggested significant differences between the CLP and CPO group. In the CLP group the upper labial area on the cleft side was 149.99±26.7 mm^2 (96.89 – 234.1 mm^2): this was significantly less than that on the other side, which was 220.14±31.03 mm^2 (153.46 – 302.14 mm^2). Compared with the CPO group, the upper labial area was significantly smaller in the CLP group. In addition, the volume of the upper lip on the cleft side was 120.51±37.74 mm^3 (72.04 – 213.66 mm^3) and was significantly different from that on the non-cleft side, which was 607.7±128.1 mm^3 (403.4 – 895.7 mm^3). The peak point of Cupid's bow on the cleft side moved more laterally, inferiorly and posteriorly than on the non-cleft side.

The width of the dental arch in the complete UCLP group was greater than in the unilateral complete cleft lip only (UCLO) group except for the distance between the most posterior points and the distance between the canines, on both sides of the dental arch. Some studies reported that the growth potential was similar between the unoperated complete UCLP patients and their normal peers. Based on our data, it seemed that the maxilla of the complete UCLP patients grew much faster within 18 months of birth than the normal group before their primary repair. However, when we measured the real palatal width by subtracting the cleft width from the total width of the dental arch (Fig. 2.2), we found that it was 33.81±5.23 mm, which was significant smaller than in the normal control group ($p=0.037<0.05$). In addition, a significant difference was also found in the distance from the most frontal point of the dental arch segment to the coronal plane between the cleft side and the non-cleft side in the anterior-posterior direction. The dental arch on the cleft side was significantly retracted posteriorly compared with the non-cleft side and the widest gap reached 10 mm [8].

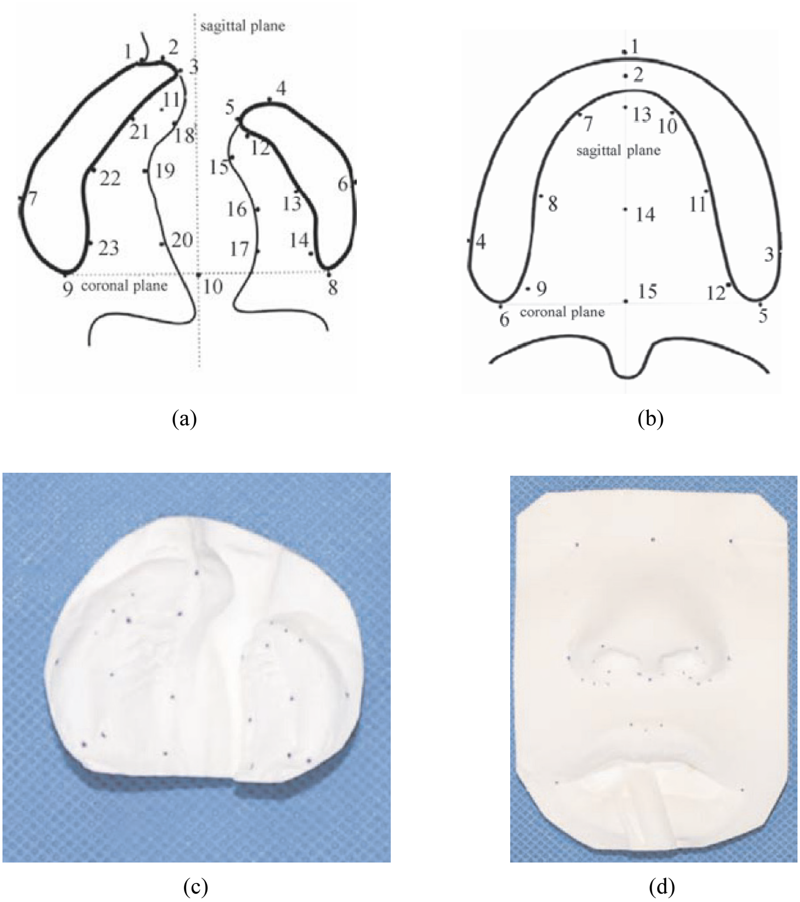

Fig. 2.2 (a) Sketch map of spotting on upper dental arch of cleft patient; (b) Sketch map of spotting on upper dental arch of normal peer; (c) Spotting on patient's maxillary model; (d) Spotting on normal peer's maxillary model

The position of the upper lip can be influenced by the position of the dental arch in the anterior-posterior direction. There appears to be a smaller distance from the peaks of Cupid bow to the coronal plane. We found that protrusion of the upper lip was significantly less in complete UCLP patients because of the underlying supporting hard tissue defect. The dental arch on the cleft side had a tendency to tilt inwardly, so the dental arches in the cleft area met together in an overlapping fashion rather than end-to-end after primary cheiloplasty. It compromised the primary cheiloplasty outcome and, at the same time, complicated secondary alveolar bone grafting. It suggested that methods preventing this inward tilting tendency before and after primary cheiloplasty, such as presurgical orthodontics, should be adopted to maintain normal maxillary width and to promote the end-to-end approximation of the dental arches.

Millard regarded the presurgical orthodontics and the lip adhesion as two important procedures before primary cheiloplasty in the cleft treatment protocol. After the presurgical orthodontics and the lip adhesion, the split lip and palate could be moved to a normal and stable position. It could provide a symmetrical bony supporting platform for primary cheiloplasty and rhinoplasty. It could even benefit later functional palatal reconstruction and reduce the occurrence of fistula on the front hard palate. However, in his opinion, there was no need for patients with a lip cleft of less than 8 mm to have any presurgical orthodontic treatments: he thought that there was no difference in the two sides of the dental arches in the anterior-posterior direction when the cleft lip gap was less than 8 mm. On the contrary, a difference did exist when the lip cleft was narrower. In our study, the difference might become more evident after primary cheiloplasty because of the constant pressure from the orbicularis oris muscle. In the complete UCLP group, there was a significant difference in the anterior-posterior position of the soft-hard palate junction on the cleft side compared with the non-cleft side. Combined with possible insufficient development of the muscles in the soft palate, speech could be affected after palatoplasty. The palatal plate inclined superiorly on both sides in complete UCLP patients and the slope was different in frontal, middle and posterior parts of the palate. There were no significant differences between both sides at the frontal and middle palate. However, a significant difference was noted between the posterior part on the cleft side and the non-cleft side – 68.32±14.65° on the cleft side and 74.2±13.6° on the other side respectively. In the control group, slopes of the frontal palate, middle palate and posterior palate were 0.27±0.18°, 29.27±5.89° and 0.26±0.23° respectively. Areas of the mucoperiosteum on the cleft side and on the non-cleft side were significantly different: areas on the cleft side and the non-cleft side were 211.27±64.27 mm^2 and 173.64±36.32 mm^2 respectively, the cleft area being 207.02±86.44 mm^2. A secure knowledge of the slope of the hard palate and the area of the mucoperiosteum can help the surgeon make proper design and correct cleft lip and palate as a whole complex.

In our study, we found that tissue defects and tissue displacement were both involved in cleft lip and palate. It suggested that both Tennison's technique based on the correction of tissue defect and Millard's technique based on the correction of tissue displacement had their own disadvantages and limitations in terms of geometrical and anatomical design. That is also why neither of the two techniques can achieve universal and consistent outcomes in all cases. Furthermore, there were intricate correlations among the measurements or parameters. For example, more than 10 parameters had some measure of correlation with the peak point on Cupid's bow. The correlations among the measurements made it extremely complex and difficult to operate on complete UCLP. When we correct the deformity in one single part, deformities in other parts may be aggravated or alleviated. Therefore, when performing the surgery, we should always keep the concept of overall treatment in mind [9, 10].

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3

Geometric Analysis of Classic Cheiloplasty

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There are several different methods of cheiloplasty and each has its individual characteristics and innovations. However, almost all the methods focus on the preservation of anatomical characteristics in the nasolabial region rather than on the geometrical principles of incisional design. When confronted with the conflicting requirements of geometric principles and traditional incisional form, the latter is always emphasized. Even when the incision is designed on the basis of geometrical principles, considering the factors influencing the rotation of the peak point on the cleft side, the surgeons always pay more attention to the length of the incision rather than the location of the key point such as the upper end of the incision. This is why only the skilled surgeons can successfully treat many different kinds of deformities, while a great number of surgeons, especially the junior clinicians, often find it hard to grasp the concept of incision design and cannot always achieve satisfying results. Some researchers think that the result of cheiloplasty is determined by the experience and skills of the surgeons rather than the chosen surgical design, because it is difficult to explain the success of cases using traditional design principles. The authors of this book believe that a successful method of cheiloplasty must conform to a design consistent with geometric principles and also one that can restore and rebuild the normal anatomical structures to the maximum extent. Only such an approach can assure that every surgeon can make the optimal design for individual patients and can always promise optimal postoperative outcomes. In order to further understand and more flexibly apply different methods of cheiloplasty, the authors specifically and thoroughly analyze the geometric principles in marking and incisional design, with the objective of instructing a new universal design of cheiloplasty [1].

3.1 Geometric Analysis of Marking in Cheiloplasty

Geometric analysis is necessary in cheiloplasty design. Sufficient descent of the peak points of Cupid's bow near the cleft edge is the most important requisite in cheiloplasty. Geometric analysis is performed using Millard's technique as an example:

Points O' and O" locate on the same vertical line and can be regarded as the center of two respective circles. Point A locates laterally and inferiorly of the vertical line (Fig. 3.1). Point A is rotated downwards with points O' and O" as the center of the rotation circle respectively, and the maximum descending distance of point A is observed. If point A is the peak of Cupid's bow near the cleft edge on the cleft side, and O' and O" are different points locating under the columellar base or under the alar base on the cleft side, the shorter the distance from point A to the center of the rotation circle in the vertical direction, the longer the distance point A will rotate downwards.

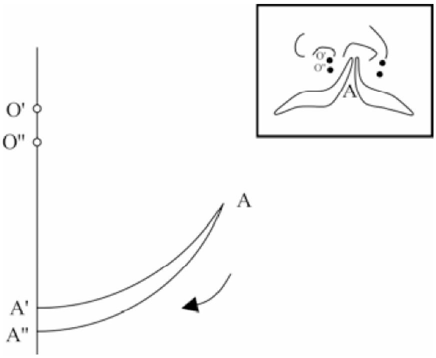

Fig. 3.1 Different rotation and descent of the peak point of Cupid's bow near the cleft edge and different marks under the columellar base in vertical direction. O', O": different points under the columellar base. A: the peak of Cupid's bow near the cleft edge. A', A": the points where point A reaches when it is rotated downward to the maximal limit with point O' and O" as the center of the rotation circle respectively

Points O' and O" locate on the same horizontal line and can be regarded as the center of two respective circles. Point A locates on the same side of points O' and O" under the horizontal line (Fig. 3.2). Point A is rotated downwards with points O' and O" as the center of the rotation circle respectively and the descending distance of point A is observed. If point A is the peak point of Cupid's bow near the cleft edge on the cleft side, points O' and O" are different points locating under the columellar base or under the alar base on the cleft side; the longer the distance from point A to the center of the rotation circle in the horizontal direction, the longer the distance point A will rotate downward.

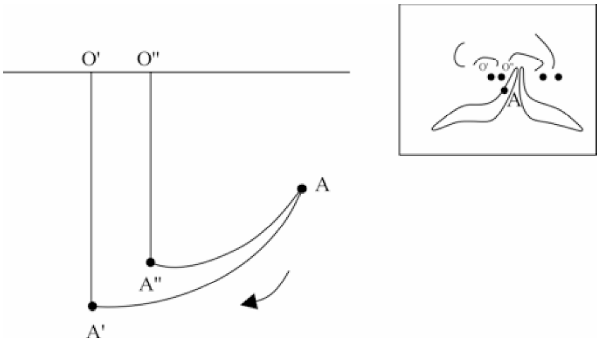

Fig. 3.2 Different rotation and descent of the peak point of Cupid's bow near the cleft edge and different marks under the columellar in horizontal direction. O', O": different points under the columellar base. A: the peak of Cupid's bow near the cleft edge. A', A": the points where point A reaches when it is rotated downward to the maximal limit with point O' and O" as the center of the rotation circle respectively

Point O is the given center of the rotation circle and point A is rotated around point O. The line (incision) connecting point A and point O is designed as different forms of a, b and c respectively. We can find that the maximum descending distance of point A is fixed (Fig. 3.3). If point A is the peak point of Cupid's bow near the cleft edge on the cleft side, and point O is the point located under the columellar or under the alar base on the cleft side, no matter what the form of the incision connecting point A and point O is, the descending distance of point A is fixed.

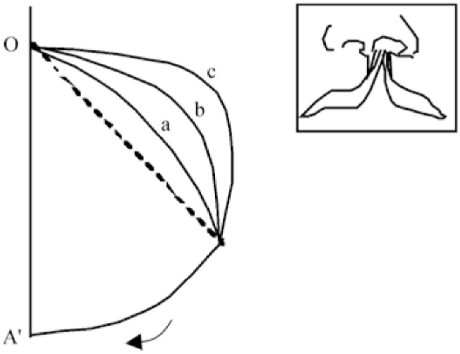

Fig. 3.3 Rotation and descent of the peak point of Cupid's bow and the incision form connecting point O and point A. O: a point under the columelar base. A: the peak of Cupid's bow near the cleft edge. A': the point where point A reaches when it is rotated downward to the maximal limit

According to the geometric analysis described above, the maximum distance that the peak point of Cupid's bow near the cleft edge on the non-cleft side could be rotated downwards is correlated with the position of the center of its rotation circle. The lower the center of the rotation circle is in the vertical direction, the longer the distance that the peak point of Cupid's bow will rotate downwards. The longer the distance from the center of the rotation circle to the peak point of Cupid's bow on the same side in the horizontal direction, the longer the distance that the peak point of Cupid's bow will rotate downwards.

In other words, the descending distance of the peak point of Cupid's bow is only determined by the location of the incision end (center of the rotation circle), and has nothing to do with the incision form [2].

3.2 Analysis of Tennison's Technique and Millard's Technique

According to Millard's design in primary unilateral cleft lip (UCL) repair, the curving incision under the columellar base on the non-cleft side is used to rotate and descend the peak point of Cupid's bow and the philtral column near the cleft edge on the non-cleft side to the normal position [3]. The origin of the incision is the peak point of Cupid's bow on the cleft side, which is definite in Millard's description. However, the end of the incision is not so precisely described. It was originally defined as the columellar base. Then it was further modified as the point locating laterally and inferiorly to the midpoint of the columellar base but medially to the normal philtral column. The end point is usually marked based on the surgeon's experience because the technical standard definition is far from clear and specific, just "cut as you go" as Millard advised in his theory. As we can see in Fig. 3.4, when the end is marked in the 3rd quadrant (in black), the peak point of Cupid's bow near the cleft edge can achieve the maximum descent because the end point locates laterally and inferiorly. Conversely, when the end is marked in the 1st quadrant (dashed), the peak point of Cupid's bow near the cleft edge cannot achieve the same descent. When the end is marked in the 2nd or the 4th quadrant (in white), the descending distance of the peak point of Cupid's bow near the cleft edge will be shorter than the former but longer than the latter.

Millard's technique has many advantages but also has some disadvantages. In order to protect the normal structures on the non-cleft side of the lip, the end of the incision is marked far from the peak point of Cupid's bow near the cleft edge on the non-cleft side in the vertical direction. It limits the descent of the peak point. In patients with incomplete unilateral cleft lip, it is easy to obtain the symmetry of the peak points of Cupid's bow on both sides. In other words, the peak point of Cupid's bow near the cleft edge on the non-cleft side can descend to the same level of the normal peak point of Cupid's bow. However, the symmetry of bilateral peak points is quite hard to restore in patients with complete UCL. Many patients with complete UCL have shorter lip height on the cleft side after Millard's cheiloplasty. It is said that Millard's technique is more suitable for patients with incomplete UCL than the patients with complete UCL. Millard modified his technique several times trying to resolve this problem. For example, he added the back-cut incision under the columellar base, which was called the "extend rotation and advancement technique" [3]. It permits more descent of the peak point of Cupid's bow near the cleft edge on the non-cleft side. Our theory can explain it as the center of the rotation circle on the non-cleft side being extended laterally and inferiorly with the back-cut (relocated in the 3rd quadrant in Fig. 3.4).

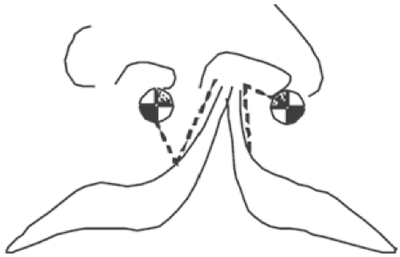

Fig. 3.4 Rotation and descent of the peak points of Cupid's bow near the cleft edge an d the marking of the points under the columellar base and the ala base on the cleft side in Millard's technique

Not only the rotation and descent of the peak point, but also the extension of the C-flap is determined by the geometry. The shorter the distance from the end of the incision to the columellar base in the vertical direction is, the longer the distance the C-flap will extend laterally. The shorter the distance from the end of the incision to the tip of the C-flap in the horizontal direction, the further the C-flap will extend laterally. This can explain the lesser tension of the upper lip after Millard's cheiloplasty.

Tennison's technique makes more use of the geometric principles described above than Millard's technique. The center of the rotation circle is located at the lowest level, and the peak points of Cupid's bow near the cleft edge can be sufficiently descended [4, 5]. The distance of the descent is determined by the location of the end of the incision. The peak points of Cupid's bow near the cleft edge can achieve the maximum descent when the end points are located in the 3rd quadrant (in black): if they are located in the 1st quadrant (Fig. 3.5), descent of the peak points will be limited.

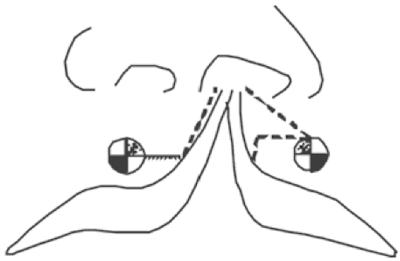

Fig. 3.5 Rotation and descent of the peak points of Cupid's bow near the cleft edge and the marking of the points under the columellar base and the ala base on the cleft side in Tennsion's technique

The shorter the distance from the incision end to the columellar base in the vertical direction, the further the C-flap will extend laterally. The shorter the distance from the incision end to the tip of the C-flap in the horizontal direction, the further the C-flap will extend laterally. This is also why the upper lip near the nasal floor is tight after Tennison's cheiloplasty. The excessive tension of the upper lip and the scar formation across the philtrum are the main disadvantages of Tennison's technique.

3.3 The Geometric Correlation between Tennison's Technique and Millard's Technique

Based on the previous analysis, the authors of this book suggest that the center of the rotation circle should be marked on the bisector of the angle formed by the peak points and the central point of Cupid's bow on the non-cleft side [6]. Based on our previous evaluation of healthy children, the middle upper lip can be simplified as a W-shape connecting the bilateral ala bases, the two peak points of Cupid's bow and the base of the columella (Fig. 3.6). The base of the columella and the two peak points of Cupid's bow form an isosceles triangle (Fig. 3.7). In unilateral cleft lip and palate patients, the isosceles triangle disappears. The restoration of the labial symmetry can be simplified as the reconstruction of the isosceles triangle.

Fig. 3.6 The corresponding relationship of the "W" shape between the non-cleft lip and the cleft lip

Fig. 3.7 The corresponding relationship of the triangle between the non-cleft lip and the cleft lip

Further research finds that the distance from one of the peak points of Cupid's bow to any point locating on the bisector of the angle mentioned above is always equal to the distance from that point to the opposite peak point of Cupid's bow. That is to say, any point located on this bisector except the crossing point with the line connecting the bilateral peaks can form an isosceles triangle with the peak points of Cupid's bow on the non-cleft side (Fig. 3.8). This bisector can also be considered as the inclined midline of the upper lip because of the cleft. When the peak point near the cleft edge is rotated downwards to the same horizontal level of the normal one, the bisector of the angle is also rotated to the middle of the upper lip. Thus, the midmost position of the isosceles triangle on the upper lip is recreated. As described above, each point on the bisector can be marked as the end of the incision used for the descent of the peak point near the cleft edge on the non-cleft side. Connect any point on the bisector with the peak point near the cleft edge on the non-cleft side, and calculate the slope between the line and the vertical reference. The higher the selected point locates on the bisector, the longer the incision is and the greater the slope. It is important to mention that the descending distance of the peak point near the cleft edge on the non-cleft side is not determined by the form of the incision connecting the peak point mentioned above and the selected point on the bisector. On the cleft side, the triangular flap becomes larger when the lateral peak point on the triangular incision moves upwards. The incision of Tennison's technique can be turned into Millard's technique as a result.

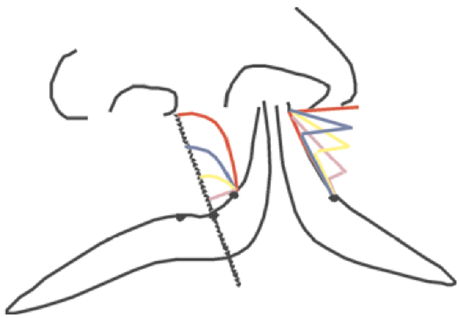

Fig. 3.8 The common geometric basis of Tennison's technique and Millard's technique. The incisions on the noncleft side with different color correspond to the triangular flaps on the opposite cleft side with the same color. The purple colored incision on the noncleft side corresponds with the smallest triangular flap on the cleft side. Similarly the red incision corresponds with the biggest triangular flap. As may be imagined, there are numerous pairs of incisions between the purple incision and the red incision with their corresponding triangular flaps. But the common ground is that the ends of all these rotation incisions on the noncleft side locate on the bisect line of the angle organized by the two peak points near cleft edge and the center point of Cupid's bow. The classic techniques of primary lip repair such as Tennison's and Millard's methods actually conform to our universal geometrical principles as two exceptions. When the end of the rotation incision exceeds or fails to reach the bisect line, the peak point of Cupid's bow on the cleft side after surgery might be higher or lower than its corresponding point on the noncleft side

This analysis reveals that Tennison's technique and Millard's technique share the same geometrical principles in rotating and descending the peak point of Cupid's bow near the cleft edge. Therefore, the reason why the lip height on the cleft side is prone to be less in Millard's technique and greater in Tennison's is clear: when the end of the incision on the non-cleft side is marked medially and superiorly to the bisector, the peak point near the cleft edge on the non-cleft side cannot achieve enough descent. Consequently, the patients, especially those with complete UCL, have lesser lip height on the cleft side after Millard's cheiloplasty. When the end of the incision on the non-cleft side is marked laterally to the bisector, the peak point near the cleft edge on the non-cleft side will achieve excessive descent. Then the patients, especially those with incomplete UCL, have greater lip height on the cleft side after Tennison's cheiloplasty. Millard's modification of the back-cut makes the end of the incision tend to locate on the bisector, according to our geometrical principles.

In a word, although Tennison's technique and Millard's technique in primary repair of unilateral cleft lip seem to be different methods with different manifestations, they share the same geometric principles.

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4

West China Technique of Unilateral Cleft Lip Repair

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The key point in primary repair of unilateral cleft lip (UCL) is to ensure sufficient downward rotation of the high points of the Cupid's bow on the cleft edges [1-3]. It may not be too difficult for experienced plastic surgeons to achieve, although for junior surgeons it is still challenging. Most of the secondary deformities that we see every day after primary cheiloplasty seem to be related to deficient or excessive descent of the high points of the Cupid's bow on the cleft edges. In order to find the universal essential surgical principles and to ensure optimal surgical outcomes for patients and surgeons, we attempted to analyse the underlying geometric theory of Millard's rotation advancement method and the Tennison-Randall's inferiorly based triangular flap technique [4].

Both downward rotation of the peak points of the Cupid's bow on the cleft edges and cleft lip nasal reconstruction are extremely important questions that need to be addressed. The rotation of the peak points of the Cupid's bow on the cleft edges is, relatively speaking, more theoretically based and has a less experiential or technical base than the cleft lip nasal reconstruction. Our surgical design and techniques are introduced in this chapter.

The West China technique, also recognized as a step-rotation-advancement method, was first introduced by the author in 1999 to repair UCL with or without cleft palate [5-10].

4.1 Reconstruction Principles

4.1.1 The Principle for Hard Palate Repair

Make incisions from the buccal sides of the alveolar processes to the end of the hard palate along both sides of the cleft. Undermine and raise the vomer mucoperiosteal flap on the non-cleft side. The flap can be used to close the clefts of the hard palate and alveolar process as well as the nasal floor on the cleft side. The aim of this procedure is to close the hard palate cleft and narrow the soft palate cleft (Fig. 4.1).

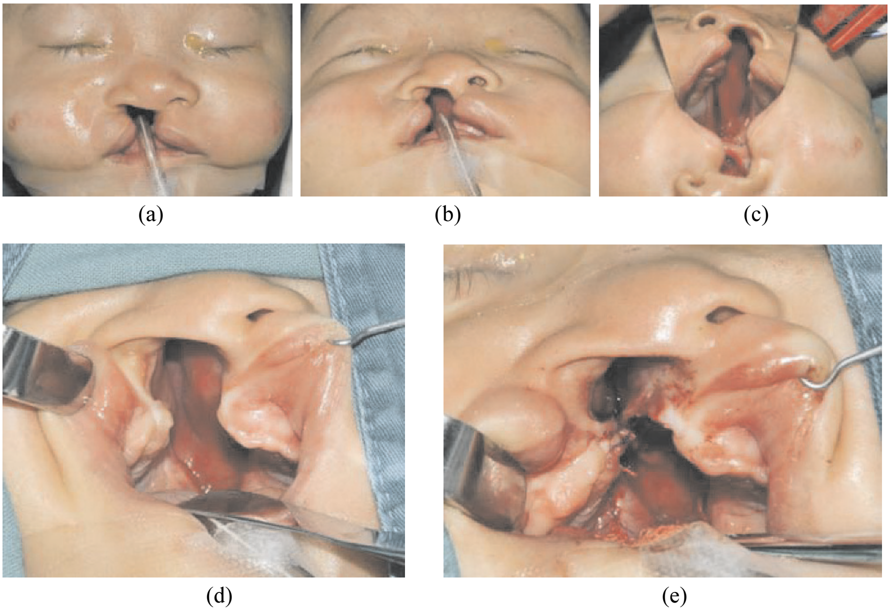

Fig. 4.1 (a) A three-month-old patient with right complete cleft lip and palate (frontal view); (b) The same patient (view from below); (c) The cleft palate of the same patient before repair; (d) The mucoperiosteum flap on the vomer bone which will be used to close the clefts of hard palate, alveolar and nasal floor; (e) Raise the vomer flap and bilateral mucoperiosteum flaps from the alveolar ridge to nasal floor on the cleft edges and suture them oppositely

4.1.2 The Principle for Nasal Deformity Correction

Perform the horizontal incision on the alar base, separate the lateral crus of the lower lateral cartilage (LLC) from the skin envelope. Dissect the maxillary periosteum and the connective tissue surrounding the apertura piriformis from the ala base on the cleft side for better repositioning of the ala. Elevation of the nasal rim, medial turning in of the alar base and extension of the columella on the cleft side are used to reconstruct a symmetrical nose. It should also include dissecting the skin and the underlying tissue from the membranous septum and nasal mid-septum cartilage which restrict the nasal apex and the columella on the cleft side from being repositioned, because only suspending the LLCs could not always solve the deviation problems. This technique can break the intrinsic bonding forces of the misplaced soft tissue and create conditions for new reconstruction of the cartilage bracket.

4.1.3 The Principle for Labial Deformity Correction

The key point is to obtain equal – lip heights between cleft and non-cleft sides based on thorough reconstruction of the orbicularis oris muscle sling. One of the objective evaluations is the position of the facial midline. The aims of this procedure are to reposition the peak points near the cleft edge, the columella and the philtrum incisure and to achieve lip height symmetry. During operation, the bisector line of the angle formed by the two peak points near the cleft edge and the center point of Cupid's bow is used as a reference of the facial midline (see Chapter 3).

4.1.4 The Principle of Overall Design

Pay close attention to achieving a harmonious relationship between the structures being corrected. The adhering relationship might influence the modality of the surrounding tissues, which should be well noticed and used.

4.2 Marking (Using a Complete Cleft Lip as an Example)

The anatomic points of the right peak of the Cupid's bow, the central point of the Cupid's bow on the non-cleft side and the ala bases are marked as points 1, 2, 6 and 7 respectively (Figs. 4.2a – 4.2e).

The distance between points 1 and 2 is measured and an equal distance from point 1 to the left peak of the Cupid's bow on the non-cleft side is marked as point 3.

The distance between points 2 and 6 is measured and an equal distance from point 7 to the peak of the Cupid's bow on the cleft side (point 4) is marked. If the distance between the peak point of the Cupid's bow and the commissure on the cleft side is too short, point 4 can be slightly adjusted medially to where the distance from point 4 to point 7 is almost equal to the distance from point 2 to point 6. According to the author's experience, the maximum difference between them should be less than 2 mm.

Theoretically, point 5 can be any point on the bisecting line of the angle 213, but we always mark the point medially to the philtral column. The key of this design is to ensure equalizing the distance from point 5 to point 2 and the distance from point 5 to point 3, i.e. the angular bisector. It also guarantees that point 3 will sufficiently rotate to the same horizontal level of point 2 (see Chapter 3).

The base of the columella (point 8): the point divides the collumella base into one-third cleft part and two-thirds non-cleft part. The horizontal location of this point is closely correlated with the shape of the postoperative sutured wound and has nothing to do with the labial peak descent. In other words, if point 8 is located partially to the non-cleft side, the suture trend will head from upper non-cleft side to lower cleft side with a considerable slope. On the contrary, the suture will be more straight-and-downwards if the point is located partially to the cleft side (Fig. 4.2a).

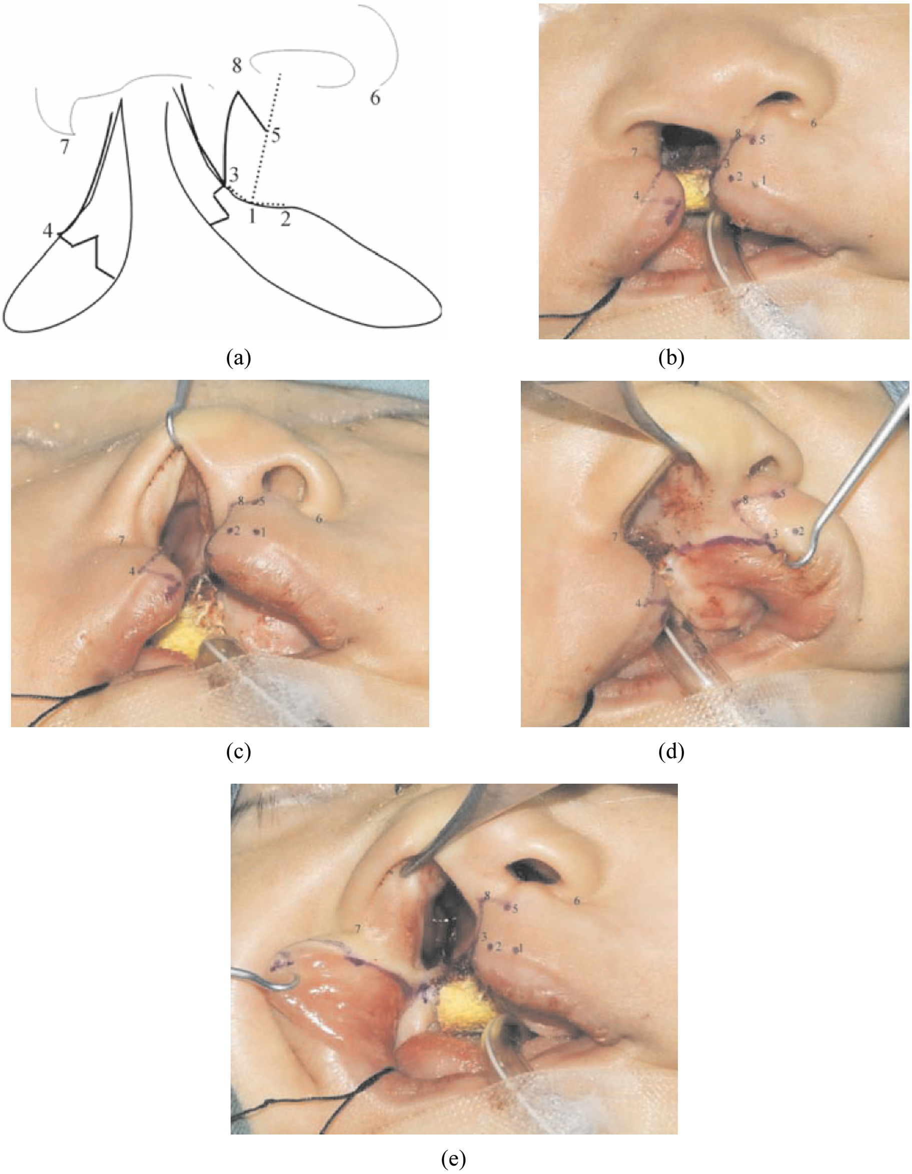

Fig. 4.2 (a) Incision design of West China technique to repair unilateral cleft lip; (b) The landmarks; (c) The landmarks, when the nostril of the cleft side is pulled cephalad; (d) The incision in the nasal vestibule on the noncleft side extends internally and connects with the incision of hard palate and alveolar; (e) The incision in the nasal vestibule on the cleft side extends internally and connects with the incision of hard palate and alveolar. To promise sufficient perimeter of the nostril after surgery, the incision on the white roll inside the nasal vestibule can be moved more internally to the mucosa side. It means that the nasal alar based flap forming the nasal floor on the cleft side would contain some mucosal tissues

4.3 Incisions

The rotation advancement incision starts from point 5 and extends superiorly towards point 8, then carries downwards to point 3. The incision on the white lip extends from point 3 superiorly along the white roll towards the nose. The incision on the cleft side starts from point 4 and extends superiorly along the white roll towards the nasal vestibule. It is not necessary to make the horizontal incision under the nasal base on the cleft edge from the beginning, because it is not the key in influencing the rotation of the peak point of the Cupid's bow on the cleft edge and can be "cut as you go" when trying to tailor the nasal bottom flap. One should be aware that the nostril will be smaller as the incision is horizontally lengthened and vertically sutured. Therefore, the rule is not to make the horizontal incision unless it is necessary. Never rely on reparative readjustment after unreasonable incision.

4.4 Surgical Manipulation

1% lidocaine with epinephrine 1∶200,000 is multipoint injected into the space between the skin and the muscle as well as the space between the mucosa and the muscle along the incision (Fig. 4.3). The injections should be located where the incisions are to be made. Minimal tissue distortion should be promised while the bleeding is diminished to the least, otherwise the swelling caused by over-injection will compromise the surgeon's judgement of the surgical outcome. Multipoint injection can be used for the hydraulic dissection.

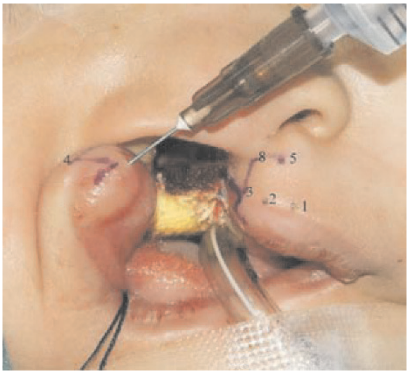

Fig. 4.3 1% lidocaine with epinephrine 1∶200,000 is multipoint injected into the space between the skin and the muscle as well as the space between the mucosa and the muscle along the incision

Cut through the skin, the underlying tissue to the superficial part of the muscle along the rotation incisions on the cleft ridges. Maintain the integrity of the muscle and mucosa. Dissect the muscle from the skin underneath the rotation advancement flap extending to the columella base on the cleft side (Fig. 4.4). The alar rim on the cleft side is raised by a hook, and then separation of the skin envelope and underlying lateral crus of the lower lateral cartilage is performed. A pair of blunt-nosed tenotomy scissors is inserted into the space between the LLCs and the overlying skin to loosen the abnormal tight attachment and to reposition the LCC (Figs. 4.5 – 4.6). Cut from point 3 to the free end of the dry lip over the white roll. The muscle is sharply dissected free from both skin and mucosa for a distance of 3 to 4 mm. The main point of the subcutaneous dissection is to maintain the integrity of the orbicularis oris muscles. These should be dissected from the maxilla underneath the nasal bases to the free edge of the vermilion and be completely separated from the surrounding tissues. The extent of dissection required is determined by easy closure of the cleft, and excessive dissection is undesirable. Only proper dissection and sufficient release of the underlying tension can ensure the appropriate appearance of the superficial anatomic features such as the philtrum fossa and the lip-columella junction after skin suture.

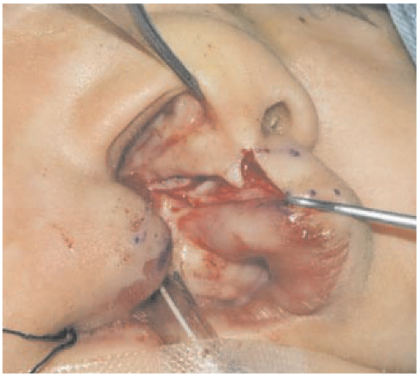

Fig. 4.4 Cut along the white roll on the cleft edges, sharply dissect the orbicularis muscle from the skin and the mucosal layer. Hold the lip gently with thumb and index finger when dissection, it helps to control the scope of dissection and also to stop bleeding

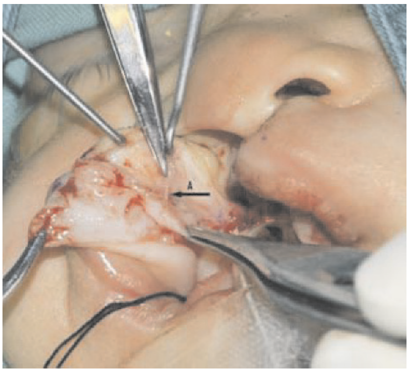

Fig. 4.5 Dissect the orbicularis muscle from its surrounding skin and mucosa till exposing the nasal alar branch of upper labial artery. If the cleft is quite wide, the artery can be dissociated and we can cut off the attachment tissues between the muscle and the nasal floor and apertura piriformis on the cleft side

Fig. 4.6 Separate the nasal alar cartilage from the skin with scissors along the alar based incision to the tip. Carefully release the nasal alar from apertura piriformis under the mucosal layer

According to the presurgical geometric design, a horizontal cut should be made where the muscles attach to the columella base to rotate the displaced muscle into a normal position. In order to achieve sufficient descent of point 3, the end of the horizontal cut can extend underneath the bisector line of angle 213. However, before that incision is made, we suggest that the surgeon release the orbicularis muscles attached to the anterior nasal spine from the underlying periosteum and surrounding soft tissues as much as possible and lengthen the muscles as much as possible (Fig. 4.7). The horizontal incision on the anterior nasal spine attachment should not be made unless the release described previously cannot produce sufficient rotation of the high points of the Cupid's bow on the cleft edges. It helps the muscles on the cleft edges to rotate downwards just as the superficial skin does. At the same time, separate the septum cartilage from the superficial skin layer with scissors from the inner crus on the cleft edge to the nasal tip and make sure that the inner crus can be lifted up along with the raising of the nasal skin layer after dissection (Fig. 4.8).

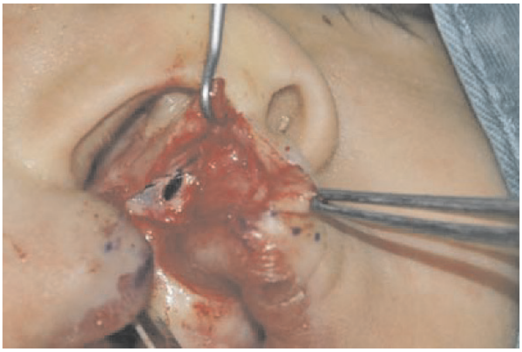

Fig. 4.7 Cut off the attachment between the orbicularis muscle and the frontal surface of maxilla in front of anterior nasal ridge, sufficiently rotate the peak of the Cupid's bow on the cleft edges downward without destroying the septum-premaxilla ligament as far as possible

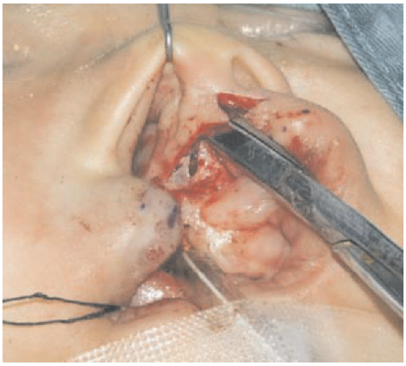

Fig. 4.8 Dissect and raise the inner crus on the cleft side to nasal tip along the surface of septum cartilage using scissors

If the underlying oral mucosa under point 3 limits the inferior rotation of point 3, a horizontal mucosal incision can be made from point 3 to the bisector line of angle 213. Commonly, when the orbicularis oris muscle is dissected free from the mucosa to the labial frenulum region, the incision from point 3 to the bisector line could be shortened, or we can make the incision when it is necessary after suturing the muscle and skin given the greater mobility and flexibility of the oral mucosa.

The incision is made from point 4 to the nasal vestibule along the white roll on the cleft side, and the end of this incision goes as far as the buccal side of the alveolar crest. Meanwhile, a mucosal incision is performed from point 4 to the free end of the vermilion. The incision is vertical to the white roll. The vertical incision along the cleft edge on the cleft side should connect with the incision along the hard palate cleft. The incision can be curved laterally when it extends to the alveolar ridge. It can increase the widths of the mucosal flaps enclosing the nasal floor. Thus, the inner diameter is large enough to avoid breathing difficulties (Fig. 4.9). Therefore, we abandoned those complex surgical procedures to reconstruct nasal floor and enlarge the nares.

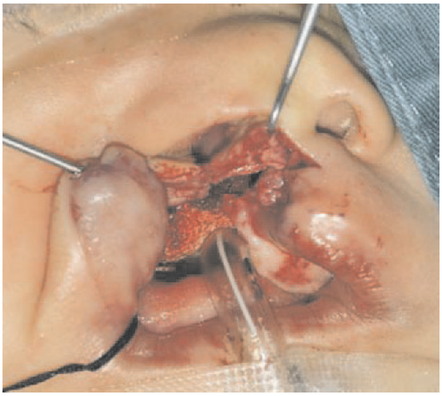

Fig. 4.9 Suture the mucosa flaps connecting with the vomer flaps and form the nasal floor before suture the muscles

The orbicularis oris muscle is dissected free from both skin and mucosa along the incisions described above. The extent of dissection should meet the request that the end of the muscle could be sutured to the anterior nasal spine. The branch of the facial artery is usually encountered on dissecting the region outside the alar base. This artery can be freed when muscle dissection is performed. The skin should be prevented from being perforated. Though exposure and dissection of the nasal ala branches of the facial artery is not imperative, it is necessary to operate carefully during muscular dissection and reduce tissue trauma.

4.5 Suturing

The vomer mucoperiosteum flap is sutured to the mucosal flap of the oral vestibule to form the roof of the intact oral vestibule. Meanwhile, the vomer flap is sutured to the flap of the nasal vestibule to form the floor of the intact nasal vestibule (Fig. 4.10).

Fig. 4.10 Suture from the most inner part to outer side and form the floor of nasal vestibule

The orbicularis oris muscles are freed from their abnormal attachment on the maxillae and rotated medially and inferiorly. This is helpful for increasing lip height on the cleft side (Fig. 4.11). The real length of the orbicularis muscles on the cleft side is greater than marked on the superficial skin because it includes the fibers attached to the piriform aperture and the alar bases. It should be noted in incomplete cleft lip repair that the excessive lengthening of the orbicularis muscle on the cleft side might cause over-prolongation of the upper lip on the cleft side after end-to-end suture of the orbicularis muscle. It can be prevented if the surgeon takes a hitch on the topmost edge of the orbicularis muscle on the cleft side, surveys it by eye and decides the optimal muscular suture position to make sure that the heights of the labial peaks on both sides are equal before suturing the muscles.

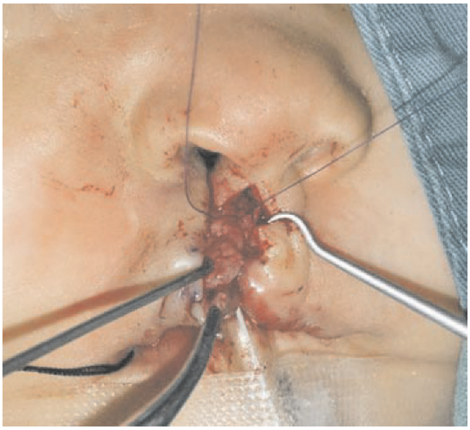

Fig. 4.11 According to Noordhoff, mattress-suture makes the margin of orbicularis muscle on the cleft side lap over the margin of orbicularis muscle on the noncleft side and this can simulate the shape of philtrum column on the cleft side

With above procedures, in most patients, point 3 and point 4 can be rotated downwards to the same horizontal level of point 2. Then, the first absorbable suture is placed in the margin of the orbicularis oris muscles, opposite points 3 and point 4. A second absorbable suture is used to draw together the subcutaneous tissue underneath points 3 and 4. The skin is closed using a 7-0 absorbable suture. The first suture in the skin approximates point 3 and point 4. The nasal rim is elevated by a hook when this suturing is performed. Then, several sutures are placed along the cleft edge of the muscles, the horizontal mattress suture can create a philtral column on the cleft side by overlapping the two margins of the muscles, and it seems natural to have a philtral ridge on the cleft side [11]. The author had tried to connect bilateral ends of the muscle directly with mattress suture at the columella base. Though acceptable forms of the philtral column and the philtral fossa might be created with this kind of suture, the philtral fossa may deviate to the cleft side as an entity while the columella base may deviate to the noncleft side in some cases. The ideal relative movement of the upper and lower parts of the upper lip should be, the columella base approach further than the alar base on the cleft side at the columella level while the muscle on the noncleft side approach laterally further than that on the cleft side at the vermilion margin level. The author is trying to suture the most upper medial corner of the muscle on the cleft side to the lower end of septum at the frontal nasal ridge with unabsorbable suturing. The traction of the orbicularis muscle help to correct the noncleft-side deviation of the columella base and also to make the muscle on the cleft side to move further to the noncleft side. The other technique to correct the columella deviation is to suture the underneath of the subcutaneous tissues under bilateral columella bases. Finally, skin and subcutaneous tissue are sutured from point 3/4 to the columella base.

The columella-based skin flap moves upwards and fills the defect formed after the inferior rotation of the skin flap on the non-cleft side. The lateral edge of the flap is sutured to the edge of the nasal vestibule skin flap on the cleft side to form the nasal floor. The incision should end at the lower part of the membranous septum. Excessive extension to the nasal tip might make the flap a columella-based slender flap on account of its usually poor healing. The incision can create better foundation for latter prolongation of the columella for its releasing the connection between the columellar skin on the cleft side and the upper lip, separating the medial crus attached with the flap and enabling the medial crus rising up to the nasal tip direction. The theoretical element is that the columella is lengthened with the tissue of the nasal apex, not the upper lip. When reconstructing the nasal floor, a horizontal incision can be made between the alar base and upper lip on the cleft side if the nostril on the cleft side is significantly larger than that on the non-cleft side. Then, the alar-based flap above the incision is rectangularly turned over and vertically sutured to the columella skin flap after trimming the superficial skin on the flap. This procedure can not only turn the alar base inwards on the cleft side, but it also hides the horizontal incision. However, this method increases the possibility of forming an excessively narrowed nostril, which is a severe secondary deformity difficult to correct and should be strictly avoided.

The shape of the vermilion mucosal flap is always difficult to decide at the beginning of the operation. It cannot be designed till the muscle is sutured and point 3 and point 4 are also sutured. The key to designing and suturing the vermilion flap is to maintain the continuity of the bilateral dry mucosa [12]. Multiple small triangular flaps can be used to shape the vermilion. Most of the time, the mucosal flaps cross at the lower two-third part of the vermilion in the vertical direction. The application of several triangular flaps can be extended into the oral vestibule cavity, so we tend to suture the vestibular layer as a last step in surgery. Sometimes, the plastic surgeon does not make as much effort to repair the vermilion as the white lip, while the parents of cleft patients always care about the shape of the vermilion edge. Hence, surgeons still ought to do their best to repair the vermilion. We repeatedly compared the outcome of two or three smaller Z-flaps. The latter design resulted in a better form of vermilion in the long-term after surgery. When the Z-plasty is performed, the triangular flap should be tailored with scissors to head upwards obliquely rather than downwards obliquely.

Three sutures are essential in nostril formation. First, punch a hole with a 5# needle from the chondroperiosteum of the upper lateral cartilage (ULC) on the non-cleft side toward the LLC on the cleft side: a 5-0 PDS II is threaded through the needle from the ala rim to the ULC, and the needle is then withdrawn under the skin. The needle is inserted again in the opposite direction, from medial to lateral, to the LLC on the cleft side and also perforates the chondroperiosteum of the ULC. Thus, the PDS II suture surrounds the inferior and lateral walls of the LLC. The LLC is rotated inwards and superiorly when we knot under it (Fig. 4.12). The second suture is passed from one side of the septum and back through the other side. This suture can elongate the columella (Fig. 4.13). The last suture is passed from the vestibular lining of the lateral rim and back through the skin in the alar groove [13, 14]. This suture can help form a visually pleasing alar groove and reduces the dead space between the mucosa and the skin caused by the dissection of the LLC (Fig. 4.14). Primary rhinoplasty should be performed on the basis of thorough dissection and dissociation of the alar cartilage-lining complex, including the nasal crus component and the nasal floor tissues. Fully separate the complex from the maxillary bone, the margin of the piriform foramen, the nasal septum and the dermal skin envelope. An absorbable suture, such as PDS II, is used to maintain long-term fixation. A thorough understanding of this theoretical refinement will help surgeons improve surgical methods and outcome [15].

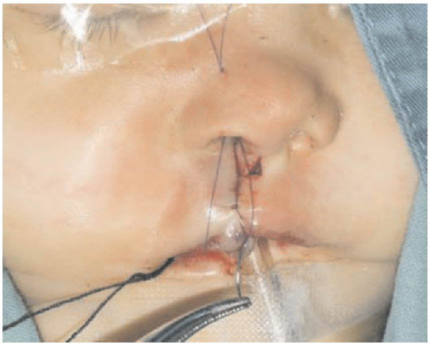

Fig. 4.12 Suspend the inferior lateral cartilage on the superior lateral cartilage using PDS II suture

Fig. 4.13 Horizontal mattress suture bilateral alar domes and use the tissue of nasal tip to lengthen the columella

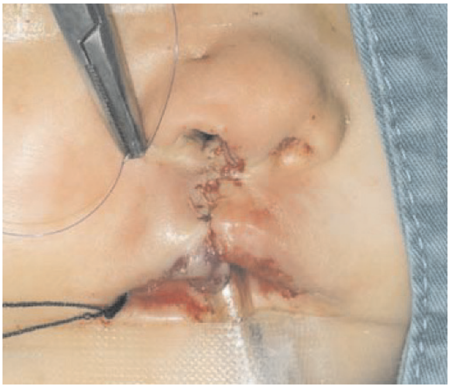

Fig. 4.14 Transfixion suture the nasal alar base with 5-0 PDS and moulding its shape

The skin wound is closed with absorbable sutures to enhance patient comfort, and the postsurgical appearance proves to be satisfying (Figs. 4.15 – 4.16). The immediate outcome after surgery or even after a short period of time cannot be regarded as the only evidence for evaluation of the surgical results. Neither could the immediate outcome of cleft lip repair be assessed in the way one assesses cosmetic surgery. Because the cleft lip is repaired at an early stage of development, the surgical reconstruction is only to assist or correct the growth direction of the malpositioned upper lip: therefore, the final result should not be judged until growth is complete. As a result, the proper design and operation of cleft lip repair should be beneficial to the potential normal growth of maxillary complex, meet future expectation and leave some leeway for secondary revision. For example, the nostril on the cleft side should be large rather than small, the incisions rather less than more (on condition that the peak points of the Cupid's bow are properly downwardly rotated), the peak point of the Cupid's bow on the cleft side higher rather than lower, the scar minimal, the orbicularis oris muscles perfectly protected, and the cleft alveolar and palate satisfactorily sealed with soft tissues. It is essential for the surgeon to explain to the parents who are looking for instant results the rationality of thinking in the long-term.

(a) (b) (c)

Fig. 4.15 (a) Sutured wound after surgery; (b) Frontal view after suture; (c) View from below after suture

Fig. 4.16 5 days later after surgery

For examples of cases repaired with this method, see Fig. 4.17.

(a) (b)

(1)

(a) (b) (c)

(2)

(a) (b)

(3)


(a)


(b)

(4)


(a)


(b)

(5)


(a)


(b)

(6)

(a)

(b)

(7)

(a)

(b)

(8)

(a)

(b)

(c)

(9)

(a) (b) (c)

(10)

(a) (b)

(11)

(a) (b)

(12)

(a) (b)

(13)

(a) (b)

(14)

(a) (b) (c) (d)

(15)

(a) (b)

(16)

(a) (b)

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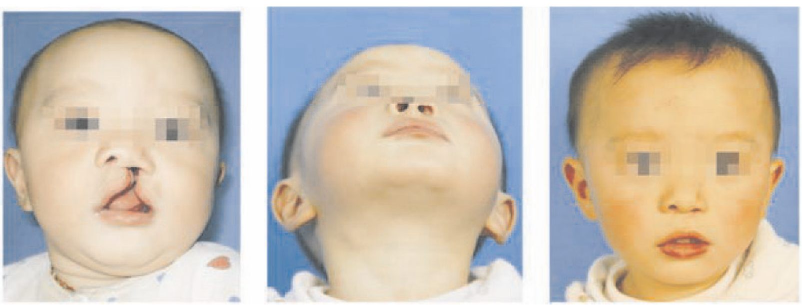
(a) (b)

(21)



(a) (b) (c)

(22)

(a) (b) (c)

(23)

(a) (b)

(24)

(a) (b) (c)

(25)

(a) (b) (c)

(26)

Fig. 4.17 Some cases before and after surgery

4.6 Basic Theory of the Technique

Principle of angle bisector line: Based on a normal population, one can envisage a "W" formed by five points: bi-ala bases, bi-peaks of Cupid's bow and the columella base. The columella base and the bi-peaks of Cupid's bow form an isosceles triangle (see Chapter 3). In complete unilateral cleft lip and palate (UCLP) patients, the integrity of the "W" is disrupted and the isosceles triangle disappears. Therefore, if the surgical intention is to make the distances from the bilateral ala to its homolateral peak of Cupid's bow equal, our target for surgery can be simplified to guaranteeing that the distances from the end of the rotate incision to the bilateral peaks of Cupid's bow are the same. Having observed numerous complete UCLP patients, we discovered that a point on the bisector of the angle 213 and point 2 and point 3 form another isosceles triangle. Therefore, the bisector of the angle 213 can be considered as the declining midline of the upper lip in cleft patients. When point 3 is rotated downwards to the same horizontal level of point 2, the bisector of the angle 213 is rotated to the middle of the upper lip. Then, the midmost position of the isosceles triangle of the upper lip is recovered [9, 10] (Fig. 4.2a). The peak of Cupid's bow on the cleft side is designed in this kind of marking technique when both the distance from the ala to the peak of Cupid's bow and the distance from the columella base to the peak of Cupid's bow are equal to the distances on the opposite non-cleft side respectively. It ensures after surgery the same labial height on the cleft side as on the non-cleft side in quite a different way from other methods, in which bilateral incisions on the cleft edges are designed to be of the same length.

Another geometric principle in this technique is that no matter what the shape of the incision between point 3 and point 5, the distance of descent is fixed if the points are unchanged. Therefore, the shape of the line between point 3 and point 5 is dependent on the deficiency and maldisposition of tissue. We design the line as a Mohler's-style incision because it makes the postoperative incision scar straighter and more like the normal philtral column. It can reduce the oblique scar of the upper lip on the cleft side, which is less pleasing than the straight scar [9].

In this technique, the peak of Cupid's bow on the cleft side is determined by the lip height on the non-cleft side rather than the lip width [16, 17]; this keeps the symmetry of lip height on both sides throughout the primary lip repair. The upper lip develops quickly in the horizontal direction compared with the vertical. Consequently, there is a stronger growth potential in the horizontal direction after primary cheiloplasty. The asymmetry of lip width between cleft and non-cleft sides may be gradually eliminated postoperatively. However, the asymmetry of lip height is difficult to eliminate. In patients with lesser lip height on the cleft side after primary operation, we usually sacrifice the lip width to offset the lesser lip height in the secondary operation. Therefore, it is important to keep the symmetry of lip height on both sides throughout the primary lip repair.

The theory of step-rotation-drop. Dissecting the skin, muscle and mucosa along different incisions is advocated in this technique. The incision on the skin forms the columella-based flap, which is used to fill the defect left by the rotation and descent of the non-cleft upper lip and to form the columella base and nasal floor on the cleft side, but not to elongate the columella. The incision on the muscle is the line which the dislocated muscle attaches to. The medial incision under the columella separates the dislocated muscle from the anterior nasal spine and the end of this incision just locates on the angular bisector. The incision on the mucosa horizontally goes through point 3 and terminates on the angular bisector. On the basis of this procedure, the descent levels of the skin, the muscle and the mucosa are all similar (Fig. 4.18).

Envelope dissection of the orbicularis oris from the skin and mucosa. The orbicularis oris muscle is important in maintaining the shape and function of the upper labium: reconstruction of the orbicularis oris muscle is a key factor in this procedure. Some earlier functional cheiloplasty paid too much attention to elaborate dissection and cross contraposition of the orbicularis oris muscle. In these techniques, the medial and lateral orbicularis oris muscles were dissected completely and elaborately sutured bundle to bundle. The main disadvantage of this complete muscle dissection is the formation of noticeable scars. Moreover, dissection of the orbicularis oris muscle in the vermilion is ignored. In our technique, the extent of dissection is from the columella base and the apertura piriformis on the cleft side to the vermilion. Therefore, the tension of the upper lip is minimized and the scar inconspicuous. The philtrum can be satisfactorily extruded when the orbicularis oris muscles are sutured overlapping, with the cleft end on the top and the non-cleft end underneath. Another important factor contributing the optimal movement of upper labial tissue is properly suturing the key points on the flaps. Ideal movements of bilateral upper lips should be: 1) the upper part closing to the nasal floor on the non-cleft side moves more medially than that of the cleft side; 2) the lower part closing to the labial peak on the cleft side moves more medially than that of the non-cleft side. To achieve these outcomes, the upper end of the muscle on the cleft side should be sutured to the anterior nasal spine or the lower end of nasal septum on the non-cleft side. The anterior nasal spine acts as the pivot and the orbicularis oris muscle on the cleft side is pulled to the non-cleft side. Meanwhile, the counterforce of the muscle will eventually retract the lower part of nasal septum to the cleft side and correct its deviation to the non-cleft side (Fig. 4.19). After locating the muscles on the cleft side, rotate the orbicularis oris muscle on the non-cleft side posteriorly and "side to side" suture it with the muscle on the cleft side. This will lay the foundations for a well-formed philtrum ridge.

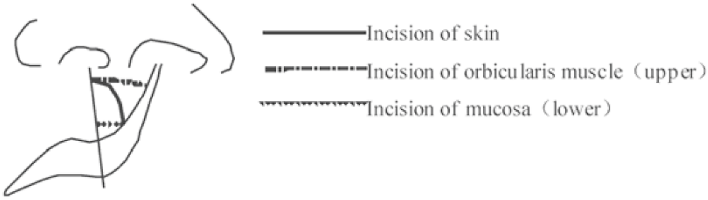


Fig. 4.18 Though the forms of the incisions on the skin, muscle and oral mucosa of the noncleft side are very different, the ends of these incisions are all located on the bisect line of the angle organized by the two peak points near cleft edge and the center point of Cupid's bow. Therefore different layer of tissue can be rotated with the same extent. The method is called step-rotation-advancement technique as the tissues are stepped downward rotated

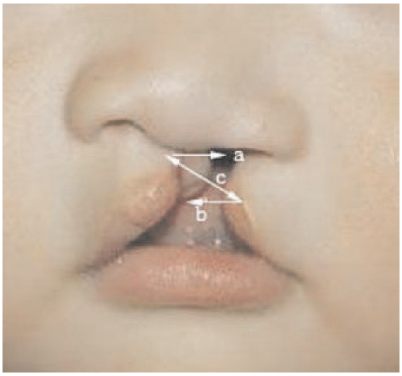


Fig.4.19 Arrow *a* is the moving direction of the upper labial tissue closing to the nasal floor; Arrow *b* is the moving direction of the upper labial tissue closing to the labial peaks; Arrow *c* is the functional vector of the orbicularis oris muscle on the cleft side after suturing with the anterior nasal spine or with the lower part of the nasal septum

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5

Sommerlad's Technique of Unilateral Cleft Lip Repair

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5.1 Introduction

Unilateral cleft lip repair is a surgical procedure that requires profound understanding of restorative theories and mastery of delicate techniques which requires long-term learning [1-6]. The basic principles are relatively easy to learn but the surgical results are not always predictable because of variation in deformity and individual differences in patient healing. The surgeon needs to be flexible in modifying the technique for individual variations. In this chapter, we will introduce a modified surgical technique based on the work of many, and summarized from our own long-term clinical experience.

5.2 Patient

The typical patient here is a 3-month old baby who had a complete unilateral cleft lip and palate, including cleft alveolus on the right side. Typical cleft patient features were present [7]: the alar cartilage of the nose is distorted and the alar base displaced downwards and backwards, the columella and septal cartilage is deviated to the non-cleft side and the philtrum is deformed (Fig. 5.1).

The lip cleft is fairly wide, with an even wider cleft of the alveolus. The upper arch is in two parts: the lateral, lesser (or minor) segment and the outwardly rotated medial, greater (or major) segment. The deformity of the lip and nose includes lateral displacement and flattening of the alae, distortion of the white roll, absence of the philtral ridge, muscle bunching on the cleft side and deviation of the nasal septum and columella (Fig. 5.2).

Fig. 5.1 The 3-month old baby with a complete unilateral cleft lip and palate

Fig. 5.2 A closer view

From a lower angle one can see that the nostrils are not symmetrical, that the cleft nostril is collapsed with a posteriorly displaced alar base. The base of the columella, together with the premaxilla, is deviated to the cleft side, making the cleft even wider (Fig. 5.3).

Inside the mouth, the lower part of the vomer is almost horizontal and its lower edge joins the palate on the non-cleft side. The horizontal component of the vomer is wide and its mucosa is available to be turned over to the cleft side for single layer repair of the hard palate cleft during primary cheiloplasty [8]. The palatal cleft is wide and the inferior turbinate hypertrophic (Fig. 5.4).

Fig. 5.3 Worms eye view

Fig. 5.4 Inside the mouth

5.3 Design

A modified rotation-advancement technique is adopted [9]. The peaks of the Cupid's bow and its midline are marked and the length of the curved medial incision is planned to produce a length equal to the non-cleft side. A small incision is made at the vermilion margin to accept a small triangular flap from the lateral segment. On the lateral (cleft) side, the point at the Cupid's bow is planned to achieve a length which is equal to the length of the non-cleft side. A small inferior triangular flap is planned and a short transverse incision at the alar base is performed (to accept a C-flap from the medial component of the lip for nostril sill reconstruction) [10] (Fig. 5.5).

On the medial (greater segment) side, the incision is designed at the junction between the pale palatal mucosa and the pinker vomerine mucosa [11]. Posteriorly, the incision extends down the crest of the vomer and anteriorly around the premaxilla on the oral side to the groove between the premaxilla and the vomer. At the skull base, a short lateral releasing incision is made to allow better mobility of the vomerine flap. On the lateral (lesser segment) side, the incision is at the junction of the oral and nasal mucosa at the margin of the cleft, and anteriorly extends just beneath the alveolus [12] (Fig. 5.6).

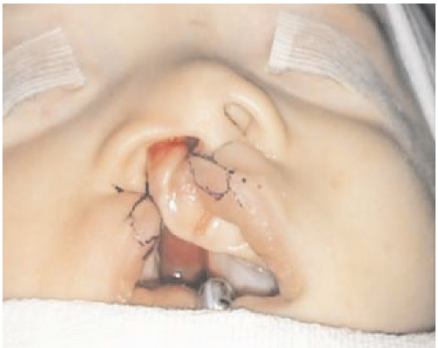

Fig. 5.5 Design of the lip incision

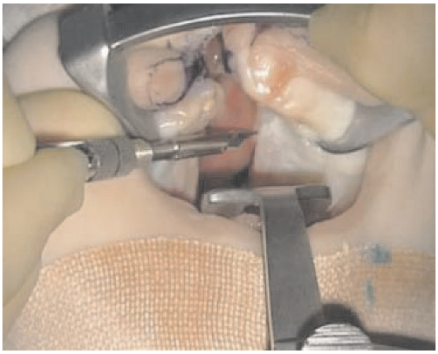

Fig. 5.6 The design of the incision for the vomer flap

5.4 Prolabium Incision

The 1 – 2 mm incision at the vermilion margin is at 90° to the vermilion margin. It breaks the straight line scar and gives a little extra length when the small triangular flap from the lateral lip is inserted (Figs. 5.7 – 5.9).


Fig. 5.7 The initial incision on the medial side

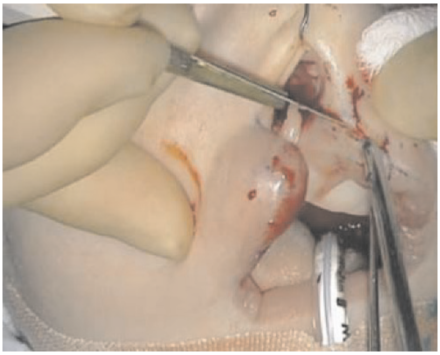
Fig. 5.8 The further incision on the medial side

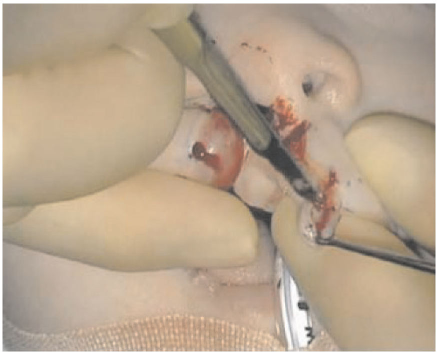
Fig. 5.9 Excess mucosa is excised

5.5 Lateral Incision

On the lateral (cleft) side, the small triangular flap [13] is defined to inset into the releasing incision made medially. This flap will: 1) help to drop the peak of the Cupid's bow; 2) help define the white roll; and 3) break the straight line scar (Figs. 5.10 – 5.11).

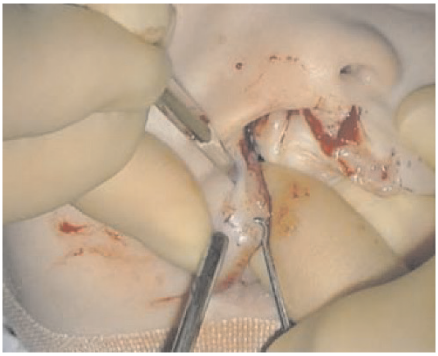
Fig. 5.10 Incision on the lateral side

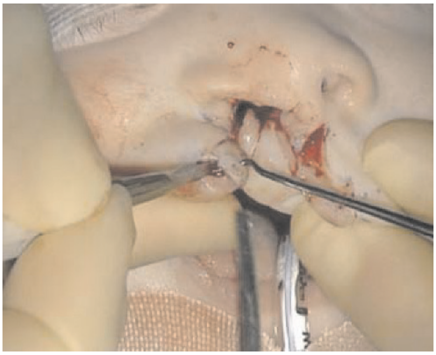
Fig. 5.11 Excision of mucosa

Medially, the incision at the lateral margin of the skin incision extends back on the oral side of the groove between the premaxilla and vomer to join the incision made from inside the mouth. Laterally, an incision is made through the mucosa and periosteum above the sulcus for a distance of about 15 mm and this incision extends around the piriform aperture, taking care not to damage tooth buds. This incision still should not damage the attached gingiva (Figs. 5.12 – 5.13).

Fig. 5.12 Deep extension of incisions

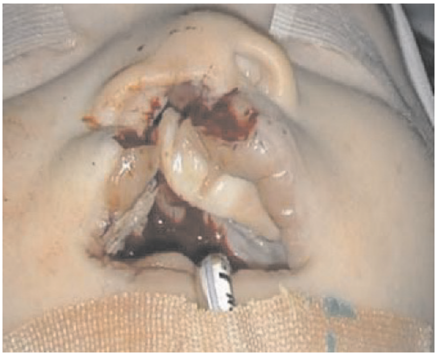

Fig. 5.13 Completion of the incisions

5.6 Vomerine Flap

The gag is replaced when lip incision is finished. In this case, the palatal cleft is moderately wide and the inferior part of the vomer is almost horizontal (Fig. 5.14).

The vomerine flap [14] is then raised in a subperiosteal plane, extending sub-perichondrially anteriorly. The most difficult part of the procedure is to lift the mucosa out of the groove at the junction of the premaxilla and the vomer (Fig. 5.15).

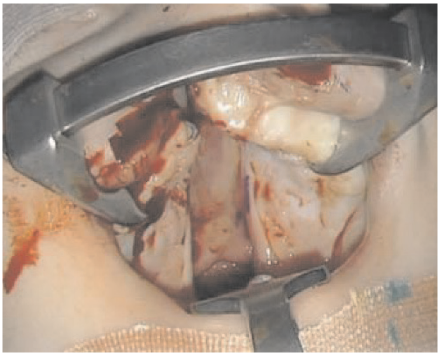

Fig. 5.14 Raising the vomerine flap

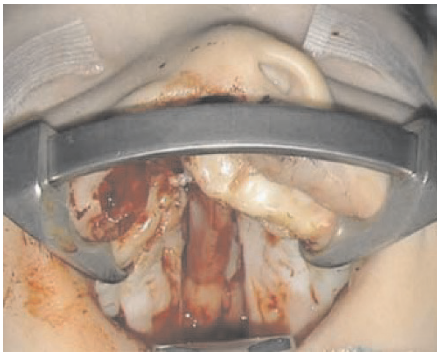

Fig. 5.15 On the non-cleft side

Using a 69 Beaver blade, an incision is made at the junction of the oral and nasal mucosa on the cleft segment. In this way, all of the oral mucosa is preserved. Mucoperiosteum is elevated for 3 – 5 mm using a dental scaler to allow interdigitation of the vomerine flap for a double-layer closure. The most difficult aspect of elevating the oral mucoperiosteum is to avoid damage to the oral mucosa at a point where there is often a groove in the hard palate about 3 – 5 mm lateral to the cleft margin (Fig. 5.16).

There is a significant antero-posterior discrepancy in this case, where the alar base is posteriorly positioned. To elevate this, the lateral nasal wall and nasal floor are divided in a vertical direction at a point about 10 mm or more behind the piriform aperture. If necessary, the inferior turbinate could also be divided by making the incision more anteriorly ending near the piriform aperture. This allows the alar base to be lifted forwards to a point where the lateral nasal wall will be in line with the alveolus (Fig. 5.17).

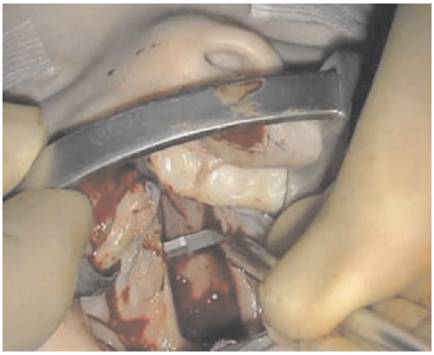

Fig. 5.16 On the cleft side

Fig. 5.17 Release of the lateral nasal wall

The periosteum of the anterior maxilla is then elevated through the incision already made in the sulcus, with care not to damage tooth buds, as the bone is often very thin in this area. Near the piriform aperture the bone is thicker. Medially, this release reaches the piriform aperture.

Having exposed the infraorbital nerve, an incision is then made in the periosteum, vertically starting from the lateral end of the release and going horizontally just beneath the level of the infraorbital nerve, taking care not to damage the infraorbital nerve, and extending medially to the piriform aperture (Fig. 5.18).

A horizontal mattress suture is used to close the hard palate. The suture passes through the oral side of the lateral segment, then through the periosteal side of the vomerine flap, back out from the mucosal side of the vomer and then back out from the deep layer of the oral layer, so that the vomerine flap is interdigitated under the oral mucoperiosteum (Fig. 5.19).

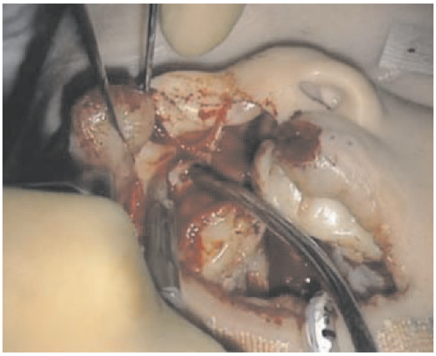

Fig. 5.18 Elevation of the mucoperiosteum from the anterior maxilla

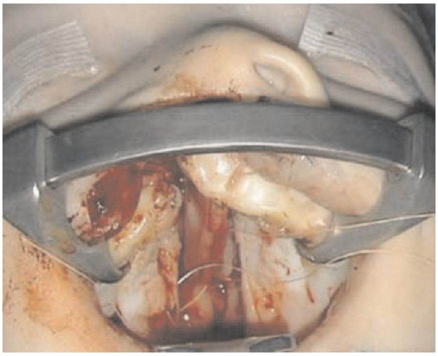

Fig. 5.19 Suturing the vomerine flap beneath the oral mucoperiosteum

Three or four 5-0 vicryl sutures are usually inserted, which are not tied until all have been placed. Sometimes, two or three small interrupted sutures (using a fine absorbable suture such as 6-0 PDS) are inserted from the edges of the oral mucoperiosteum to the periosteum of the vomerine flap to increase the surface area of contact between the two (Fig. 5.20).

Anteriorly, the vomerine flap becomes continuous with the lateral skin incision, and the mucoperiochondrium of the nasal septum is elevated (Fig. 5.21).

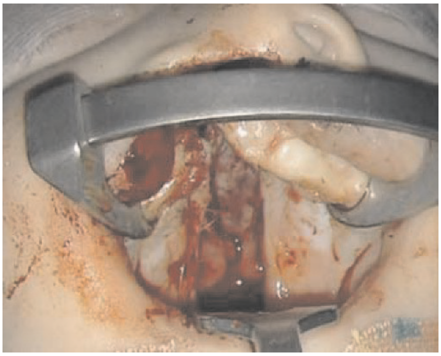

Fig. 5.20 Completing suture of the vomerine flap

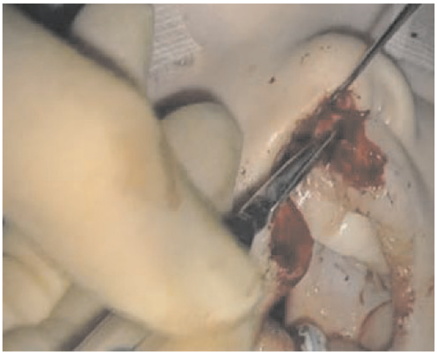

Fig. 5.21 Dissection of the mucoperichondrium of the nasal septum

5.7 Dissection of Lip

The muscle dissection is very important [15, 16]. The dissection is carried out with a new No. 15 blade – first between skin and muscle and then between muscle and mucous glands on the oral side. Inferiorly, the muscle passing very close to the mucosa should be freed, leaving a very thin layer of mucosa at the vermilion margin. The muscle is then divided superiorly and rotated downwards (Fig. 5.22).

The nose can be seen as a three-layered structure, with thin mucosa closely attached to the alar cartilage, and a much thicker skin and subcutaneous layer. The dissection begins medially, passing between the two medial crura of the alae and then between the skin and the alar cartilage, and extending up on to the bridge of the nose. This allows the alar cartilage to be adjusted in a position similar to the non-cleft alae [17] (Fig. 5.23).

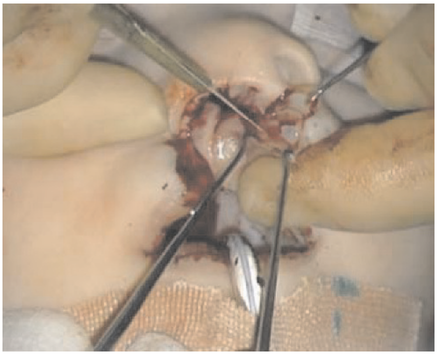

Fig. 5.22 Muscle dissection

Fig. 5.23 The medial nasal dissection

It needs to be confirmed that adequate length has been achieved. If it is too short, the medial side could be lengthened by extending the incision medially (but not beyond the column of the philtrum on the normal side) [18]. On the lateral side it can be lengthened by moving the point of the incision on the vermilion margin further laterally (Fig. 5.24).

In this case, the incision in the small triangular flap is moved a little further laterally for length (Fig. 5.25).

Fig. 5.24 Evaluation of lip length

Fig. 5.25 Adjustment of lateral length

Again, the dissection of the muscle is made by scalpel, with dissection of the skin from the muscle in a clearly defined plane leaving a little white tissue on the muscle and passing closer to the surface inferiorly at the triangular flap, vermilion margin and vermilion (Fig. 5.26).

If necessary, the skin is separated from the alar cartilage from the cleft side and this dissection should reach the dissection already made from medially (Fig. 5.27).

The alar base is held in proper position and the nasal correction then appears satisfactory (Fig. 5.28).

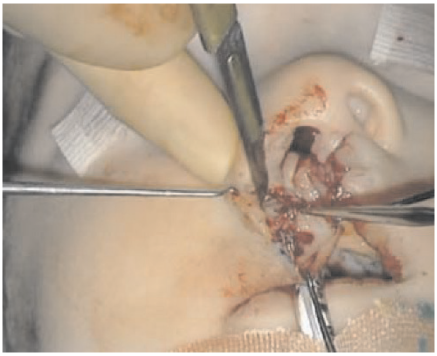

Fig. 5.26 Dissection of the muscle on the cleft side

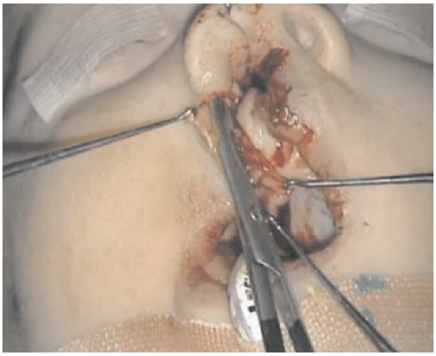

Fig. 5.27 Dissection of the alar from the cleft side

Fig. 5.28 Positioning of the alar base

5.8 Closure of Lip

The anterior part of the alveolar margin is closed with the lateral nasal wall and the vomer/septal mucosa. At the junctional point at the alveolus, a three-way stitch is made between the alveolus, the vomerine mucosa and the lateral nasal wall. It is important to hold the alar base forward to ensure that the anteriorly-shifted lateral nasal wall does not restrict the forward correction of the alar base (Fig. 5.29).

Having almost closed the nasal floor, a non-absorbable suture (4-0 or 5-0 nylon) is then placed between the alar base and a position medially, which needs to be below the anterior nasal spine to preserve symmetry. If the stitch is inserted into the anterior nasal spine, the alar base will be too high (Fig. 5.30).

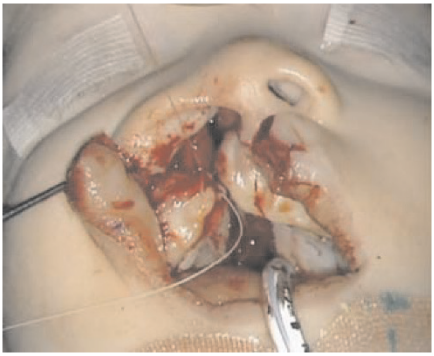

Fig. 5.29 Closure of the nasal floor

Fig. 5.30 Alar base positioning stitch

Positioning of this alar base stitch is critical in correcting the position of the alar base and preventing over-narrowing the cleft side nostril (Fig. 5.31).

Suturing the lip mucosa accurately is important. Stay sutures are inserted at a point equidistant from the vermilion margin on each side and then the mucosal suturing begins in the sulcus, preserving the quality of length and position (Fig. 5.32).

Fig. 5.31 Alar positioning stitch

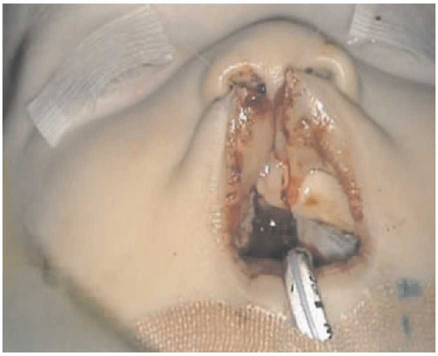

Fig. 5.32 Suturing the mucosa

The stay sutures are held in two separate artery forceps to improve the accuracy of mucosal closure (Fig. 5.33).

The lateral muscle is sutured over the medial muscle using 5-0 nylon sutures. This involves a series of horizontal mattress sutures with knots buried deeply. Again, the sutures are not tied until all have been put in place (Fig. 5.34).

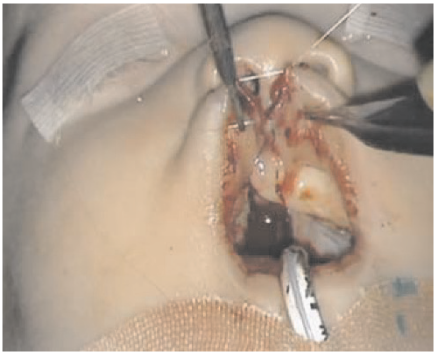

Fig. 5.33 Preserving symmetry in mucosal closure

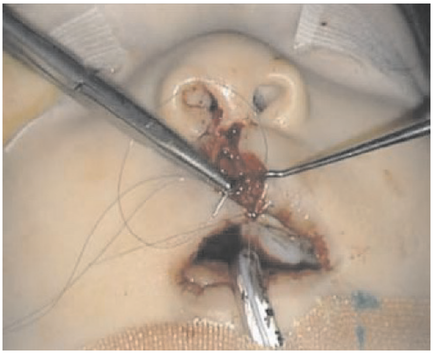

Fig. 5.34 Muscle suture

The muscle of the cleft side overlaps the muscle of the non-cleft side [19]. This helps create a philtral ridge and provides a strong muscle repair. Often a final muscle suture is inserted anteriorly (Figs. 5.35 – 5.37).

The first skin suture is at the pre-marked vermilion margin and the small triangular flap is then sutured into position with angle stitches. In this case 8-0 nylon sutures are used (Fig. 5.38).

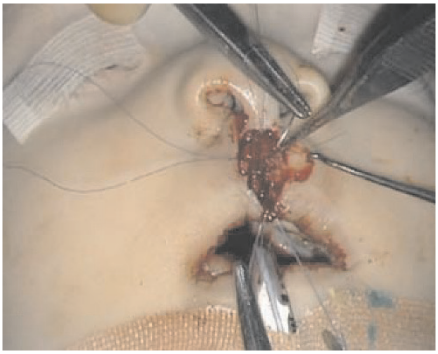

Fig. 5.35 Continuing muscle suture

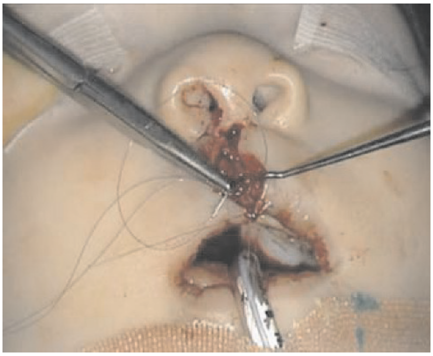

Fig. 5.36 Near-completion of muscle suture

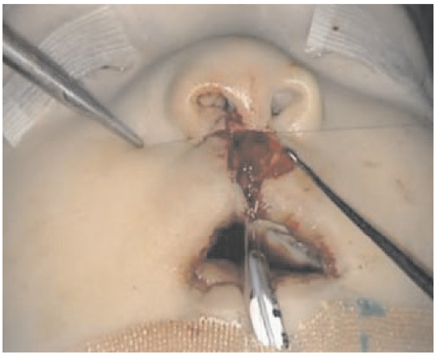

Fig. 5.37 Completion of muscle suture

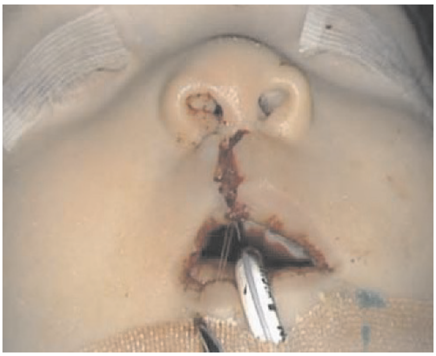

Fig. 5.38 Skin closure

The lateral flap is then inserted into the defect at the base of the columella (Fig. 5.39).

The remainder of the triangular flap is sutured (Fig. 5.40).

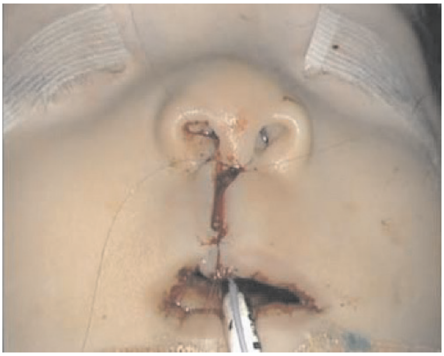

Fig. 5.39 Continuing skin suture

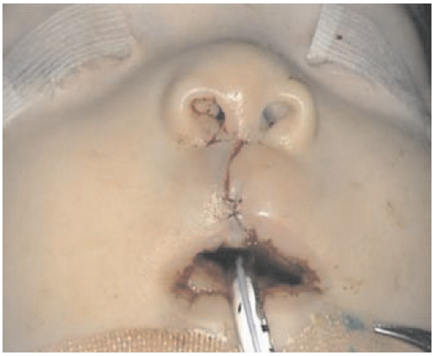

Fig. 5.40 Continuing skin suture

The skin suturing is finished, using in this case 8-0 nylon sutures. Mucosa is trimmed when necessary (Fig. 5.41).

At this stage, the wet mucosa tends to be distinct from the dry mucosa because blood sticks to it. A Z-plasty at this point [20], with the lateral limb based anteriorly and the medial limb based posteriorly, will correct the wet/dry junction discrepancy and avoid a straight line scar and whistling deformity [21, 22] (Fig. 5.42).

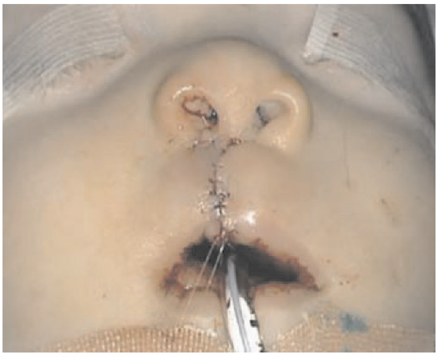

Fig. 5.41 Completion of skin suture

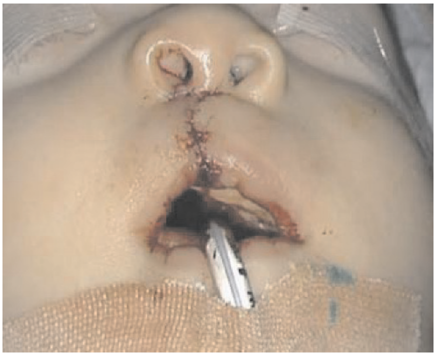

Fig. 5.42 Wet/dry junction

5.9 Suture Technique of Nasal Deformity

A 21 needle is inserted from the nasal dorsum, passing out close to the nostril rim at the point where it is depressed. A 5-0 PDS suture is inserted through the needle, out through the hub. The needle is then withdrawn but the point is not actually withdrawn through the skin and is re-inserted in a different direction to come out also at the nostril rim but at a little distance from the first point. The aim is to have a fixed point superiorly over the nasal bridge and as the suture is tightened the alar rim should be lifted. On occasions, sutures pass from the cleft alar dome to the non-cleft side. These sutures often require adjustment and several may need to be inserted (Figs. 5.43 – 5.45).

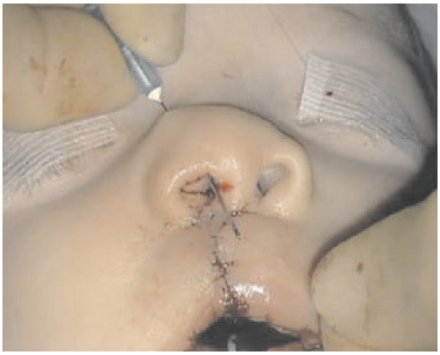

Fig. 5.43 Nasal suture

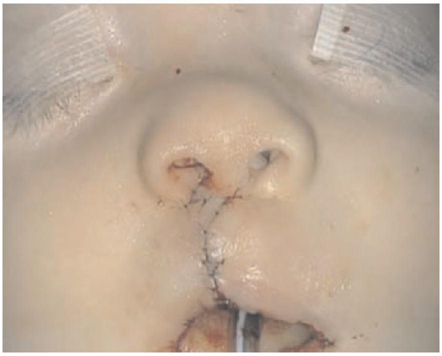

Fig. 5.44 At completion of the repair

Fig. 5.45 This is the child at 6 months (3 months after the lip repair and at the time of palate repair). The scar is still a little active

5.10 Conclusion

This is basically a modified Millard technique. The design mainly follows Millard's concept. The C-flap is not as large as which in Millard's technique, and the back-cut is not adopted as routine. Besides the rotation flap and advancement flap, a triangular flap of the lower end is designed to avoid straight line of scar. This is not really a Randall-Tennison because it is very small. The C-flap will be used to close the nasal floor.

We analyzed and compared the dental arch relationships of the cleft patients who accepted vomerine flap repair before and five years after surgery. Only a few of these patients required lateral releasing incisions during their later palate repair. Generally, there is no need for lateral releasing incisions at the time of palate repair after using the new technique of vomerine flap at lip repair, while the early technique of single cheiloplasty, during which the hard palate is not repaired at the time of lip repair, usually needs lateral releasing incisions in the later Langenbeck palatoplasty. The results of 5-year follow-up showed a much better growth outcome in the vomerine flap group. It makes palate repair much easier and less traumatic and means that there is no need for lateral incisions in most cases of palate repair. The vomerine flap repair can provide better anterior palate closure, lower the incidence of alveolar fistula after surgery, and provide a better base for later alveolar bone graft.

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6

Cutting's Technique of Unilateral Cleft Lip Repair

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6.1 Evolution of Cutting's Variant of the Mohler Repair

The extended Mohler repair is an evolution of the classic Millard repair. Although the Millard procedure is the most commonly performed cleft lip repair internationally, we and many others believe the extended Mohler repair has many distinct advantages over the Millard's classic rotation-advancement repair. The advantages, as well as additional modifications to the extended Mohler repair as practiced by the authors, will also be described.

Millard's introduction of the rotation-advancement technique to unilateral cleft lip repair in 1955 [1, 2] was a quantum leap for the treatment of the unilateral cleft lip deformity. The revolution of his technique was in the downward rotation of virtually the entire philtrum and associated Cupid's bow through a back-cut under the columella. The incision followed the line of the cleft side philtral column at its lower two-thirds, at which point the back-cut was made under the columella. The Cupid's bow, philtral dimple and most of the philtral column were, therefore, unscathed by the procedure. The medial lip element was elongated by the downward rotation of the medial lip composite and the defect created by this downward rotation was filled by medial advancement of the lateral lip element. The rotation-advancement was a distinct advantage over the Tennison-Randall method, which employed a Z-plasty through the pristine philtral valley [3, 4].

Although the Millard repair revolutionized our approach to unilateral cleft lip repair, we and many other surgeons have also appreciated some of the limitations of this technique and have further modified the classic rotation-advancement [5, 6].

The design of the medial lip incision violates the esthetic subunit borders in the superior third of the lip by curving the philtral line scar medially, towards the nasal floor on the unaffected side. Furthermore, the defect created by the "back-cut" incision to the upper lip is filled with lateral lip element skin. As a larger back-cut is used, particularly in wide clefts with very short medial lip, the defect created by the downward rotation of the Cupid's bow becomes larger and more of the philtral subunit is replaced by the lateral lip element. Consider, once again, the cleft lip requiring a large back-cut but focus on the effect of the lateral lip element advancement on final alar base position. Using the lateral lip element to fill the downward rotation of the Cupid's bow commits medial movement of the alar base to be dictated by the size of the back-cut on the medial lip element rather than the ideal alar base position. As the lateral lip element is used to fill the downward rotation of the Cupid's bow, a large back-cut will necessitate a large medial advancement of the lateral lip element and significant medialization of the alar base. This will result in a "micro-nostril", which is very difficult to correct. Attempts have been made to separate the lateral lip element from the nose by a perialar incision but the resulting scars are waxy, protuberant and unesthetic.

In Mohler's variation of the Millard repair (Fig. 6.1), Millard's classic markings are followed [5-7]; however, the back-cut is placed on to the columella instead of across the upper lip. The resulting scar will follow the entire line of the philtral column with the addition of a small horizontal scar at the base of the nose. This final scar pattern respects the subunit principle of the upper lip and preserves the philtral dimple in its entirety. In Mohler's original design, the back-cut extends only to the middle of the philtral dimple. Millard accurately criticized Mohler's original description of his columellar back-cut as being inadequate for use in complete clefts and likely useful only in incomplete clefts [8]. The rather small back-cut originally described by Mohler would provide a limited degree of downward rotation of the Cupid's bow. In order to utilize the full potential of the columellar back-cut, the apex of the Mohler incision is "extended" to just beyond the midline of the columella and the back-cut brought down to the opposite philtral column but no further [6, 7] (Fig. 6.2). This modification of the original design will allow for full downward rotation of the Cupid's bow in any unilateral cleft lip patient, regardless of the severity. A final modification from Mohler's original description of his cleft lip repair is the avoidance of borrowing nasal floor skin to extend the vertical height of the lateral lip element. The significance of this modification will be discussed later.

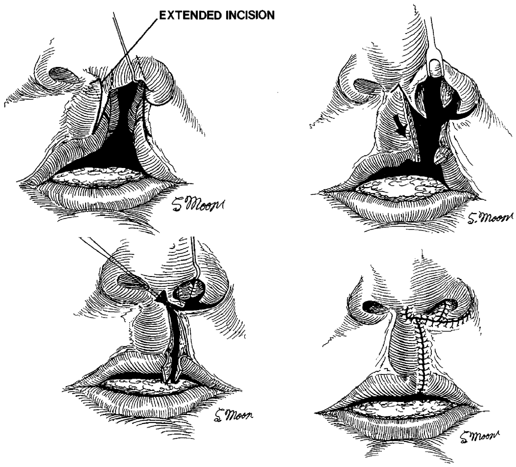

Fig. 6.1 Mohler's variation of the Millard's repair

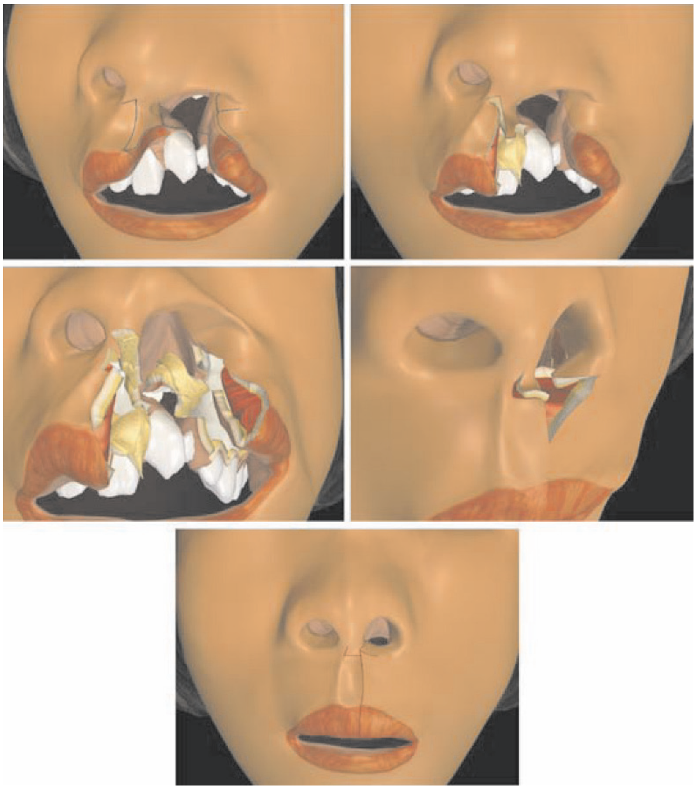

Fig. 6.2 Modification of the original design. In order to utilize the full potential of the columellar back cut, the apex of the Mohler incision is "extended" to just beyond the midline of the columella and the back-cut brought down to the opposite philtral column, which will allow for full downward rotation of the Cupid's bow in any unilateral cleft lip patient

The C-flap, rather than the lateral lip element, is used to fill the entire defect created by the downward rotation of the Cupid's bow. As the back-cut is placed in the columella, the defect created by the downward rotation of the Cupid's bow remains largely on the columella and the C-flap is predominantly used to elongate the columella, rather than add tissue to the upper lip. As the lateral lip element is not used to fill the defect created by the downward rotation of the Cupid's bow, less medial advancement of the lateral lip element is generally required. More importantly, there is no differential degree of advancement required between the lateral lip element (to fill the downward rotation of the Cupid's bow) and the alar base (to create an esthetic and balanced nostril). Therefore, there is little need to separate the lateral lip from the ala with an unesthetic perialar incision. A short, near horizontal incision at the alar base is all that is needed.

It is interesting to note that Millard's evolution of the C-flap showed a transition in the use of the C-flap from reconstructing the nasal floor to partially filling the defect created by the downward rotation of the Cupid's bow. This occurred during the development of his primary rhinoplasty technique in which the C-flap was used to elongate the columella and elevate the depressed crural footplate on the cleft side [2, 9]. This was aided by a hemi-membranous septum incision. The Millard's C-flap, however, was never used to fully fill the defect created by the downward rotation of the Cupid's bow and the signature advancement of the lateral lip element remained as part of this reconstruction.

There are several additional points of divergence from the Millard repair regarding the design of the lateral lip element flaps. The lateral lip element is widely mobilized from the face of the maxilla through a gingivobuccal sulcus incision that is made in continuity with a piriform aperture incision. Anterior and medial advancement of the lateral lip element in patients with clefts results in a mucosal defect of the lateral nasal wall and an oronasal fistula. Millard addressed this defect by rotating his L-flap into the piriform aperture defect. However, Millard based the L-flap on the alveolus, creating a mucosal lined oronasal fistula when the flap is inset [2]. To prevent formation of this fistula, the inferior incision line of the L-flap is extended beyond the alveolus and into the base of the lateral nasal wall [7, 10]. The L-flap can then be dissected free from the alveolus and all intraoral attachments, basing its blood supply on the mucosa of the lateral nasal wall.

The incision line of the lateral lip element skin does not follow the border of the vermillion with the upper lip skin as described by Millard. Instead, the incision line transects the white roll in a perpendicular fashion just medial to the tattoo point, then quickly turns to meet the junction of the superior limit of the white lip with the mucosa. This modification will prevent peaking of the vermillion at the area of closure, a deformity which has been addressed by Millard in his white roll flap [2, 9]. In addition, the soft curve of the lateral lip element will vertically elongate the lateral lip skin. Critics point out that the vertical dimension of the upper lip is elongated at the price of upper lip width. Our own studies have confirmed that the foreshortened horizontal dimension of the upper lip corrects over time [11]. As the vertical height of the lateral lip element can be extended either through the curvilinear incision on the upper lip skin or by lateralization of the white roll point on the lateral lip element, the superior border of the lateral lip element incision should never be extended into the nostril sill to lengthen the vertical height of the lateral lip flap. This principle of "borrowing from Peter to pay Paul", commonly applied to this important marking in cleft lip repair, is misguided. By removing the precious skin of the nasal floor, the surgeon is at risk of creating a micro-nostril on the cleft side, a deformity that lacks an esthetic reconstructive solution.

The final modification to the lateral lip element is the addition of a triangular vermillion flap as described by Noordhoff [12]. This flap takes advantage of the generous amount of vermillion present at the lateral lip element and inserts this tissue into the deficient vermillion of the medial lip element. This technique restores fullness to the vermillion, avoiding a whistling deformity and anatomically reconstructs the wet line of the upper lip. The latter is of particular benefit in Asian and Black patients who commonly have a distinct border between the wet and dry lip.

Several long-term studies have confirmed the benefit of primary rhinoplasty at the time of cleft lip repair [13, 14] and a comprehensive rhinoplasty is performed in all the authors' cases at the time of lip repair. The approach for the primary rhinoplasty is medially via the C-flap in combination with a hemi-membranous septum incision as advocated by Millard [2]. A composite flap of depressed lower lateral cartilage, nasal skin and mucosa is mobilized and elevated to a super-corrected position. Critical to the success of the rhinoplasty is the wide mobilization of the nasal tip skin from the upper and lower lateral cartilages. As there is no soft triangle of the cleft side [15, 16], the nasal skin on the cleft side must be dissected inferiorly to the nostril rim so that elevation of the lateral crura will result in folding of the nasal skin under the nostril and formation of a soft triangle. No external bolsters or nostril packing are used to obliterate the vestibular web. Instead, internal retention sutures are applied, behind the vestibular web, out of the nasofacial groove, back into the suture hole at the alar-facial groove and anterior to the vestibular web inside the nostril. Tying this suture will obliterate the vestibular web and accentuate the typically non-distinct alar-facial groove [7].

6.2 Statement on Nasoalveolar Molding

The authors use nasoalveolar molding (NAM), whenever feasible, in preparation for unilateral cleft lip repair. Although cleft lip repair can certainly be performed without the use of presurgical infant orthopedics, we feel that NAM provides many distinct advantages that result in a more predictable rhinoplasty and a decrease in the overall number of surgical procedures for the child. The specifics of the technique and predicted results of NAM are addressed elsewhere in this text. In summary, when the alveolar segments are aligned within 1 mm, a gingivoperiosteoplasty can be performed, which can avoid a secondary bone grafting procedure in

60% – 73% of patients [17, 18], without detriment to midface growth by midterm follow-up [19]. The benefit of avoiding a secondary surgery in at least 60% of patients is advantageous both in precluding additional patient morbidity as well as in decreasing healthcare costs [20]. In addition to alveolar repositioning, the nose can be significantly altered preoperatively, resulting in a more conservative and predicable rhinoplasty with the columella lengthened, the lower lateral cartilage repositioned, the septum straightened, the alar base medialized and curved and the nasal lining stretched. The cumulative effects of these changes in preoperative nasal form is a more conservative and predicable rhinoplasty as well as statistically significant improvements on nasal symmetry when compared to cleft lip repair without preoperative NAM by midterm follow-up [21].

6.3 Markings

The traditional Cupid's bow points are first marked, and then tattooed on the upper lip. The height and depth of the Cupid's bow on the white roll of the medial lip element are identified. The distance between these two points is used to mark the height of the Cupid's bow on the cleft side. The white roll usually starts to disappear at this point. In cases where the Cupid's bow is wide and indistinct, the marks can be placed more narrowly so that less downward rotation is required. The Cupid's bow point on the lateral lip element can be marked in three ways. Millard advocates measuring the distance between the commissure and the height of the Cupid's bow on the non-cleft side, to determine the location of the Cupid's bow point of the lateral lip element [2]. This marking has no regard to the height of the upper lip. This can be corrected at the time of closure by incising on to the white roll of the lateral lip element to extend the vertical height of the lateral lip. Noordoff marks this lateral lip element point by sighting the point of maximum width of the vermillion between the white roll and the red line (the dry lip) [12]. If this anatomic point is used, the height of the upper lip segment is often deficient. The authors mark this point by measuring the height of the lip from the alar base to the height of the Cupid's bow on the non-cleft side with a caliper. This distance is usually around 10 mm. This distance is measured on the lateral lip element and the corresponding mark is made on the white roll. This mark is usually slightly lateral to "Noordoff's point" and can result in a horizontally foreshortened lip on the cleft side, although follow-up studies have shown that this corrects over time [11].

The apex of the extended Mohler back-cut is critical to the success of the design. It should be high enough on to the columella to allow for full downward rotation of the Cupid's bow. Placing the point too close to the cleft side will result in a narrow C-flap which will inadequately fill the defect created by the downward rotation of the Cupid's bow. Placing the point too far towards the non-cleft side will result in a narrow philtral column at the superior aspect of the upper lip. Placing the point too low will result in inadequate downward rotation of the Cupid's bow. The apex of the Mohler back-cut is made on the columella approximately 1.5 mm superior to the base and just over halfway (four-sevenths) across the columella on to the non-cleft side. A line is drawn connecting this point to a point just lateral to the height of the Cupid's bow on the cleft side. This line should be bowed out about 1 mm to recreate the subtle curve of the philtral column of the unaffected side. Another line is drawn from the apex of the Mohler back-cut to the height of the philtrum on the non-cleft side but no farther. The angle formed by these two lines will affect the degree of downward rotation of the Cupid's bow. The more acute the angle, the more downward rotation is produced.

The C-flap and M-flap are drawn in the usual manner. Care should be taken to incorporate the maximum amount of white upper lip skin into the C-flap without incorporating mucosa, as the C-flap will be used to reconstruct the defect created by the downward rotation of the Cupid's bow. This is of particular importance in wide clefts in which presurgical orthopedics is not used. In these cases, the C-flap may be used virtually in its entirety to fill the defect created by the downward rotation of the Cupid's bow. If mucosa is left on the C-flap, the mucosal tissue will be transposed on to the nose and upper lip.

On the lateral lip element, a line is drawn lateral to medial along the alar base crease, traveling slightly inferiorly to a point at the junction of the white lip and mucosa, approximately 1 mm inferior to the alar crease. This line is not extended superiorly into the nasal floor, as advocated by Millard, to add vertical length to the lateral lip element [9]. If more vertical length is needed, the white roll point should be placed more laterally. A line is then drawn, starting from a point 1 mm inferior to the white roll and just medial to the tattoo point on the white roll. The line transects the white roll at a right angle, and extends 1 mm on to the white lip as a straight line, and then quickly, yet softly turns to meet the alar base crease line at its medial extent. The inferior aspect of this line is curved slightly in the lateral direction, no more than 1 mm, to match the subtle bow created on the philtral line of the medial lip element. It is critical to transect the white roll at a right angle; Otherwise, the white roll on the lateral and medial lip elements will not come together as a straight line and a notch will be created. Noordhoff and Millard addressed this problem with the triangular flap [12] and "white roll flap" [2, 9], respectively, which are not utilized in this extended Mohler repair. The Noordhoff Z-plasty is drawn on the lateral element in the usual fashion [12]. A "receiving" incision is drawn on the vermillion of the medial lip element as an oblique line starting at a point 1 mm inferior to the white roll, traveling laterally and inferiorly to the red line. The inferior border of the L-flap is marked on the lateral lip element with care to leave a mucosal cuff at the gingivobuccal sulcus.

6.4 Surgical Technique

After markings are incised through skin/mucosa, the M-flap and C-flap are sharply mobilized. A transverse incision is made across the orbicularis oris muscle in its full thickness 1 mm inferior to the apex of the Mohler back-cut to effect further downward rotation of the Cupid's bow. If additional downward rotation is required, the Mohler back-cut can be extended along the philtral line of the opposite side; however, this will lower the location of the horizontal scar of the upper lip. On the mucosa of the medial lip element, the frenulum of the upper lip is located and an incision is made parallel to, then transecting across the frenulum. The frenulum is transected only enough to allow for full downward rotation of the Cupid's bow. The M-flap is advanced into this mucosal defect and the defect is closed. The skin of the medial lip element is then dissected free from the underlying orbicularis oris to the depth of the philtral dimple but no further.

The L-flap is then sharply dissected from the lateral lip element. Care should be taken to preserve the lip muscle under the triangular component of the Noordhoff Z-plasty as this will add bulk to the vermillion. As the L-flap is dissected towards the gingivobuccal sulcus, the depth of the dissection changes from a submucosal to a subperiosteal plane. A piriform aperture incision is then made at the junction of the squamous epithelium and the nasal mucosa. The piriform aperture incision should go to the bone. This incision is made superior to inferior to meet the superior border of the L-flap. Completing this incision will pedicle the L-flap on the lateral nasal wall. A periosteal elevator is inserted into the piriform aperture incision and the L-flap is mobilized in a subperiosteal plane from the inferior aspect of the lateral nasal wall. An incision is made through the mobilized L-flap at the base of the lateral nasal wall. This L-flap/lateral nasal wall mucoperiosteal flap will be used to close the nasal floor. A corresponding vomer flap is raised. If appropriate, perform a gingivoperiosteoplasty at this time.

The L-flap is tucked into the nose and a gingivobuccal sulcus incision is made and connected to the piriform aperture incision. The cheek and upper lip composite is then sharply mobilized in a supraperiosteal plane off the face of the maxilla. This dissection may be extensive if no presurgical orthopedics was performed. After the appropriate degree of lateral lip element advancement is obtained, the L-flap is inset into the lateral nasal wall defect created by mobilization of the lateral cheek element. The base of the L-flap is then sutured to the alar base. The L-flap is trimmed as needed and inset into the mucosal defect of the lateral nasal wall. The nasal floor defect is closed by suturing the vomer flap to the inferior border of the L-flap in horizontal mattress fashion. The lateral lip element is then advanced into anatomic position and the oral mucosa and gingivobuccal sulcus incision are closed.

Converse tip scissors are inserted under the C-flap and between the crural footplates. Using blunt dissection, the medial crura are separated. A hemi-membranous septum incision is made on the cleft side only. The dissection pockets formed between the medial crura with the hemi-membranous septum incision are connected. Through this merged dissection pocket, blunt dissection is performed to separate the nasal skin envelope from the domes and upper lateral cartilages on the cleft and non-cleft side. This dissection should proceed superiorly and posteriorly to the upper lateral cartilages on both sides of the nose and inferiorly to the nostril rim on the cleft side. The depressed dome is elevated to a super-corrected position with a Ragnell retractor. Using a long-lasting absorbable stitch, the medial crura of both lower lateral cartilages are sutured together in horizontal mattress fashion, along the length of the columella. These sutures will affix the lower lateral cartilage in its new position and also help shape the columella. The hemi-membranous septum incision is closed with several transfixion sutures.

The dermomuscular pennant under the alar base on the cleft side is sutured to the crural footplate on the unaffected side using a long-lasting absorbable suture. The alar base should be placed into anatomical position through this step. This suture should be reinforced, with at least one additional stitch. The orbicularis oris is reconstructed from superior to inferior using a buried horizontal mattress technique. The horizontal mattress will evert the muscular closure, creating a prominence that will resemble a philtral column. The upper lip skin and dry lip are closed and the Noordhoff Z-plasty is inset. The C-flap is trimmed and inset to fill the defect created by the downward rotation of the Cupid's bow in its entirety. A straight line closure of the upper lip along the philtral column should be the end-result. Care should be taken to avoid the four corners of the upper lip incisions, C-flap and alar base flap from converging (quadrapoint).

Lastly, modified McComb retention sutures are placed within the nose using a long-lasting absorbable stitch. The first suture is the most technically and conceptually difficult suture of the entire surgery. An oblique horizontal mattress suture is passed from the cleft side nostril to non-cleft side nostril and back again with the goal of elevating the downwardly displaced lateral crura. The entrance is just posterior to the nostil rim in the area of the nostril apex overhang. The suture is placed through the lateral crura on the cleft side and into the dissection pocket previously created between the dome cartilages and the nasal skin. The suture is passed, within this dissection pocket, following a slight posterior trajectory, then through the lateral crura on the non-cleft side and into the non-cleft side nostril. The suture is then returned into the cleft side nostril following the same trajectory and pathway but in the opposite direction and 2 mm posterior to the first suture. Tying this stitch will elevate and medialize the depressed lateral crura. Vestibular web obliterating sutures are then placed using a long-lasting absorbable suture. The suture is passed from within the nostril, behind the vestibular web, then out through the alar/facial groove externally. The suture is then passed back into the nostril through the same skin puncture at the alar/facial groove; however, the stitch enters the nostril anterior to the vestibular web. Tying this suture has the dual effect of obliterating the vestibular web and accentuating the alar/facial groove. Typically, two to three sure sutures are required.

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7

Chang Gung Technique of Unilateral Cleft Lip Repair

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7.1 Introduction

The evolution of Millard's early presentation in 1957 to his more recent reports [1-4] spans a lifetime of change and innovation. Anyone with a career in cleft lip/palate surgery needs to wait 18 years before he sees the final results. Very often, new techniques are a modification of an older one. Abandoned techniques frequently continue in textbooks supposedly as useful procedures and are used again by the unwary, inexperienced surgeon. The techniques presented here are based on the experience in the Chang Gung Craniofacial Center during the past 30 years in a Chinese population [5-8]. Some modifications were original; some were adopted or modified from other surgeons. The improved results are contributed from an integrated approach with presurgical management, surgical refinements and postsurgical maintenance.

7.1.1 Overall Cleft Treatment Plan in Chang Gung Craniofacial Center

The overall treatment plan in Chang Gung Craniofacial Center is shown in Table 7.1 [6].

Table 7.1 Cleft treatment protocol in Chang Gung Craniofacial Center

Timing	Treatment
First visit	Nasoalveolar molding
3 – 5 months	Lip surgery
9 – 12 months	Palate surgery
2.5 years	Speech assessment every 6 months
3.5 years	Speech therapy
4 years	VPI surgery
5 – 6 years	Lip & nose revision if indicated
8.5 – 9 years	Presurgical orthodontics
9 – 11 years	Alveolar bone grafting
>12 years	Definitive orthodontics
17 – 18 years	Orthognathic surgery/lip & nose revision

7.1.1.1 Treatment before Lip Repair

The newborn cleft baby should have a pediatric evaluation. Parents are counseled about feeding and given information for subsequent care and treatment. Presurgical nasoalveolar molding (NAM) is started at 2 weeks or even earlier. It usually takes 3 months before completion of NAM.

7.1.1.2 The Surgical Approach

There are several different treatment plans leading to the surgical correction of the deformity. With effective presurgical NAM, a definitive cheiloplasty is done at the age of 3 to 5 months when the alveolar gap is narrowed and nasal deformity is improved. Whenever presurgical orthopedics is not available or if the child is older than 3 months, a definitive cheiloplasty with nasal correction is performed because presurgical orthopedics is usually not effective in older children. If there is a wide cleft (>12 mm) and an associated tissue deficiency, a nasolabial adhesion cheiloplasty is performed at 3 months followed by a definitive cheiloplasty at about 9 – 12 months. With presurgical NAM, an adhesion cheiloplasty is seldom performed. The decision-making for lip repair is shown in Fig 7.1.

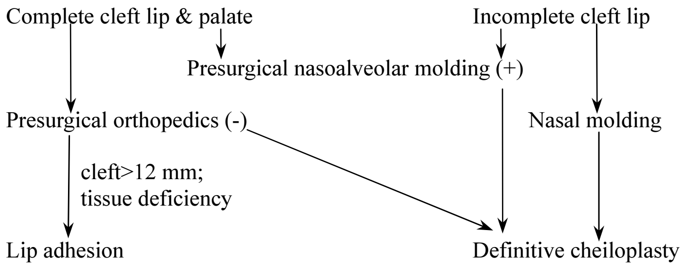


Fig. 7.1 Decision making in cleft lip repair

7.1.1.3 Treatment after Lip Repair

A Furlow technique two-flap palatoplasty on the soft palate is performed at 9 to 12 months. Timing of alveolar bone grafting relates to the eruption of the central incisor or canine. This is determined by the orthodontist. This is usually at the age of 5 to 7 years for the central incisor or 9 to 11 years for the canine. Speech evaluation starts at the age of 2.5 years. Early intervention for velopharyngeal insufficiency is performed as soon as the diagnosis is confirmed by nasopharyngoscopy. With continued improvement in the result of primary nasal reconstruction, secondary correction of nasal deformities can usually be delayed until adulthood. However, if there is any psychological reason that warrants correction, it can be done at any time. Orthodontic treatment in the mixed dentition is considered to correct anterior crossbite or to align deviated incisors before alveolar bone grafting. For most patients, a fixed orthodontic appliance is used to improve dental occlusion in the permanent dentition. Orthognathic surgery is considered for maxillary hypoplasia associated with malocclusion at the time of skeletal maturity.

7.1.2 Classification of the Clefts

A good classification system should be simple, easy to remember, accurate to record all the details in different conditions and easily adapted to the modern database program. The classification suggested by Veau [9] is too simple to record the extent of the cleft. The Kernahan's "stripped Y" system is more comprehensive [10]. The limitation of the Kernahan Y classification, however, is that clefts of the secondary palate cannot be classified into right or left side. The double-Y numbered classification, reported by Noordhoff in 1990 [6, 11], is a more accurate method for recording as well as a more suitable system for computer database documentation (Fig. 7.2).

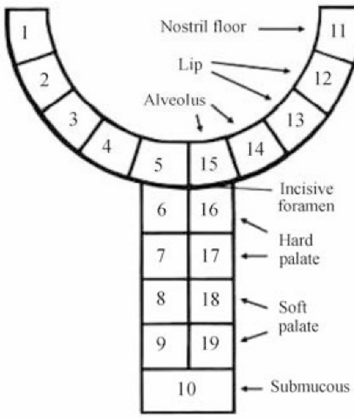


Fig. 7.2 The double Y numbered classification system. Clefts of the primary palate anterior to the incisive foramen are numbered 1 – 5 and 11 – 15. Clefts of the secondary palate posterior to the incisive foramen are numbered 6 – 9 and 16 – 19. Submucous cleft is numbered 10. Any number combination can be used to describe the extent of in an accurate way

7.2 Integrated Approach

The pathology in unilateral clefts involves all components in the oral region (Figs. 7.3 – 7.4). The skeletal problems consist of wide alveolar cleft, protruding premaxilla and retro-positioned maxillary segment in the cleft side (the lesser segment). The orbicularis muscle, when separated, inserts into incorrect places, namely, the alar base on the cleft side and the columellar base. There is a skin problem of short columella, nasal vestibular deficiency and nostril hood, all on the cleft side. The cartilaginous framework is distorted, more severely on the cleft side. The purpose of the presurgical orthopedics or NAM is balancing the skeletal base, narrowing cleft width, as well as correcting the shape of the deformed alar cartilages and correcting the soft tissue deficiency in the nose [12-30].

Fig. 7.3 A 3 months old baby with left complete cleft of primary and secondary palate shows the pathology in different components including bone, cartilage, muscle, mucosa and skin

Fig. 7.4 The same patient in worm-eye's view shows the depressed skeleton and cartilage framework as well as the soft tissue deficiency on the cleft side

7.2.1 Presurgical Orthopedics

The two factors influencing the width of the cleft are: (1) The pulling force from the separated orbicularis muscle; (2) The pushing force from the tongue [31].

Keeping the tongue out of the cleft by an acrylic dental plate and replacing the pulling force from the separated lip muscle by tape traction across the lip should be able to narrow the cleft [32]. Increasing the pressure on the cheek by putting the patient in the prone or side-lying sleep position [25] can further increase the force pushing the maxilla inward and thus can further narrow the cleft (Fig. 7.5). This technique is simple but effective in narrowing the cleft width before surgery. The only drawback is that it cannot correct the deformed cartilage.

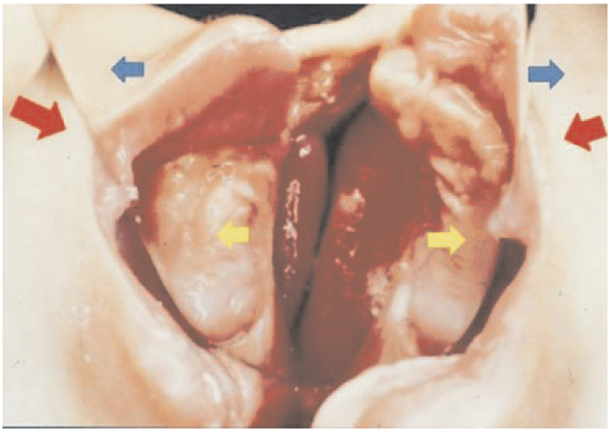


Fig. 7.5 The forces that exert an influence on the cleft alveolus are the central tongue force, pushing the cleft laterally. The separated orbicularis muscle will separate the cleft and the cheek pressure will approximate the palate

7.2.2 Nasoalveolar Molding

The following techniques have been used in the Chang Gung Craniofacial Center since 1997. There were some modifications from the original technique.

7.2.2.1 Liou's Method

This is a modification of the original Figueroa's technique [26]. It uses a molding bulb attached to a dental plate as an outrigger to mold the nose along with the external taping of the lip (Fig. 7.6). The device is held to the palate with dental adhesives. The force from the taping and counterforce from the molding bulb provide the force necessary to bring the alveolus into proper position. The nasal molding and alveolar molding are done at the same time, taking approximately 3 months. Over-stretching of the nasal cartilage on the cleft side is avoided by gradual movement of the maxilla during the time of nasal molding. Nasal projection and the dental plate are modified or adjusted every 1 to 2 weeks until the arch and nose are properly positioned. A new molding device with the spring mechanism has been used in Chang Gung Craniofacial Center in recent years (Fig. 7.7). It can greatly lengthen the duration between each clinical visit from one week to one month, thus greatly reducing the burden of care for the parents.

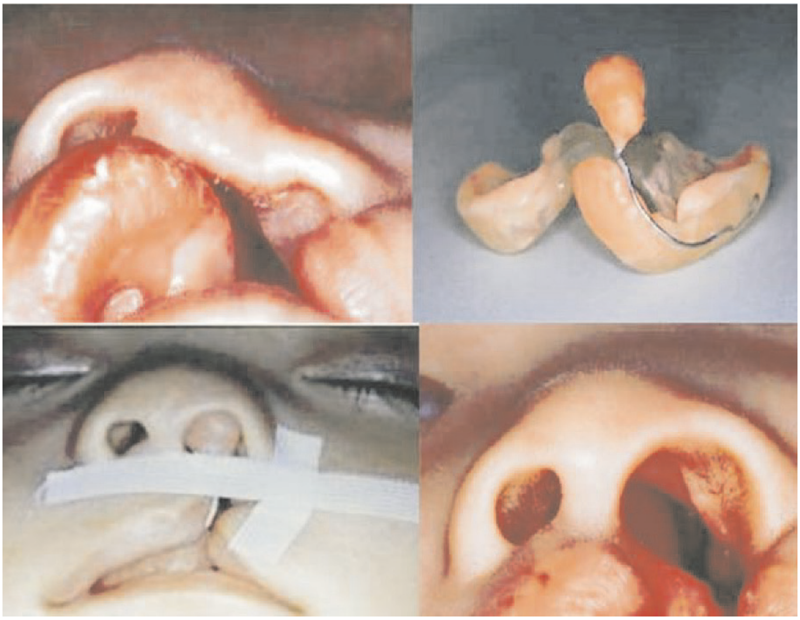


Fig. 7.6 Nasoalveolar molding, Liou's technique. *Left upper*: At 2 weeks before molding. *Right upper*: The molding device and the dental plate. *Left lower*: During molding with dental plate and attached soft acrylic bulb in place at 1 month. *Right lower*: After molding at 3 months before operation

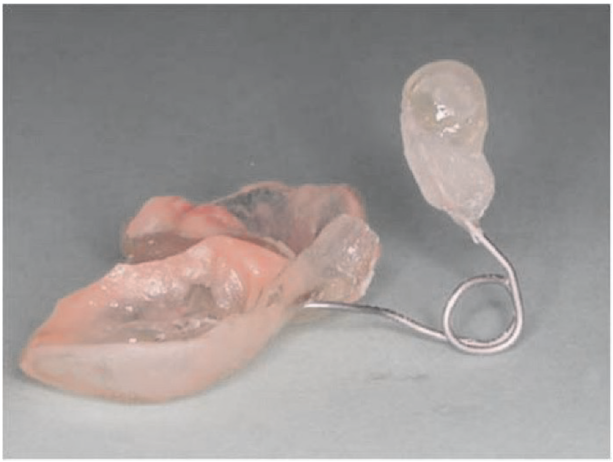


Fig. 7.7 The new molding device in Chang Gung Craniofacial Center using a spring mechanism in the nasal molding device

7.2.2.2 Grayson's Method

Grayson's method is to perform separated alveolar molding and nasal molding [24]. Nasal molding is delayed until the alveolar gap is approximated to avoid over-stretching of the nasal cartilage. The molding device is a dental plate with one forward and downward resin projection holding the dental plate and one forward and upward wire, or resin extension, for nasal molding. Micropore tape and orthodontic elastics hold the dental plate to the palate (Fig. 7.8). Gradually adding soft resin on the inner surface of the buccal flange and grinding out the palatal surface of the dental plate controls the maxillary movement. The nasal projection is added and adjusted underneath the deformed cartilage. This technique should be started within the first 2 weeks of birth; careful monitoring is required every 1 to 2 weeks for a period of 3 to 6 months to complete it.

Fig. 7.8 Nasoalveolar molding, Grayson technique. *Left upper*: Position of alveolus before nasoalveolar molding at 2 weeks. *Right upper*: The molding device. *Left lower*: During nasoalveolar molding. *Right lower*: After nasoalveolar molding before surgery at 4 months

7.2.3 Discussion on Presurgical Orthopedics/Nasolaveolar Molding

The primary objective of presurgical orthopedics is to correct the skeletal deformities of the cleft maxilla before surgery. Regardless of no improvement of facial growth, presurgical orthopedics provides a better bony framework with a narrower cleft. Presurgical NAM can not only correct the skeletal base, but also greatly improve the nasal shape before operation, thus facilitating nasal reconstruction. Though controversies still exist regarding the long-term benefit of NAM, there is more evidence showing that NAM results in a better nasal repair [27-29]. The technique was frequently criticized for being time-consuming and costly. The new molding device with the spring mechanism can greatly reduce the burden of parental care.

7.3 Surgical Refinements

The techniques presented here are based on the experience in the Chang Gung Craniofacial Center during the past 30 years in a Chinese population. It is a continuously evolving process with periodic outcome assessments, technical modifications of our own or adopted from other surgeons to correct the residual deformities and reassessment for the new residual deformities [33-42].

The key principles of the present technique are:

1) Mohler's incision on the rotation flap [35];

2) Mucosal flaps for nasal floor reconstruction and piriform deficiency [7, 8];

3) Elimination of the perialar incision on the advancement flap;

4) Mobilization of alar base;

5) Nasal floor reconstruction with complete mucosal closure;

6) Muscle release and reconstruction to simulate the philtral column;

7) Anchoring of the advancement flap to the nasal septum;

8) Correction of central vermilion deficiency with a triangular vermilion flap from the lateral lip [5];

9) Semi-open rhinoplasty with reverse U incision on the cleft side and rim incision on the non-cleft side [41];

10) Atraumatic dissection to release the fibrofatty tissue from lower lateral cartilages (LLCs);

11) Advancement and fixation of the cleft side LLC to the non-cleft side LLC and to the skin in an over-corrected position;

12) Definition of the ala-facial groove with alar transfixion sutures.

7.3.1 Lip Measurements and Markings

7.3.1.1 Cupid's Bow and Vermilion

The landmarks of the lip and essential measurements are shown in Fig. 7.9[43]. The points of the Cupid's bow (CPHR, IS, CPHL) marked on the white skin roll (WSR) (Fig. 7.10). The vermilion-mucosa junction line, the red line, is also marked. This clearly defines the vermilion. Other points marked are the base of the ala (SBAR, SBAL) and the commissure (CHR, CHL).

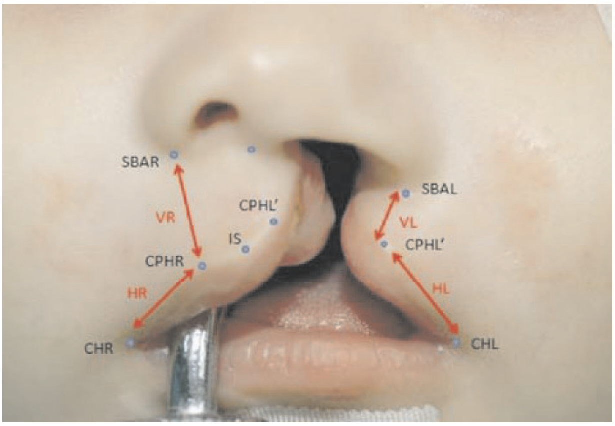


Fig. 7.9 Left: Unilateral complete cleft with anthropometric markings for measurements; CHR, CHL,commissure; HR, HL, right and left horizontal length; VR, VL, right and left vertical length; CPHR, noncleft-side philtral column; CPHL, cleft-side Cupid's bow; IS, central Cupid's bow; CPHL', cleft-side philtral column; SBAR, SBAL, right and left base of ala

7.3.1.2 The Base of the Cleft-side Philtral Column

The base of the cleft-side philtral column (CPHL') is a definite anatomic point. There is frequently a distinct point where the WSR changes directions and makes a slight curve about 3 to 4 mm lateral to the converging point of the WSR and the red line. It is also the point where the vermilion first becomes widest. This is an important anatomic point and can only be moved when there is a severe discrepancy in horizontal measurements between the cleft side and non-cleft side lips (Fig. 7.10).

Fig. 7.10 Landmarks in a case with right complete cleft lip and palate: CPHR, IS, CPHL, CPHL', and the redline

7.3.1.3 Discussion on the Markings

The landmarks on the medial lip are fixed points which can be easily identified. The point CPHL' is somewhat controversial. There is a distinct point where the WSR changes direction. This point is also where the vermilion first becomes its widest. Unless the horizontal length of the cleft side lateral lip is too short, this point should not be moved. If there is a discrepancy greater than 4 mm between the lateral lips, the point can be move slightly medially for better lip balance.

7.3.1.4 Medial Lip Incisions

A Mohler's rotation incision line is marked as a curvilinear line from CPHL going upwards into the base of the columella, then turning back to the nasolabial junction of the non-cleft side philtral column (Fig. 7.11). The height of this rotation

Fig. 7.11 Incision lines for the rotation flap, C-flap and advancement flap. The incision on rotation flap is a Mohler's incision. A small white skin roll flap is designed above the point CPHL'

Fig. 7.12 The height of the non-cleft side philtral column

incision should be the same as the height of the non-cleft side philtral column (Figs. 7.12 – 7.13). The angle of the back-cut is dependent on the width of columella. If the columella is wide, a wider angle can be made. The incision across the free border of the lip at CPHL should be at right angles to the axis of the WSR to facilitate subsequent lip closure (Fig. 7.11).

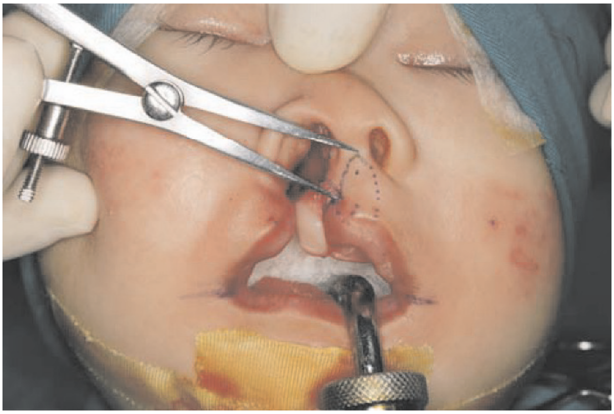


Fig. 7.13 The height of the Mohler's incision should match the height of the philtral column on the non-cleft side measured in Fig. 7.12

7.3.1.5 Discussion on the Medial Lip Incisions

The Mohler's incision will result in a more vertical incision line which is more similar to the position of the philtral column compared to the original rotation-advancement technique. The pivot point for the rotation is at the columellar base of the non-cleft side. As the Mohler's incision gives the most natural-looking philtral column compared with other incisions, it is used in most of the author's practice with the only exception of median facial dysplasia. Even in the presence of highly peaking Cupid's bow, the author will still use the Mohler's incision instead of making different incisions and changing the pivot point.

7.3.1.6 Lateral Lip Incisions

The skin incision line on the free border of the lip starts from point CPHL'. A triangular shaped small WSR flap is designed at CPHL'. The width of the WSR flap is exactly the same as the width of the WSR above the point CPHL'. The length of the WSR flap is only 1 – 2 mm (Fig. 7.11). An L-flap is marked based on the maxilla, extending on the free border of the lip to the point where the red line and WSR converge, preserving the vermilion on the lateral lip (Fig. 7.14). The length of the vermilion is about 4 − 5 mm (Fig. 7.11). The upper incision line of the L-flap extends to the skin-mucosa junction medial to the alar base, then continues along the skin-mucosal junction on the piriform area up to the inferior edge of the inferior turbinate, then turns inwards to include an inferior turbinate flap.

Fig. 7.14 The L-flap and the incision line along the piriform which extends to the base of the inferior turbinate

7.3.1.7 Discussion on the Lateral Lip Incisions

The incision line is made along the free margin, then its direction changes along the piriform area. There is no incision along the nasal floor or around the alar base. Though the alar base and lip are moved in different directions during reconstruction, this horizontal incision is still unnecessary as the lip skin can be stretched. The Cupid's bow and alar bases can be leveled without this horizontal incision in most patients.

7.3.2 The Rotation Flap

The rotation flap is developed by using a No. 67 blade with two single hooks and fingers to stabilize the lip (Fig. 7.15). The incision across the free border of the lip at CPHL is cut at right angles to the WSR. The abnormal muscle insertion to the columellar base and the nasal floor on the cleft side is released using tenotomy scissors (Figs. 7.16 – 7.17). Traction on the free border of the lip will determine whether the rotation is adequate (Fig. 7.18). The muscle is freed from the skin in the subdermal plane for a distance of 2 – 3 mm (Fig. 7.19).

Fig. 7.15 The rotation flap is cut with fingers to stabilize the lip

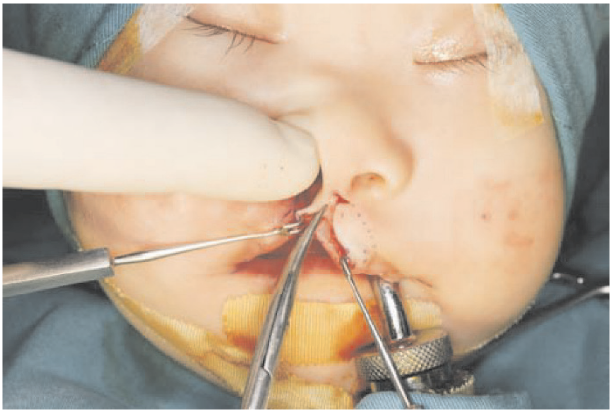


Fig. 7.16 The rotation flap and the C-flap are separated with tenotomy scissors

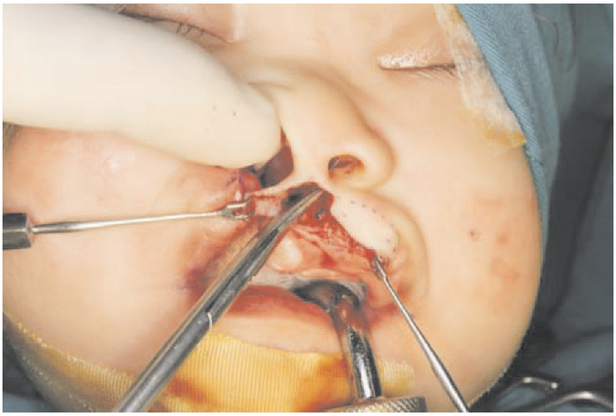


Fig. 7.17 Dissection of the abnormal muscle insertion to the columellar base and the nasal floor on the non-cleft side

Fig. 7.18 Apply traction at the Cupid's bow with a hook to check the adequacy of rotation

Fig. 7.19 Dissection of the muscle from the skin in rotation flap. The dissection is performed with a No. 15 blade

Discussion on the Rotation Flap

Even if the rotation is inadequate, extension of the rotation incision across the philtral column of the non-cleft side should still be avoided as it will result in a long lip. Millard's back-cut is not preferred as it will lead to a defect on the upper lip, which is wider and lower than the defect after a Mohler's incision. The defect after a Millard's back-cut is best filled by a square-shaped advancement flap, which is somewhat difficult owing to tissue deficiency in that area. The inadequate rotation can be corrected by a small triangular flap above the WSR after muscle reconstruction.

7.3.3 The C-flap and the Medial Crura

The C-flap incisions are made on a line that extends laterally from point CPHL along the junction of skin and vermilion/mucosa to the most lateral point of skin overlying the premaxilla. The incision line then turns superiorly at the junction of the columellar skin and septal mucosa for a distance of 5 mm or even longer (Fig. 7.20). A blunt-tip tenotomy scissors is used to separate the medial crura of the cleft side LLC from the non-cleft side (Fig. 7.21). This allows mobilization of the C-flap and repositioning of the downwardly displaced footplate of the medial crura. The tip of the C-flap (point at CPHL) will be rotated medially to fill in the defect on the columellar base after the Mohler's incision.

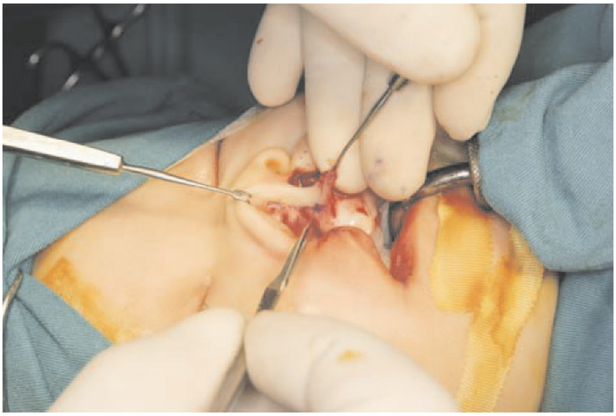


Fig. 7.20 Incision lines of the C-flap. The incision on the membranous columella is extending upward for more than 5 mm

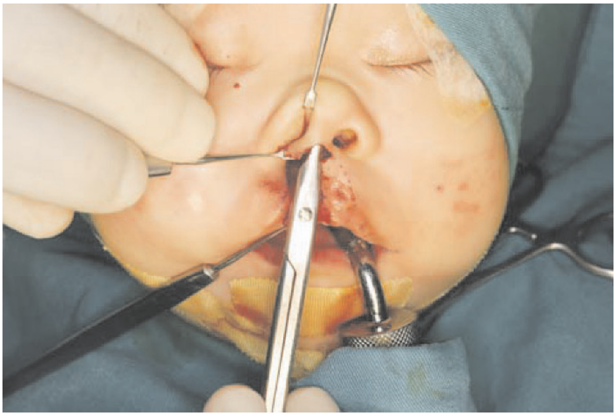


Fig. 7.21 A tenotomy scissors is used to release the foot plate of the medial crura of the cleft side lower lateral cartilage

Discussion of C-flap

The C-flap has two tips. One is the point CPHL and the other is the deepest point at premaxilla. The point CPHL should always be rotated medially to fill the defect after the Mohler's incision. The footplate of the cleft side LLC is in the C-flap. This footplate is downwardly displaced. It should be released from the intercrural ligaments and advanced superiorly to match its counterpart on the non-cleft side.

7.3.4 The Advancement Flap

The advancement flap is also developed by a No. 67 blade for an accurate cut. It also needs to be stabilized by a single hook and fingers (Fig. 7.21). The incision starts at CPHL', along the free margin of the lip, to the skin-mucosal junction on the alveolus of the cleft margin (Fig. 7.22, Fig. 7.14). An L-flap based on the alveolus of the cleft margin is cut with a No 15 blade (Fig. 7.23). The upper margin of the L-flap is cut along the skin-vermilion and skin-mucosal junction. The incision line turns 90° at the deepest point of the skin-mucosal junction (the upper margin of the base of the L-flap) along the skin-mucosal junction on the piriform area to the base of the inferior turbinate (Fig. 7.14). An L-flap about 5 mm wide is raised including a thin layer of muscle for better blood supply (Figs. 7.24 – 7.25). An inferior turbinate flap based on the vestibulum is raised in a retrograde fashion (Figs. 7.26 – 7.29). After raising the inferior turbinate flap, the ligamentous attachments of the LLC to the piriform area are released.

Fig. 7.22 Incision line of the advancement flap is along the free margin to the piriform aperture

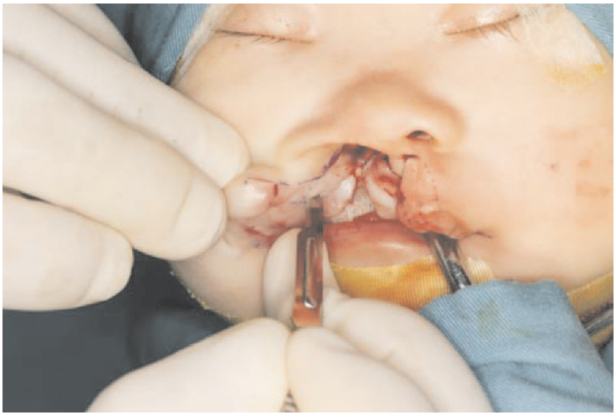


Fig. 7.23 The L-flap is incised with a No. 15 blade. The width of the L-flap is about 0.5 cm

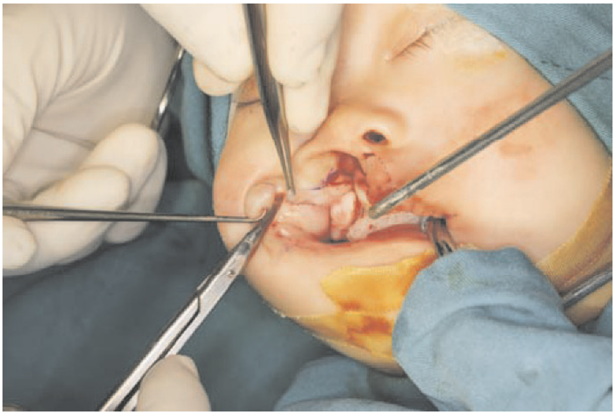


Fig. 7.24 Dissection of the L-flap with a tenotomy scissors. A thin layer of muscle is left on the L-flap for better blood supply

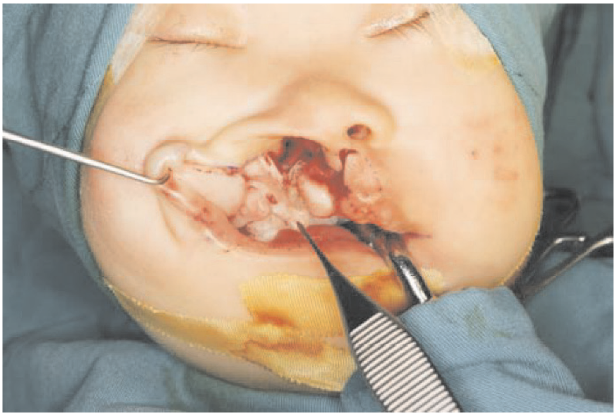


Fig. 7.25 Completion of the dissection of the L-flap to its base on the alveolus

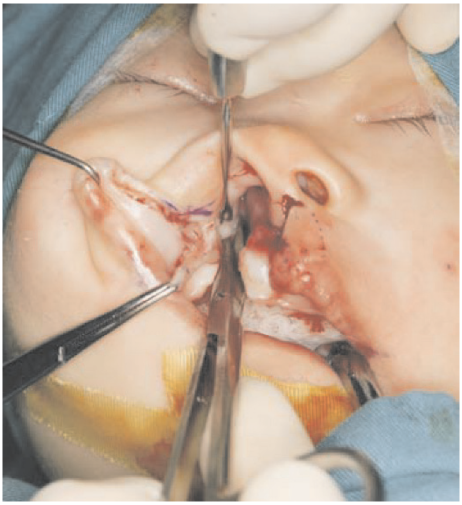


Fig. 7.26 Raising the inferior turbinate flap in a retrograde dissection started from its deeper margin

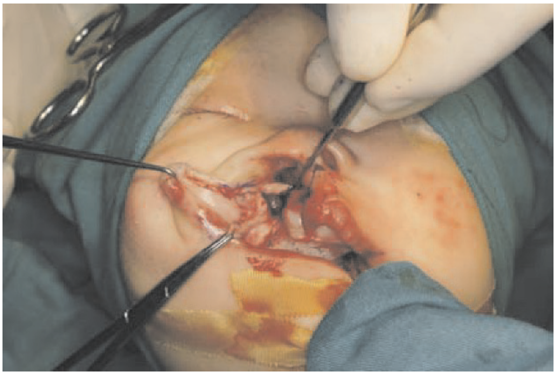


Fig. 7.27 The inferior turbinate flap is raised to its base on the piriform

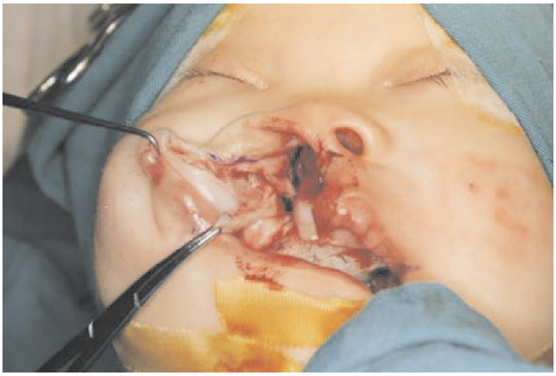


Fig. 7.28 The L-flap (grasped by the hemostat) and the inferior turbinate flap

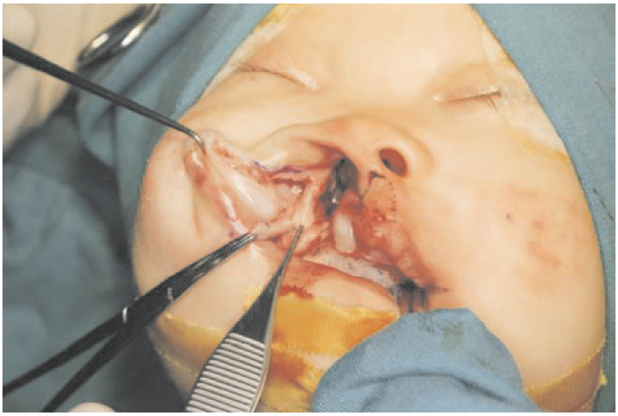


Fig. 7.29 The inferior turbinate flap will be rotated 90° to fill in the raw surface in piriform area

Discussion on the Advancement Flap

The point where the initial incision along the free margin changes direction (the deepest point medial to the alar base at the skin-mucosa junction) is an anatomical point. This point is the tip of the nasal floor and should be advanced medially across the cleft and sutured to the nasal septum for nasal floor reconstruction. The tissue from the alar base to this point is the natural nasal sill tissue. This nasal sill tissue should be carefully preserved during operation. One of the difficult problems in secondary revision is to reconstruct the absent nasal sill which was excised during previous operations. The length of the L-flap is determined by the width of the cleft. About 4 – 5 mm of vermilion medial to the point CPHL' is enough for later vermilion reconstruction. All the rest can be included into the L-flap for extra length.

7.3.5 The Dissection of the Orbicularis Peripheralis Muscle

The orbicularis peripheralis muscle is freed from the maxilla in a plane above the periosteum, which gives a better release of the abnormal muscle insertions (Fig. 7.30). The lateral lip mucosa is incised and dissected free for only 2 mm. Excessive dissection contributes to submucosal scarring and should be avoided. The dissection on the skin side is started with a No. 15 blade, leaving a thin layer of muscle at the wound margin. The dissection plane is moved closer to the skin by using blunt-nosed tenotomy scissors. The dissection is continued on a subdermal plane superiorly under and around the base of the ala. This releases the abnormal insertions of the paranasal muscles including the transverse portion of the nasalis muscle, the depressor septi, and the levator muscles of the upper lip and ala. The angular artery is used as a landmark for the muscle dissection around the alar base (Fig. 7.31). The extent of dissection should be lateral and superior to the vessel to assure most of the abnormal muscle insertions to the alar base are released (Fig. 7.32). Release of the muscle from the overlying skin and ala allows the tethered, bunched-up muscle to be stretched. After muscle approximation, the skin will always stretch in a similar manner, gaining increased vertical height. The completion of the dissection on the maxilla can be checked by grasping the muscle at the tip of the advancement flap and trying to approximate the muscle (Fig. 7.33).

Fig. 7.30 The orbicularis peripheralis muscle is dissected from the maxilla on the plane above the periosteum

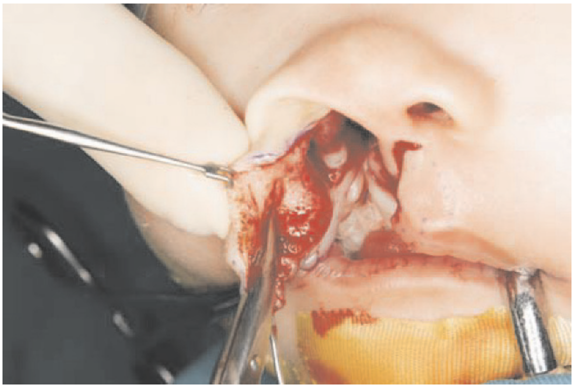


Fig. 7.31 The orbicularis peripheralis muscle (OP) is released in a subdermal plane. The abnormally inserted fibers of the nasalis, depressor septi, and levatormuscles are released from the base of the ala. The Angular artery (pointed by the hemostat) is used as a landmark for muscle dissection

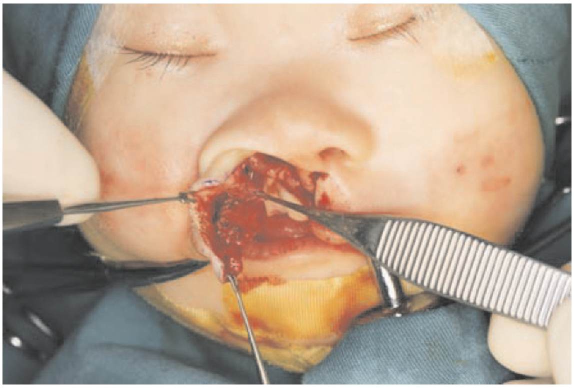


Fig. 7.32 The abnormal muscle insertions are completely released from the alar base. The muscle grasped by the forceps originally inserts above the alar base

Fig. 7.33 The adequacy of muscle dissection is checked by pulling the muscle of the advancement flap medially trying to approximate the muscle

Discussion on Muscle Dissection

Failure to release all the abnormal muscle insertions to the alar base is responsible for the lateral and downward displacement of the alar base seen in secondary cleft nasal deformities. The angular artery is used as a landmark as it runs lateral to the alar base. Muscle dissection lateral to this vessel will have a better chance of releasing the abnormal muscle insertions to the alar base. Another advantage of adequate muscle dissection is to increase the lateral lip in its vertical and horizontal dimensions. The vertical height of the lateral lip is usually short at initial measurements, comparing with the non-cleft side. By dissecting the muscle higher than the alar base and rotating the muscle downwards, the height of the lateral lip can always match the height of the rotation flap.

7.3.6 Elevation of the Orbicularis Marginalis Flap

The orbicularis marginalis (OM) flap is incised along the incision line of the advancement flap to include the OM muscle, the vermilion medial to point CPHL', and the corresponding mucosa posteriorly (Fig. 7.34). The OM flap is elevated to its base beneath the point CPHL' in such a way that the volume of the flap at its base is similar to the volume of the free border at the point CPHR on the non-cleft side (Fig. 7.35). The incision plane of the OM flap should be perpendicular to the skin of the lateral lip and not beveled (Fig. 7.34).

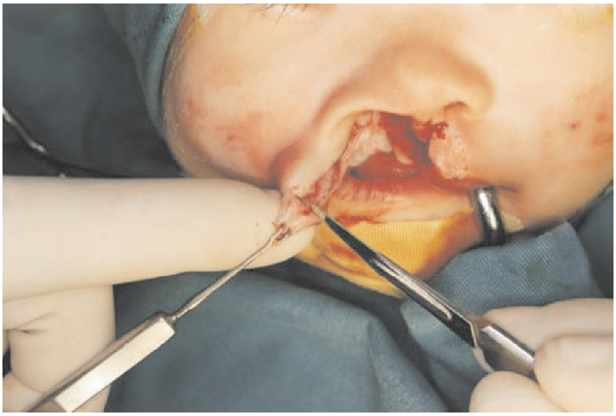


Fig. 7.34 The orbicularis marginalis flap is elevated to its base beneath the philtral column (CPHL') with a No. 11 blade. The cut surface is perpendicular to the skin

Fig. 7.35 The orbicularis marginalis flap is raised in such a way that the volume of muscle at its base CPHL' is similar to the volume of muscle at the opposite point CPHR on the noncleft side of the lip

7.3.7 Nasal Floor Reconstruction

The previous attachment of the lateral crura of the LLC to the piriform area is repositioned superiorly with its lateral crura fixed to the upper lateral cartilage with interrupted polyglactin sutures. The inferior turbinate flap is rotated 90° to fill in the defect on the piriform rim (Fig. 7.36). Its superior edge is sutured to the inferior margin of the previous piriform incision. The inferior turbinate flap corrects the mucosal deficiency in the piriform area after mobilization of the alar base. The L-flap is brought across the cleft and sutured to the perichondrium of the previous incision behind the columella (Fig. 7.37). The C-flap mucosa is turned laterally and placed below the L-flap (Fig. 7.38). It is attached to the maxilla and sutured to the inferior edge of the L-flap. The inferior edge of the turbinate flap is sutured to the superior edge of the L-flap with interrupted 5-0 polyglactin sutures (Figs. 7.39 – 7.40). This gives good mucosal coverage of the nostril floor and lateral nostril wall without any raw surface or tension. The vestibular skin with attached ala is advanced over the mucosal bridge (Figs. 7.41 – 7.42). The point at the junction of free margin incision and piriform incision should be sutured to the uppermost point of the incision behind the columella (Fig. 7.43). The upper free edge of the vestibular skin flap and bridging T-flaps and L-flaps are closed with interrupted 5-0 polyglactin sutures. This gives a good two-layer closure of the nostril floor and effectively corrects the tissue deficiency in this area. The vestibular skin is advanced as far as necessary to achieve a slightly over-corrected nostril width. Great care must be taken to preserve the nasal sill while doing an over-correction. Final positioning and closure of the nostril floor are done after muscle reconstruction.

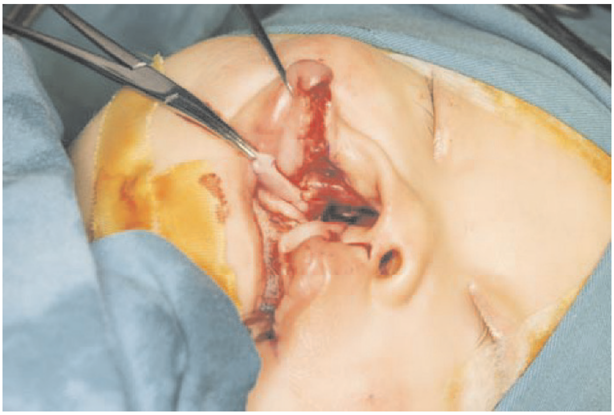


Fig. 7.36 The inferior turbinate flap is rotated into the piriform area. Its superior edge is sutured to the lower margin of the piriform incision

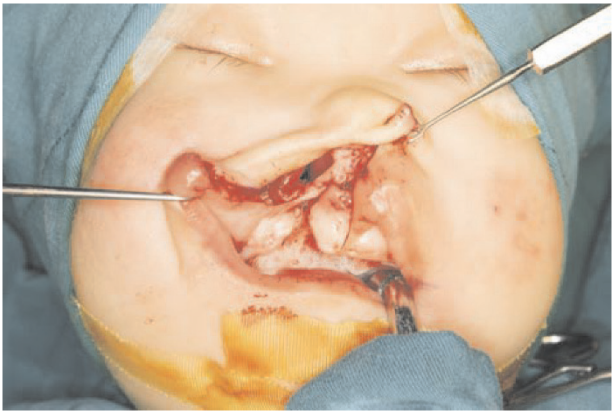


Fig. 7.37 The nostril floor is reconstructed with the L-flap sutured to the nasal septum

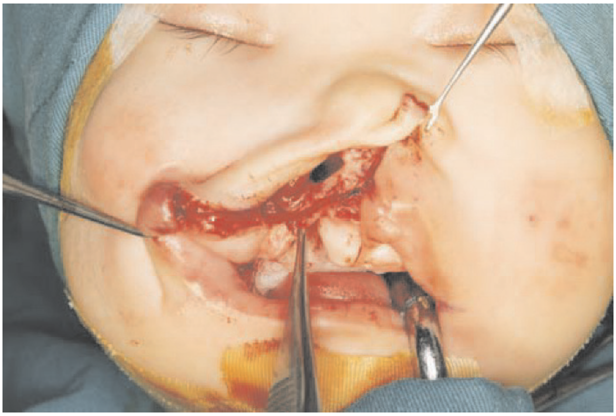


Fig. 7.38 The C-flap mucosa is sutured laterally to the maxilla below the L-flap

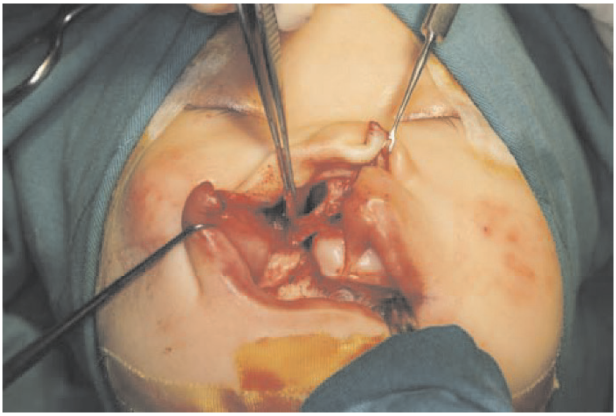


Fig. 7.39 The inferior turbinate flap is flipped over for the reconstruction of the upper and lateral part of the nasal floor

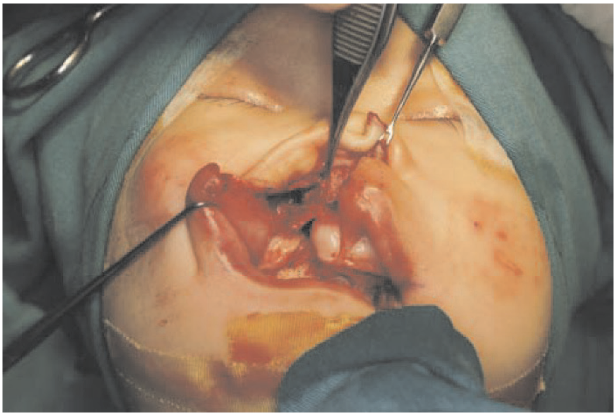


Fig. 7.40 The inferior edge of the inferior turbinate flap is sutured to the L-flap

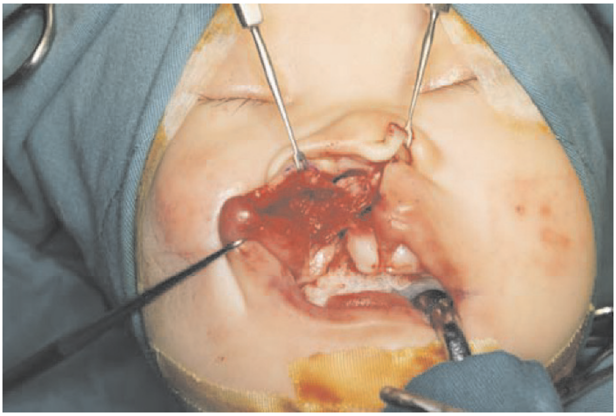


Fig. 7.41 Advancement of the vestibular skin inward

Fig. 7.42 Approximation of the margin of vestibulum to the upper edge of the inferior turbinate and L-flaps

Fig. 7.43 Completion of nasal floor reconstruction. There is complete wound closure without any raw surface in nasal cavity. The deepest point medial to alar base at the skin/mucosal junction is now sutured to the superior edge of the incision on the nasal septum

Discussion on the Nasal Floor Reconstruction

There are some variations on the tissue used for nasal floor reconstruction. With presurgical NAM (nasoalveolar molding), the alveolar gap at the time of lip repair is usually narrower than 5 mm. If the alveolar gap is narrow, an L-flap might not be necessary or could be used to fill the defect on the piriform area to replace the inferior turbinate flap. If the alveolar gap is very wide, i.e. wider than 15 mm, the L-flap might not be long enough to reach the nasal septum. A B-flap based on nasal vestibulum might be the alternatives for the L-flap as the B-flap, with its base on the nasal vestibulum, can be advanced easily with the alar base; thus its length will not be a problem in the presence of a very wide cleft. The inferior turbinate flap is a useful technique to provide tissue to the piriform area when an L-flap is needed to bridge over the cleft. The technique can be applied in secondary revisions when there is severe lining deficiency causing problems in repositioning of the LLC.

7.3.8 Muscle Reconstruction

A traction suture is placed in the center of the muscle, at points CPHL and CPHL' and pulled downwards to level the Cupid’s bow (Fig. 7.44). This traction suture allows the surgeon to put each muscle suture in its correct place. The muscle is approximated with a 5-0 polydioxanone suture. The first stitch is passed through the caudal edge of the nasal septum, catching the tip of the muscle in the advancement flap and back through the septum to anchor the lateral lip to the septum (Figs. 7.45 – 7.49). This anchoring suture helps to pull the lateral lip medially and centralize the Cupid's bow. The muscle sutures are placed in such a way that the lateral muscle is on top of the medial muscle to increase the muscle thickness and simulate a philtral column (Figs. 7.50 – 7.51). The muscle in the OM flap is also sutured to the medial lip in a mattress fashion to avoid any depression in this area after operation (Fig. 7.52).

Fig. 7.44 A traction suture is placed in the center of the muscle, at points CPHL and CPHL' and pulled downward to level the Cupid's bow. The tip of the C-flap at CPHL is rotated medially to fill in the defect on columellar base. The inferior edge of the C-flap is sutured to the superior margin of the rotation flap

Fig. 7.45 The septal anchoring suture: passing the needle through the nasal septum

Fig. 7.46 The needle comes out through the columellar base

Fig. 7.47 The needle then catches the muscle at the tip of the advancement flap

Fig. 7.48 Then go back through the muscle again as a mattress suture

Fig. 7.49 The needle then comes out through the nasal septum then the knot is tied

Fig. 7.50 The muscle sutures are all in vertical mattress overlapping the lateral lip on top of the medial lip. The needle is passed through the muscle in the lateral lip

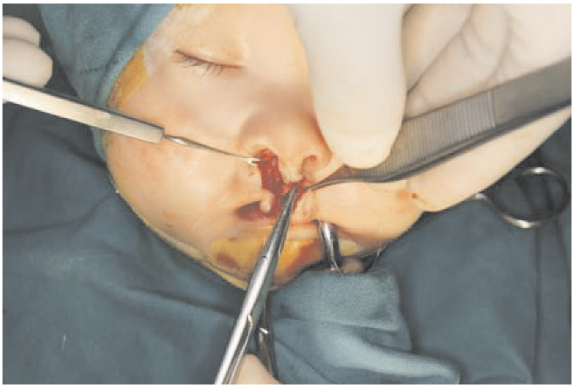


Fig. 7.51 The catches the muscle in rotation flap, passing through the medial lip again then back to the lateral lip as a mattress suture

Fig. 7.52 The orbicularis marginalis muscle is sutured in a same fashion

7.3.8.1 Discussion on the Septal Anchoring Suture

The septal anchoring suture helps to pull the cleft side lateral lip medially towards the center. It helps to prevent the lateral lip from deviating to the cleft side, which is commonly seen in secondary deformities. This suture is in the cephalic direction; thus it will shorten the lateral lip vertically. Adequate muscle dissection to the level higher than the alar base is essential before putting in this anchoring suture.

7.3.8.2 Discussion on the Philtral Reconstruction

Reconstructing the philtral column in repairing unilateral clefts needs several important steps: 1) Correct skin incision line: the Mohler's incision is more vertical and more lateral compared with the incision line of the original rotation-advancement technique. The final position of the suture line of the Mohler's incision is more coincident with the position of the philtral column on the cleft side. 2) Thicker muscle to mimic the philtral column: the overlapping mattress muscle sutures can effectively increase the muscle thickness needed for a philtral column. 3) Skin laxity: besides the muscle thickness, loose skin is necessary to recreate a bulging philtral column. The "excessive' skin appearing after muscle reconstruction is preserved to provide enough laxity for the bulging of a philtral column. 4) Thicker skin: the thin layer of muscle left on the wound margin helps to increase the skin thickness for a philtral column.

7.3.9 Incisions on the Nasal Floor

The points CPHL and CPHL' are approximated with 7-0 polyglactin sutures. The Cupid's bow is leveled with a small hook to check the alar base position (Fig. 7.53).

No lateral horizontal skin incisions for the lateral rotation-advancement flap are made initially, as the surgeon can now better visualize how to make appropriate incisions that will eliminate incisions around the ala: these are avoided and seldom needed. If the alar base and the peak of the Cupid's bow on the cleft side are still high, incision is made inside the cleft side nasal floor in the direction shown in Fig. 7.54. This incision can vertically lengthen the lip and level the alar base and Cupid's bow (Figs. 7.55 – 7.56). The other tip of the C-flap (the most lateral point of skin overlying the premaxilla) is brought laterally to fill in the defect on the nasal floor after the incision. If the alar base has been already leveled after muscle reconstruction, incision is made in the direction shown in Fig. 7.57. The incision can maintain the alar base position (Fig. 7.58). Every attempt is made to preserve the nasal sill. The nostril width on the cleft side is slightly over-corrected (narrower than the non-cleft side) as the authors' experience shows the cleft side nostril will widen in time after operation.

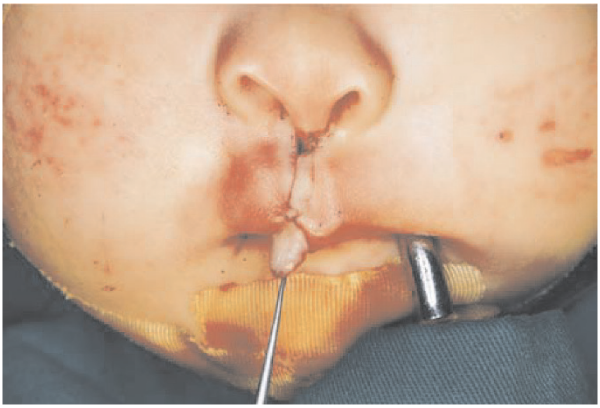


Fig. 7.53 The points CPHL and CPHL' are approximated. The philtral base at CPHL/CPHL' is pulled down by a single hook to check the adequacy of the rotation

Fig. 7.54 If the alar base on the cleft side is still high after leveling the Cupid's bow, nasal floor should be incised along the marked line inside the nasal floor

Fig. 7.55 The alar base will move downward after the nasal floor incision

Fig. 7.56 The other tip of the C-flap is brought laterally to close the nasal floor

Fig. 7.57 If the alar base is symmetrical in their position a the incision line should be made along the marking line for maintaining the alar base position

Fig. 7.58 The other tip of the C-flap is also brought laterally for nasal floor wound closure

Discussion on Nasal Floor Incision

After approximation of the orbicularis muscle, it is necessary to interdigitate the C-flap and the nasal floor for leveling of the nasal floor. The incision of the nasal floor depends on the alar base position. The incision on the nasal floor and around the alar base in the original rotation-advancement technique has been eliminated in the Chang Gung Craniofacial Center for almost 20 years. This incision always leaves an unsightly scar on the nasal floor. The perialar incision tends to flatten the ala-facial groove. Another advantage of our technique is the ability to preserve the nasal sill. The nasal sill is a unique tissue which is very difficult to reconstruct in secondary deformities and should be carefully preserved in primary repairs.

7.3.10 Reconstruction of the Free Border of the Lip and the Buccal Sulcus

The vermilion flap is marked and incised on the OM flap while the OM flap is held under tension (Figs. 7.59 – 7.60). After the vermilion flap is incised, an incision is made along or above the red line of the medial lip beneath the point CPHL to open the lip for insertion of the vermilion flap. The width of the vermilion flap should correct the vermilion deficiency under the Cupid's bow. The tip of the vermilion flap should not cross the natural lip tubercle (Fig. 7.61). The excess mucosa on the free border of the lip is trimmed so the two edges fit together without excessive tissue. The most common error is to leave too much muscle or mucosa on the free border. Incisions on the vermilion are closed with continuous 7-0 polyglactin sutures. The lateral lip buccal mucosa is trimmed and closed with interrupted fine absorbable sutures. The upper edge of the buccal mucosa is sutured to the C-flap mucosa that bridges the alveolar gap. This gives a complete mucosal closure without tension.

Fig. 7.59 Markings of the vermilion flap

Fig. 7.60 The vermilion flap is cut with a No. 11 blade with the flap held under tension

Fig. 7.61 The medial lip is opened and the vermilion flap is inserted into the defect to correct the vermilion deficiency under the Cupid's bow

Discussion on the Free Border and Vermilion Flap

The free border of the lip consists of vermilion, mucosa, submucosal tissue and OM muscle [44, 45]. The junction of the vermilion and mucosa is a distinct line in histology, the red line. The deformity in this area is usually described in literature as the "vermilion deformity". However, the pathology might be due to vermilion itself, mucosal problems, muscle problems or a mixture of components. The vermilion is always deficient beneath the point CPHL. A straight-line closure of the free border of the lip will result in a characteristic deformity with the red line interrupted with a step-off appearance. Using the triangular vermilion flap from the lateral lip, vermilion deficiencies below CPHL can be satisfactorily corrected. A common mistake in this technique is to include too much muscle in the vermilion flap, which will result in a bulging appearance in the free border. Keeping the same volume in the base of the vermilion as its counterpart below the point CPHR is important to avoid this problem. The size of the vermilion flap can be accurately measured. Its width should be the difference of the vermilion height below CPHR and CPHL. The tip of the vermilion flap should not exceed the central lip tubercle; thus the length of the vermilion flap should be less than half of the Cupid's bow. The notching in the free border is usually due to muscle or mucosal problems. The muscle problem can be corrected by approximation of the OM muscle. A mattress suture for the marginalis muscle will have less risk for residual notching in this area. The mucosal tightness can be corrected by a Z-plasty, VY-plasty or local transposition flaps. Excessive mucosa should also be avoided to prevent lip distortion. If the lip is thin without a full free border of the OM muscle, it can be augmented with temporoparietal fascia. A bulging free border is frequently encountered in incomplete clefts even after the septal anchoring suture. It should be corrected in primary lip repair if the bulging is very prominent. The most accurate way to correct this deformity is to make an incision along the red line, raising an inferiorly based mucosal flap with a thin layer of marginalis muscle, trimming the excessive muscle in this area, re-draping the flap and trimming the excessive mucosa along the incision line.

7.3.11 Nasal Reconstruction

Several techniques have been used in the Chang Gung Craniofacial Center during the past 30 years. The evolution of the techniques includes:

1) A closed rhinoplasty with dissection of cleft side LLC from both skin and mucosa through columella and alar base;

2) A closed rhinoplasty with dissection of LLC from skin through columella and alar base;

3) NAM without cartilage dissection and repositioning;

4) NAM with dissection and repositioning of both LLCs through bilateral rim

incisions;

5) The present technique of a semi-open rhinoplasty with presurgical NAM, dissection and repositioning of both LLCs through rim incision on the non-cleft side and reverse U-incision on the cleft side, and over-correction of cartilage on the cleft side.

7.3.11.1 Incision

A rim incision is marked on the non-cleft side nostril and a reverse U-incision is marked on the cleft side. The reverse U incision is made about 1 – 2 mm higher than the alar rim on the non-cleft side (Figs. 7.62 – 7.63).

Fig. 7.62 The reverse U-incision on the cleft side nostril. It is made about 2 mm higher than the alar rim on the non-cleft side

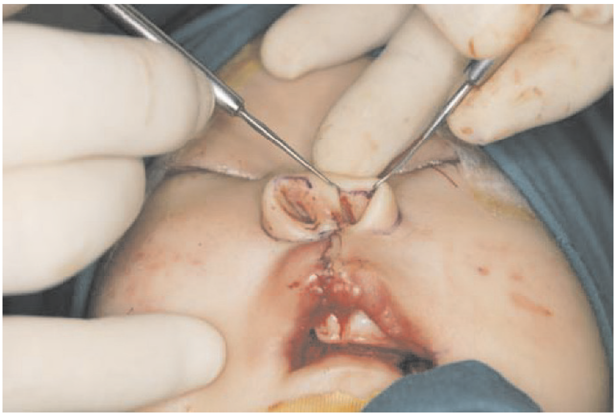


Fig. 7.63 The rim incision on the non-cleft side nostril

7.3.11.2 Dissection of LLCs

Incisions are made with a No. 67 blade. The caudal edges of both LLCs are easily seen through these incisions. The fibrofatty tissue above the LLCs is carefully released with sharp scissors to avoid any risk of iatrogenic injury to the cartilaginous framework (Figs. 7.64 – 7.67). The dissection is less traumatic compared with a closed rhinoplasty. The extent of dissection on the cleft side should be lateral to the groove on the caudal edge of the LLC to eliminate this groove.

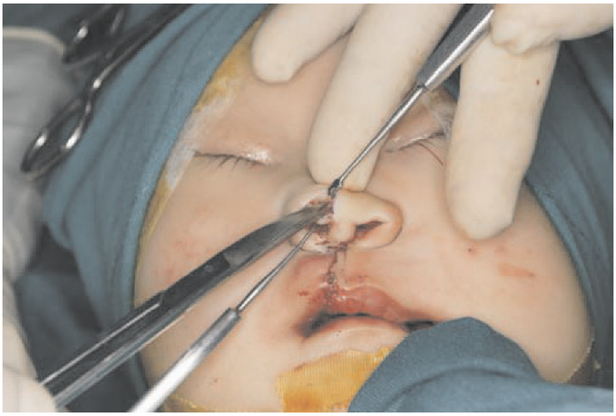


Fig. 7.64 The lower lateral cartilage is released from the fibrofatty tissue with sharp dissection

Fig. 7.65 The dissection on the cleft side is extending lateral to the lower edge of the lower lateral cartilage to eliminate the groove on the alar rim

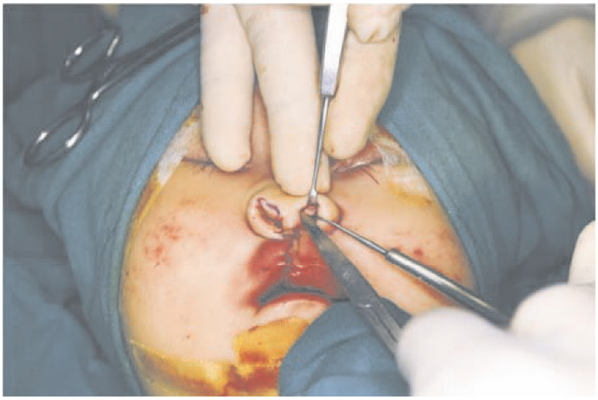


Fig. 7.66 The non-cleft side is dissected in a similar fashion

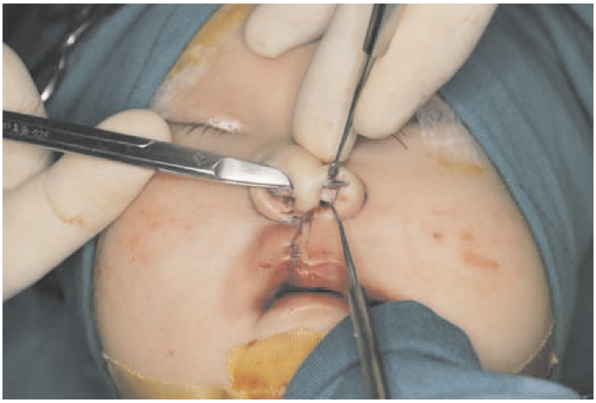


Fig. 7.67 Passing the scissors from one side to the other to make sure the tip fibrofatty tissue is completely released from the cartilages

7.3.11.3 Approximation of LLCs

The LLCs are approximated with 5-0 polydioxanone mattress sutures for medial rotation of the cleft side LLC. The alar domes are marked for accurate placement of the stitches. The stitches are placed more laterally on the cleft side LLC for over-correction (Figs. 7.68-7.73).

Fig. 7.68 The alar domes are marked for accurate placement of the sutures for approximation of the lower lateral cartilages. The needle is passing through the point lateral to the alar dome on the cleft side for more medial advancement of the cartilage

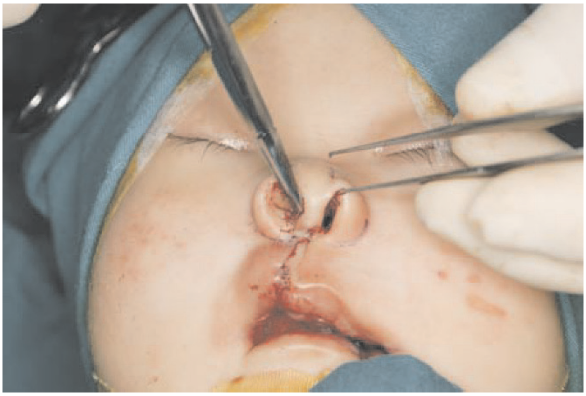


Fig. 7.69 The needle is passed through the subcutaneous tunnel with its tip pointed backward to prevent catching the soft tissue

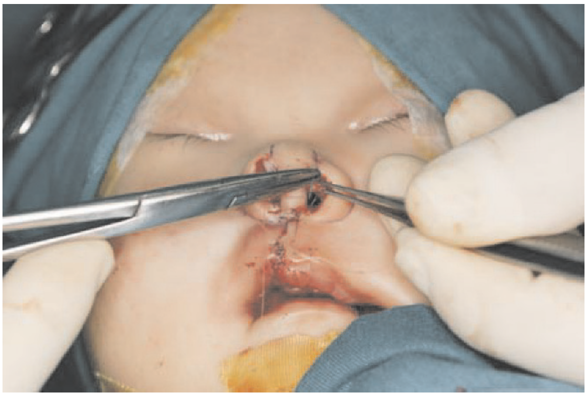


Fig. 7.70 The needle is then passed through the lower lateral cartilage on the non-cleft side at the alar dome

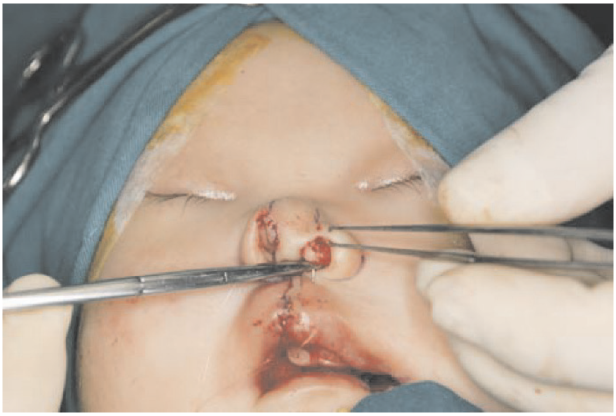


Fig. 7.71 The needle is passed through the cartilage again as a mattress suture

Fig. 7.72 Passing through the subcutaneous tunnel in the same fashion as Fig.7. 69

Fig. 7.73 Passing through the cartilage on the cleft side lateral to the alar dome. Tie the knot in the nostril

7.3.11.4 Re-draping the Soft Tissue

After repositioning of the LLCs, the nasal tip soft tissue is re-draped on top of the alar domes. There will be some excessive skin on the upper part of the cleft side columella which is the skin originally below the reverse U-incision. This excessive skin is responsible for the webbing on the soft triangle in secondary cleft nasal deformity. This excessive skin is carefully trimmed with sharp scissors and the wound is closed with 5-0 polyglactin sutures (Figs. 7.74 – 7.75). Another mattress suture stitch is placed on the medial crura below the first suture approximating the LLCs for reinforcement (Figs. 7.76 – 7.77).

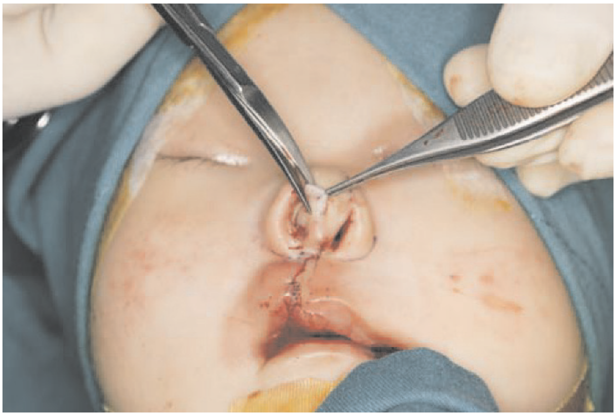


Fig. 7.74 Trimming the excessive skin on the upper part of the columella

Fig. 7.75 Wound closure in both alar rims. The cleft side is over-corrected (higher and narrower on the cleft side)

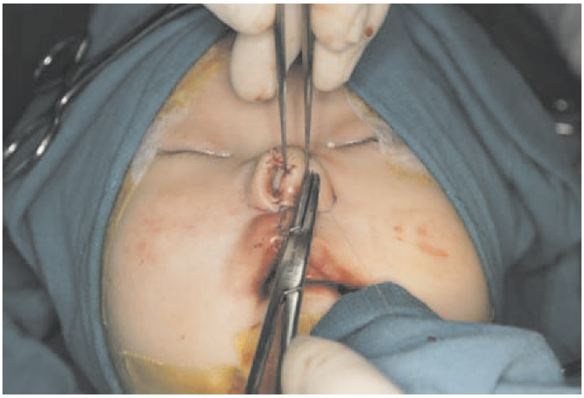


Fig. 7.76 Another mattress suture on medial crura under the first one for reinforcement. Passing the needle from the non-cleft side nostril through the septum

Fig. 7.77 The needle comes out through the cleft side nostril and back through the septum again

7.3.11.5 Alar Base Repositioning

Achieving symmetry in the position of the alar bases is essential for a good nasal reconstruction in repairing unilateral clefts. The most important factor in achieving good alar base symmetry is adequately releasing the abnormally attached paranasal muscles. In reconstructing the nostril floor, the alar base is advanced medially to a slightly over-corrected position, i.e., the nostril width on the cleft side should be slightly narrower than its counterpart. The alar-facial groove is further accentuated by the approximation of the lip musculature.

7.3.11.6 Alar Transfixion Sutures

Dissection between the skin and LLC releases their fibrous attachments. It also leaves a dead space under the skin. Mobilization of the alar base off the maxilla will accentuate the vestibular webbing inside the cleft side nostril. The alar transfixion sutures help to solve these problems and define the alar-facial groove (Figs. 7.78 – 7.79). Two sutures are usually required. The lower suture is used to close the dead space and tack the vestibular webbing. The upper suture catches the leading edge of the LLC and helps to support it. Skin dimpling from the sutures disappears by 2 weeks after surgery.

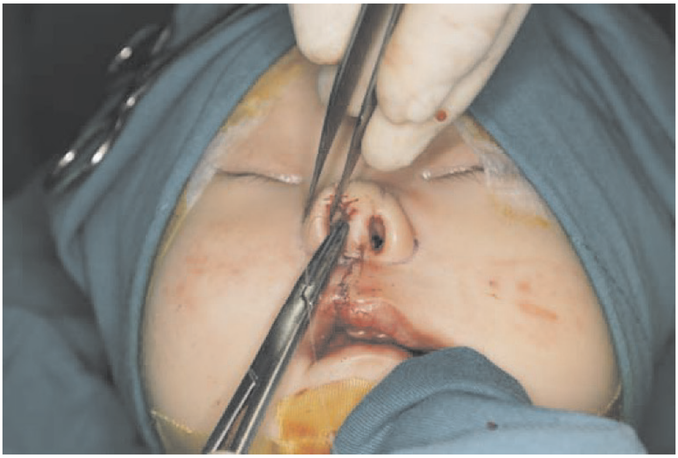


Fig. 7.78 The alar transfixion suture: passing the needle through the vestibulum on the cleft side nostril

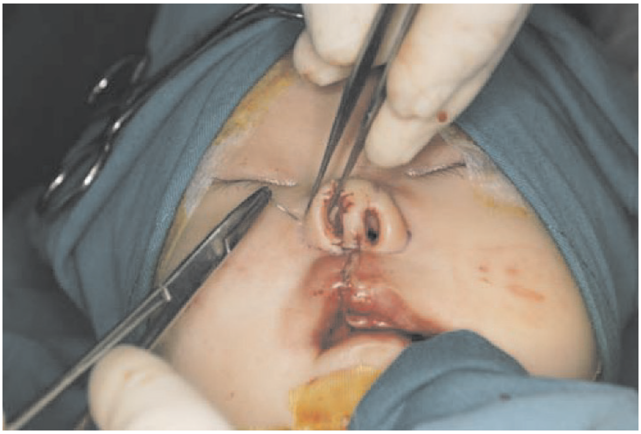


Fig. 7.79 The needle comes out at alar-facial groove then back through the same puncture hole to the vestibulum

7.3.11.7 Discussion on Nasal Reconstruction

The cleft rhinoplasty is notorious for its relapse. The evolution of the rhinoplastic techniques in the Chang Gung Craniofacial Center represents the efforts we have made in improving our results. The historic technique of a closed rhinoplasty with dissection of the cleft side LLC from skin and mucosa through columella and alar base was given up owing to the high risk of internal stenosis in the cleft side nostril and the high percentage of relapse of the cartilage position. The second technique of closed rhinoplasty with dissection of LLC from skin through columella and alar base, although it had less risk of internal stenosis, still had a high percentage of recurrence of the deformity. During the late 1990s, we were quite happy with the result of NAM that no cartilage dissection was performed during lip repair. The nasal shape was purely resulting from the molding effect. A study of three years long-term follow-up of that group of patients revealed a high percentage of recurrence of the initial deformity. Cartilage dissection and repositioning was performed again after that study despite the good nasal shape from NAM before lip repair. It was performed through bilateral rim incisions for an atraumatic cartilage dissection. A common residual deformity after this technique is the hooding in the soft triangle area in the cleft side nostril. A reverse U-incision was suggested to overcome this problem. Part of the skin under the margin of the reverse U-incision was turned in into the lining in the alar dome. The apparent excessive skin in this area is responsible for the residual hooding and should be trimmed carefully during operation.

It was uncommon to see that deformed or hypoplastic cartilages in the cleft side during secondary rhinoplasty in patients who had closed-type rhinoplasty in their primary repairs. The cartilage quality was much better in patients who did not have any cartilage dissections in their primary repairs. Iatrogenic injury of the cartilage during blunt dissection in closed rhinoplasty was thought to be the reason for this difference. This finding explains why we used reverse U-incision and rim incision as these incisions can get easy access to the caudal edge of the LLCs, thus providing a clean dissection over the cartilages to avoid the risk of iatrogenic injury during cartilage dissections.

The alar transfixion sutures are important to close the dead space under the ala after dissection of cartilage from skin, to tack down the vestibular webbing after releasing the alar base from the maxilla and provide extra support to the LLC by restoration of the fibrous attachment between the skin and LLC in its caudal edge of the lateral crura [46]. The vestibular webbing tends to recur after this alar transfixion suture. However, the author prefers to leave this excessive webbing in place till the time of secondary rhinoplasty to prevent any lining deficiency in this area in secondary rhinoplasty.

7.3.12 Final Skin Closure

The tip of the advancement flap is sutured to the most lateral point on the junction of the C-flap and the rotation flap. The suture line on the lateral part of the rotation flap thus mimics the philtral ridge. Excess skin on the nostril floor is excised as necessary with careful preservation of the nasal sill. The nasal floor is closed with 5-0 polyglactin sutures and lip skin is closed with 7-0 polyglactin sutures (Figs. 7.80 – 7.81). The small triangular WSR flap on the lateral lip is directly approximated to the medial lip to reconstruct the bulging of the WSR. If the WSR on the medial lip is less prominent, a small horizontal incision can be made slightly above the point CPHL and the WSR flap from the lateral lip can be inserted into the medial lip for augmentation of the WSR above the CPHL.

Fig. 7.80 Final appearance after wound closure. Note the insertion of the small white skin roll flap to a small cut above point CPHL

Fig. 7.81 Worm-eye's view. Note the over-correction of the cleft side nostril

7.3.13 Adequacy of Rotation (Small Triangular Flap)

It is important to make any necessary minor adjustments before finishing the operation.

The cleft side Cupid's bow must be adequately rotated. If it is slightly elevated, a small hook is used to place the Cupid's bow under tension. A short transverse incision is made above the WSR to release the Cupid's bow into its proper position (Fig. 7.82). An appropriately sized small triangular skin flap, 1 – 2 mm in width, is incised from the lateral lip and used to fill the defect above the WSR. It is held with fine 7-0 polyglactin sutures. This small triangular skin flap is also helpful for improving the lip pout as it tightens the skin above the WSR.

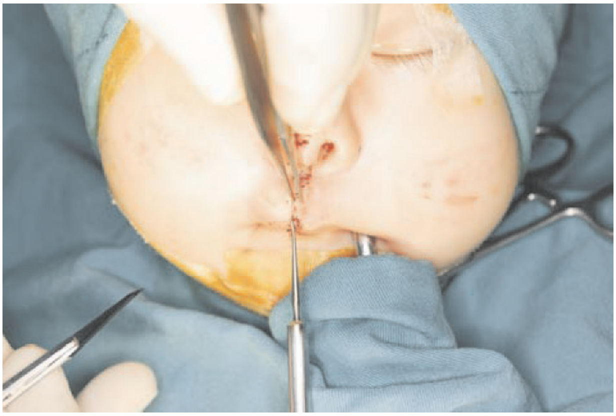


Fig. 7.82 If the rotation is inadequate after muscle approximation, the white skin roll flap can be inserted into a transverse cut above the point CPHL. If a bigger triangular flap is needed, the transverse cut can be made above the white skin roll

7.4 Postoperative Care and Maintenance

7.4.1 Postoperative Care

The parents are instructed to cleanse the wound with normal saline-soaked cotton swabs. The suture line is covered with a thin layer of antibiotic ointment to prevent crusting. There is no limitation for bottle feeding, no arm restraints and no wrapping over the hands. Postoperative bottle feeding has been used in the Chang Gung Craniofacial Center for over 20 years. There was no increased risk of wound dehiscence. The patient can leave hospital as soon as oral feeding is accepted. Stitches are removed in the outpatient clinic under sedation with oral chloral hydrate.

Discussion of Postoperative Care

Use of the same feeding device can avoid the possible feeding problem from a new device. Arm restraints or hand wrappings can make the child uncomfortable and are therefore not suggested after operation. The experience in the Chang Gung Craniofacial Center supports our theory that to keep the patient comfortable is essential for a smooth postoperative course.

7.4.2 Scar Care

The scars are supported with Micropore tapes and silicone sheet. Massage of the scar is helpful to facilitate scar maturation. Silicone sheet is also found to result in a better scar.

7.4.3 Maintenance of Nasal Shape

Silicone nasal conformer (Koken, Japan) is used for postoperative maintenance of nasal shape [47-50]. The shape of the conformer is modified to keep the cleft side nostril in its over-corrected position. The modification is made with gradual increase of the nostril height by adding silicone sheet on top of the alar dome in the conformer. Increase in the size of the conformer is not suggested, as our experience shows that the cleft side nostril will widen by itself. Only the height of the conformer on the cleft side needs to be increased. The thickness of the silicone sheet is 1 mm. It usually needs to be 3 – 4 mm higher on the cleft side to maintain the over-corrected position (Fig. 7.83). The child needs to wear the conformer as long as possible, usually 6 to 9 months. The success of the nasal conformer depends on good cooperation of the parents rather than the compliance of the patient.

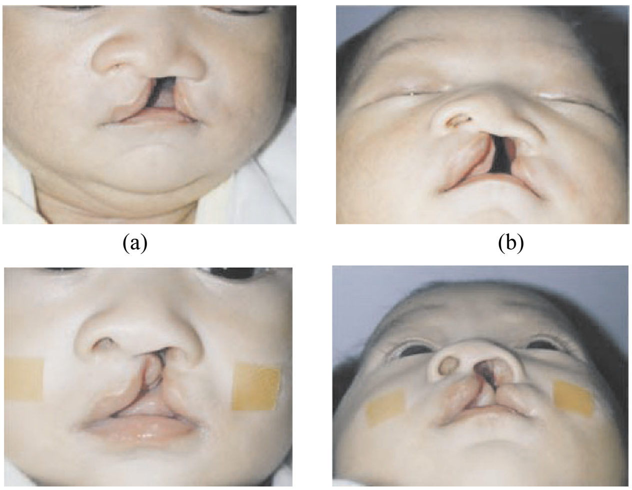
Fig. 7.83 Modification of the silicone nasal conformer: the height on the cleft side is gradually increased by adding silicone sheet on top of the dome. One layer of silicone is 1 mm in thickness. Here the cleft side is 3 mm higher than the non-cleft side

7.4.4 Complications

The possible complications after lip repair include airway problems, feeding problems, bleeding, hematoma, wound infection, wound dehiscence, stitch abscess and hypertrophic scars. 129 patients receiving unilateral cheiloplasty in the Chang Gung Craniofacial Center from January 2007 to December 2008 were evaluated for these postoperative complications. There were no instances of airway problems, no feeding problems, no bleeding episodes, no hematoma, and no wound dehiscence. There was one minor separation of the nasal floor and one minor separation of the nasolabial junction that healed without problems. There was no wound infection except for 6 stitch abscess. Hypertrophic scar was noted in 4 patients.

7.4.5 Patient Satisfaction

There are no definitive criteria to evaluate the result of cleft lip repair. The percentage of patients needing a major or minor revision depends on the surgeon's skill and subjective evaluation. The same surgeon might have classified the same patient into the category of "needs minor revision" 10 years ago and reclassify to the category of "needs major revision" 10 years later when the surgeon has become more skillful. The other criterion using the percentage of patients who had revision or who asked for revision is also controversial. It depends on the parents' or patients' psychosocial adaptation. A patient with a good result in one center might ask for a revision in another center. However, it can be used as a criterion for the same surgeon or the same center. About 60% of the patients in the Chang Gung Craniofacial Center asked for a lip/nose revision before school age in the early 1990s. Few patients at the same age have asked for lip/nose revision in recent years (Figs. 7.84 – 7.85).



(a) (b)

(c) (d)


(e)

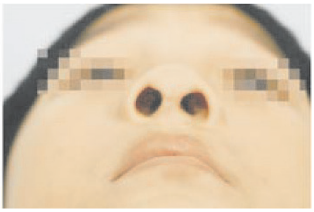

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Fig. 7.84 A boy with left complete cleft of primary and secondary palate. (a), (b): First visit; (c), (d): After nasoalveolar molding; (e) to (h): 5 years after initial lip repair


(a)


(b)


(c)


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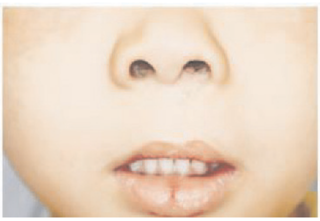
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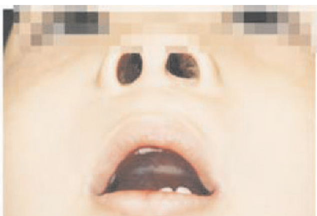
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(g) (h)

Fig. 7.85 A girl with left complete cleft of primary palate. (a), (b): First visit; (c), (d): After nasoalveolar molding; (e) to (h): 6 years after initial lip repair

7.4.6 Long-term Results

A symmetrical balanced lip is our goal for cleft lip repair. A study was performed in the Chang Gung Craniofacial Center in 2007 to evaluate a group of 19 unilateral complete cleft lip and palate patients with 4 years follow-up for their lip symmetry. The surgical technique is similar to the present technique except for the septal anchoring suture. It was found that the Cupid's bow deviated to the cleft side; thus the measurements from alar base to the peaks of the Cupid's bow (VR, VL) and the horizontal lip length (HR, HL) are significantly different (Fig. 7.8). This is the merit for the septal anchoring suture which helps to pull the lateral lip to the nasal septum to centralize the Cupid's bow.

A study at 3 years' follow-up of the nasal morphology in a group of patients who had presurgical NAM but no cartilage dissection and repositioning during lip repair revealed that although the nasal shape was quite symmetrical immediately after operation, there were significant differences among the measurements in nostril height, columellar length and nostril width. The cleft side nostril height and columellar height were significantly shorter than their counterparts on the non-cleft side and the cleft side nostril was significantly wider. Another study, on a group of patients receiving modified Grayson's technique for NAM and surgical repositioning of the LLCs through bilateral rim incisions, revealed better results compared with the previous study. However, there was a similar trend among the different measurements. This is the merit of our present technique of nasal reconstruction: integrated approach with presurgical NAM; surgical refinements using reverse U-incision on the cleft side and rim incision on the non-cleft side; sharp dissection to release the fibrofatty tissue from cartilage; cartilage repositioning in an over-corrected position and trimming of the webbing in the soft triangle; and postoperative maintenance of the over-corrected nasal shape.

7.5 Summary

The integrated approach based on the experience in the Chang Gung Craniofacial

Center is an evolution over the past 30 years. It is a progressive process of periodic evaluation and re-evaluation of our own results, and refinements in treatment protocols. The presurgical management has varied from simple lip taping plus prone sleep position to very sophisticated NAM. The surgical refinements are combinations of techniques of our own original modifications or techniques adopted from other surgeons. The method of postoperative care has also been changed several times to try to achieve a better result. Although our approach is the experience based on Chinese populations, the technique has also been tested in other racially diverse centers. Even in some other centers without the facilities and personnel for presurgical NAM and postoperative maintenance, simply using the surgical refinements in our approach can still achieve a much improved result.

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Part III

Primary Repair of Bilateral Cleft Lip

8

Features of Bilateral Cleft Lip

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The deformity is more severe and the face is much more variable in bilateral compared with unilateral cleft. In bilateral cleft, the premaxilla is isolated from the lateral segments, and in many cases it protrudes far beyond the lateral segments [1-8]. This may be the most significant deformity in bilateral cleft when it is contrasted with the unilateral form. Furthermore, soft tissue defects are more severe [9-13].

In this chapter, the deformity of bilateral cleft has been anthropometrically. Casts of 16 bilateral cleft patients were used for measurement. The parameters were the following: length of prolabium, width of lateral lip, nasal width, protrusion of premaxilla, width of mouth, width between inner canthi. In addition to the measurements themselves, statistical analysis was carried out (Figs. 8.1 – 8.3).

Fig. 8.1 Frontal view of patient's nasolabial model before surgery and spotting

Fig. 8.2 Supine view of patient's nasolabial model before surgery and spotting

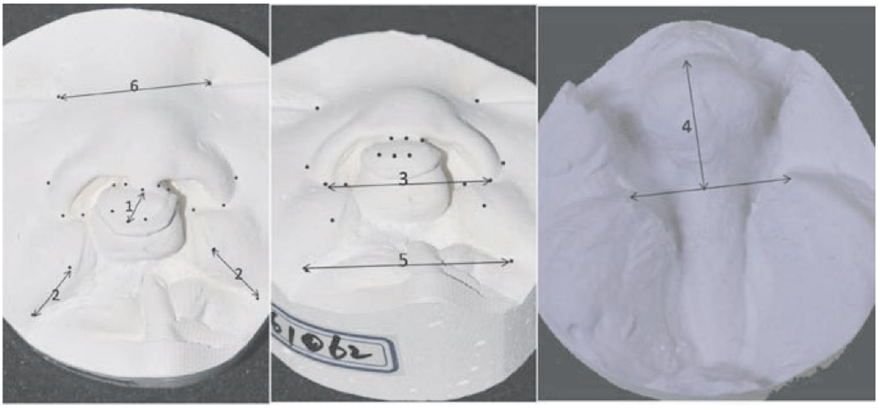

Fig. 8.3 Measurements: 1, Length of prolabium: base point of columella to the philtral; 2, Width of lateral lip: peak to the commissure. The lateral lip peak was identified on the white roll where the dry vermilion border at the greatest width. Lip width on either side is equal; 3, Nasal width: distance between nasal base; 4, Protrusion of premaxilla: vertical height between the midpoint of the premaxilla to the maxilla arch; 5, Width of mouth: distance between commissure; 6, Width between inner canthus: distance between the inner point of bilateral canthus

The length of the prolabium ranged from 4.10 – 8.82 mm, with an average of 6.46 mm. The prolabium is shorter and smaller in bilateral cleft lip before primary cheiloplasty. In some cases with a very short prolabium, a flap from the lateral lip should be designed and transferred to extend the short prolabium. But this flap transferred from the lateral lip should not be wider than 2 mm, or scar-formation would be obvious. Together with the premaxilla, the prolabium always protrudes beyond the lateral segments. In some of the most severe cases, this kind of protrusion ranges from 6.88 – 26.46 mm. This makes it more difficult to perform the operation. There is an observed tendency for there to be a smaller prolabium with a more protrusive premaxilla. However, this is just an impression without sufficient statistical confirmation. Sometimes, the prolabium is just a “piece” of skin and mucosa attached to the nasal tip and premaxilla. In these cases, the columella has also disappeared. Muscle might rarely be found in such a small and thin prolabium. In our study, there is no significant correlation between the length of prolabium and premaxillary protrusion. During the presurgical treatment of bilateral cleft, the protrusion could be corrected but the length of the prolabium could not be increased.

A close correlation between nasal width and prolabium width was found in our study. Nasal width varied from 24.93 – 33.98 mm, with an average of 29.52 mm. The surgeon always focuses on nasal width, which should be narrowed by cheiloplasty. Greater nasal width will make restoration difficult even though there is greater prolabium width. The ideal design for bilateral cleft is not to reconstruct a wide philtrum, so the width of the prolabium does not help too much during cheiloplasty. In our study, we did not analyse prolabium width because we consider that its length is more important than its width. A narrow and shield-shaped philtrum always looks better than a wide round one [14, 15].

There was a positive linear correlation between nasal width and nasal tip height. Nasal width and nasal tip height are sensitive parameters describing the nasal deformities. Nasal tip height ranged from 5.57 – 11.28 mm, though the columella might be short or even have disappeared. A flat nasal tip is a typical deformity in bilateral cleft. The cartilage might not be well shaped, and the outside base is always stretched outwards, leaving a space beneath the nasal tip occupied by fibrofatty tissue. This makes the nasal tip flat and rounded. During primary cheiloplasty or revision, a flat nasal tip should be narrowed. This space should be dissected thoroughly, and the fibrofatty tissue should be cleared. By this operation, the columella can be elongated, and the collapsed nostril can be corrected. There was no linear correlation between nasal tip and prolabium length. They should be repaired separately.

Commissure distance and nasal width are horizontal parameters. In our study, commissure distance ranged from 33.79 – 44.23 mm. There was a positive linear correlation between them. It is easy to understand that the wider the nasal width, the wider the cleft. When the cleft is closed, there will be a disharmonious relationship between the upper and lower lip. The dissection of muscle and mucosa must be thorough, or there will be a considerable pressure on the premaxilla. This would result in ~~a~~ growth retardation of the midface [16, 17].

The width of the nostril is another deformity in the bilateral cleft. It ranged from 12.01 – 23.05 mm on the left side and from 10.42 – 23.25 mm on the right side. Together with the lateral segment, the lateral lips were stretched outwards significantly, widening the nostril. Compared with a control group in our previous research, there is a significant difference. Nostril width is not merely a vertical or horizontal distance, but a distance from the center to the outside and from front to back. This is more difficult to repair than in unilateral cleft. To make the operation easier, presurgical treatment is strongly recommended. Except for prolongation of the columella, narrowing of the nasal floor cleft and pushback of the premaxilla are also of great importance [18-20].

Palate cleft ranged from 25.78 – 36.20 mm, much wider than in unilateral clefts. In addition, the vomer is thinner and shorter. And it may be a concern that the vomer flap may be insufficient to close the hard palate cleft. Some surgeons tend to do this on one side to ensure the flap obtains sufficient blood supply. The mucoperiosteum is narrower than in the unilateral cleft. The releasing incision is always needed in palatoplasty, which leaves much more bone surface exposed [21].

We found that tissue deficit and tissue displacement are more severe in bilateral compared with unilateral cleft lip and palate. There is a different range of muscle deficit in the prolabium. In some of the most severe cases, there is even no muscle tissue between the skin and mucosa, or just a few strands of muscle which are not usable. The philtrum ridge and Cupid's peaks could not be defined. The vermilion could be thinner or nearly normal. Lip heights in the prolabium and in the lateral lip do not match each other [22, 23]. In the lateral lip, Cupid's peak might or might not be discerned. Muscle bulge could be seen in some cases. Nasal deformity is typical in bilateral cleft. The columella may be short or have disappeared in some cases, leaving the nasal tip directly connected to the prolabium. The nasal tip becomes lower and flatter. The alar base is significantly displaced outwards. The premaxilla could vary in size, and in some cases, the premaxilla was too large to be covered by the repaired upper lip [24, 25].

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9

West China Technique of Bilateral Cleft Lip Repair

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The reasons why the post-operative nasolabial morphology is better after unilateral cheiloplasty than after the bilateral procedure are as follows: (1) The lack of natural anatomical landmarks in patients with bilateral cleft lip, and the surgical techniques for unilateral cleft cases cannot be applied directly to bilateral cleft cases. (2) The severe separation and displacement of the mal-positioned upper lip, premaxilla and maxilla increase the complexity of the surgical procedures and the uncertainty of the result [1, 2].

9.1 Characteristic Deformities of Patients with Bilateral Cleft Lip Before and After Primary Cheiloplasty

The most prominent deformations before primary cheiloplasty include the following: the prolabium height does not coincide with the lateral lip height (the height of the prolabium is always shorter); the prolabial vermilion is insufficient and its color is different from the lateral vermilion; the gap in the anterior-posterior direction is large between the premaxilla and the lateral maxilla (the maximum distance can be 30 mm) and usually the premaxilla rotates; the columella is short or does not exist; the shape of the nasal dome is not evident; the nasal perimeter is long and even prolonged as the patient getting older.

There are several main deformities after primary cheiloplasty. There is an obvious scar on the upper lip because the tissue tension is strong in patients with bilateral cleft lip; the peak points of the Cupid's bow are asymmetric; the philtrum is not obvious; the shape of the Cupid's bow is distorted; there is no labia tubercle or the shape is abnormal; the columella is short; the nasal tip is not evident; the nasal base is too wide [3].

9.2 Presurgical Treatment for Patients with Bilateral Cleft Lip

Compared with patients with unilateral cleft lip, bilateral cases seem to be more pliable to presurgical treatment. Based on our experience in treating patients with Grayson's nasal alveolar molding (NAM), we think that the presurgical treatment has beneficial effects on treating bilateral cleft lip. A longer columella, and a flatter and larger prolabium can always be achieved after the presurgical treatment. In addition, the premaxilla comes back to a relatively central and retrusive location. Parents agree that the presurgical treatment largely helps in feeding. Presurgical treatment can reduce the difficulty of primary cheiloplasty, reducing tissue tension, and lengthening the columella. Therefore, presurgical treatment has value for patients with bilateral cleft lip [4, 5] (Fig. 9.1).

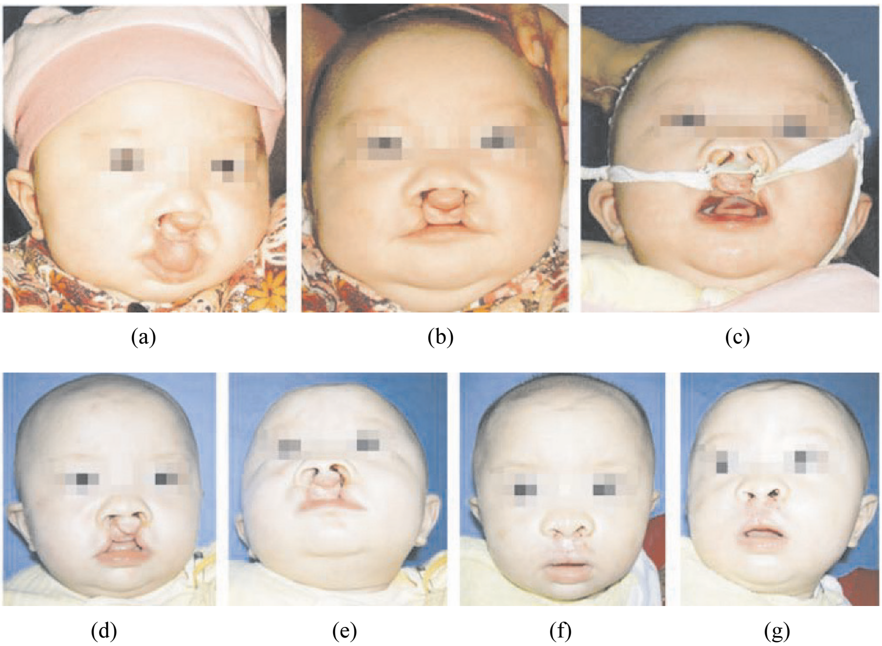


Fig. 9.1 (a) Patient before the presurgical treatment; (b) Front aspect before the molding; (c) During the molding; (d) Front aspect after the molding; (e) Inferior aspect after the molding; (f) Front aspect after the stitch removed; (g) Inferior aspect after the stitch removed

9.3 Surgical Principles of Treating Patients with Bilateral Cleft Lip [6]

Before the discussion of detailed operature techniques, some important principles should be described first.

9.3.1 The Time and Protocol of Operation

The ideal time of operation should be in 3 months. This will alleviate the development of nasal deformity. A one-stage operation should be applied for bilateral cleft lip because patients and their parents prefer fewer surgical interventions. A more important reason is that symmetry can be more easily achieved in a one-stage operation, which guarantees the proportional growth of the bilateral upper lip and premaxilla.

9.3.2 The Design of the Prolabium

In most cases, the height of the pre-operative prolabium can be used to determine the height of the upper lip after cheiloplasty and to recover the philtrum. However, this does not mean that we never use the pre-operative lateral lip. In fact, the lateral white lip near the vermilion can be used to mimic the white roll of the prolabium and to hide the scars in some cases. Based on our experience, the height of the upper lip after cheiloplasty would not become excessive. Conversely, this manipulation can lead to better symmetry between the prolabium and the lateral elements.

9.3.3 Reconstruction of the Vermilion

Several techniques have been reported to be successful in vermilion reconstruction in the literature. However, none of the techniques can be successful in all cases. Based on our experience, in most cases, the vermilion of the lateral elements can be used to reconstruct the vermilion of the postoperative prolabium while discarding the vermilion of the original prolabium.

9.3.4 Restoration of Continuity of the Orbicularis Oris Muscle

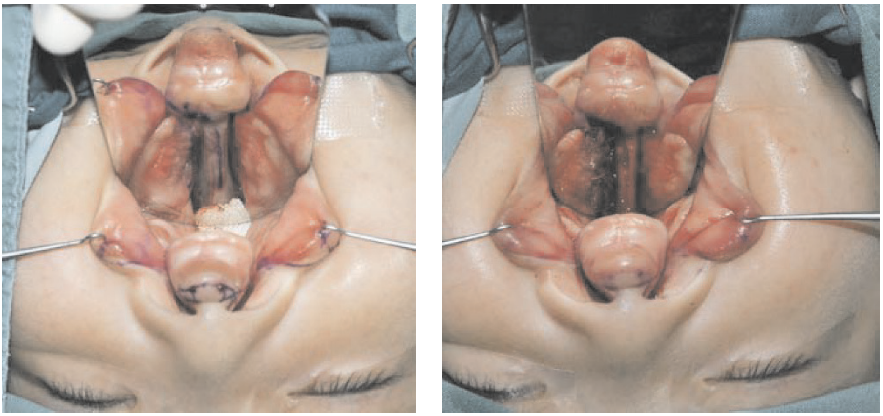
The upper end of the bilateral orbicularis oris muscles should be sutured beneath the prolabium-columellar skin flap. This assures continuity of the orbicularis oris muscle in the upper two-thirds of the prolabium.

9.3.5 Management of the Columella and Nasal Floor

It is difficult to lengthen the columella if the patient has not undergone any presurgical orthopedic treatment. The skin of the bilateral nasal domes is the only tissue that can be used to lengthen the columella in the operation. The nasal width of the patients with bilateral cleft lip is always greater than that of the normal population, and the difference becomes more distinct when the patients grow up. Therefore, the nasal width should be intentionally designed to be within normal limits.

9.3.6 Management of the Premaxilla

Before primary cheiloplasty, presurgical orthodontic devices and elastic bandages are used to push the protruded premaxilla posteriorly. We use a vomer flap to close the wider half of the palatal cleft, the ipsilateral alveolar cleft and nasal floor before cheiloplasty, just in the same way as we do in unilateral cleft lip repair (Fig. 9.2). Surgical transection or excision of the partial vomer to pull back the premaxilla should not be considered unless the nonsurgical method was practically ineffectual. However, the surgical manipulation will severely inhibit development of the maxilla. Furthermore, it will lead to dysplasia of the midface, collapse of the nose and lip and malocclusion. Therefore, surgical transection of the vomer should be postponed until the age of 9 to 11 years because the rapid development of the maxilla will have been completed by that time. After transection of the vomer, the premaxilla can be pulled posteriorly. Simultaneous bone grafting in the alveolar cleft can stabilize the bony structure of the premaxilla and promote the normal canine eruption. For patients with extremely severe protrusion of the premaxilla and mandibular deficit, the operative age can be advanced to 5 to 6 years old or even earlier. For patients with repaired bilateral complete cleft lip without cleft palate and with prominent protruded premaxilla, premaxillary osteotomy is necessary before alveolar bone graft.



(a) (b)

Fig. 9.2 (a) Design of vomer flap repairing bilateral cleft lip and palate; (b) Vomer flap covered left half of the palatal cleft

9.4 Incision Design for Patients with Bilateral Cleft Lip

Natural reference marks in patients with bilateral cleft lip are fewer than in patients with unilateral cleft lip. Cheiloplasty for bilateral cleft lip is complete reconstruction of the upper lip. The only parameter we can consult is the lip height of the original prolabium before operation. Reconstruction of the prolabium is the key procedure in the cheiloplasty for bilateral cleft lip because it determines the shape of the columella, the Cupid's bow and the whole upper lip. Up to now, there are no recognized universal data on the upper lip to guide the design for all patients. In our technique, we keep the whole white lip length of the pre-operative prolabium, utilize the white roll on the lateral sections to lengthen the lip height and shape the reconstructed prolabium based on the individual charactenistics of each patient [3] (Fig. 9.3).

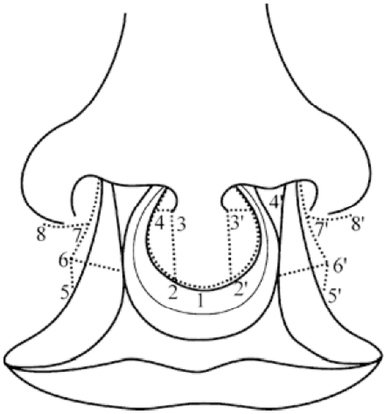


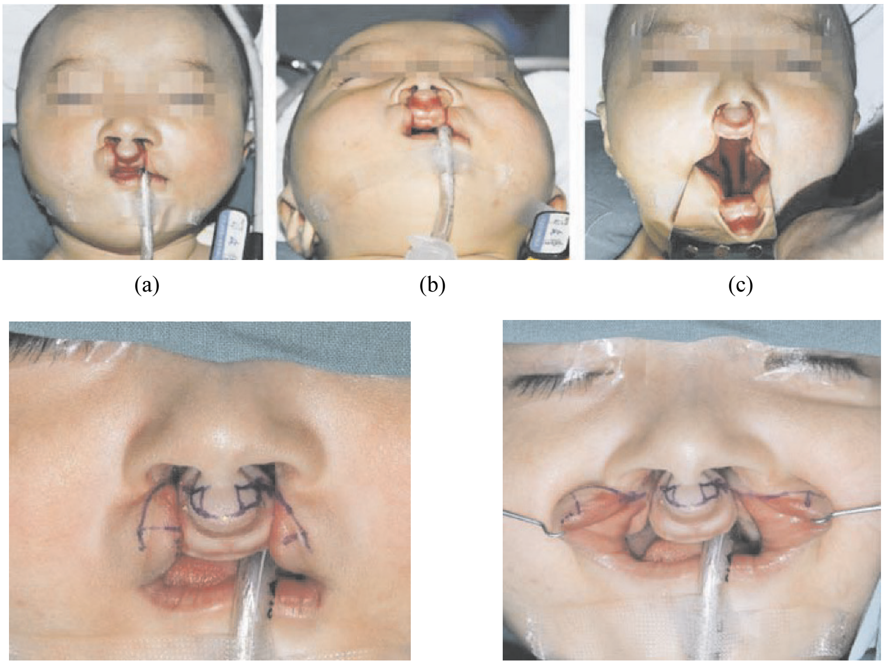
Fig. 9.3 Landmarks on bilateral cleft lip

Regarding the width of the prolabium, some experts emphasize that this should be designed according to the normal standard or even narrower. However, the fact is that the suture tension increases considerably and more scars form when the width of the prolabium is too narrow. Consequently, the practice has always been to avoid making the width of the prolabium too narrow in primary repair. It can not only alleviate the suture tension and scar formation, but also enhance the reconstruction of the labial tubercle and the elongation of the columella in secondary plastic repair with the redundant tissue.

There is no sense in designing the lateral lip height because this should be adjusted on the basis of the prolabium height during operation. The lateral lip height always seems to be too great. Therefore, the redundant skin of the lateral lips is usually excised at the time of final nasal floor repair.

9.4.1 Incisions on the Prolabium

No matter how the prolabium develops, the pre-operative prolabium should always be first chosen to build the philtrum. The lateral lips should not be arbitrarily utilized to lengthen the height of the philtrum because it might lead to an excessively long prolabium and asymmetry after operation. However, it does not mean that we never use the lateral lip. In fact, the white lip near the vermilion on the lateral sections can be used to mimic the white roll of the prolabium and to shade the scars in some cases. The distance of 1-2 is equal to the distance of 1-2' and the distances of 1~2+1~2' add up to 4 mm. The distance of 2-3 is equal to the distance of 2'-3'. The width between point 3 and point 3' is a little less than the width between point 2 and point 2'. The incision is along the lines 2-1-2', 3-2 and 3'-2' (Fig. 9.4).



(a) (b) (c)

(d) (e)

Fig. 9.4 (a) Bilateral complete cleft lip and palate (frontal view); (b) Bilateral complete cleft lip and palate (view from below); (c) Intraoral view of bilateral cleft lip and palate; (d) Landmarks and surgical design on bilateral cleft lip (frontal view); (e) Landmarks and surgical design on bilateral cleft lip (interior view)

9.4.2 Incisions on the Lateral Lip

The lateral lip height is usually greater than the prolabium height before cheiloplasty in patients with bilateral cleft lip, especially those with the incomplete condition. Therefore, a stable anatomic mark should be selected as the reference point on the lateral lips. In our technique, the peak point of Cupid's bow on the lateral lip is marked by identifying the greatest width of the vermilion border across from the white roll. The peak points of Cupid's bow on the lateral lips before operation are marked as point 5 and point 5'. The central points of Cupid's bow before operation on the lateral lip are marked as point 6 and point 6', which are located 2 – 3 mm medially and superiorly to points 5 and 5'. The distance from points 5 and 5' to their respective ipsilateral labial commissures should be equal. At the same time, the distance from points 5 and 5' to their respective ipsilateral alar bases should be equal.

Whether one locates points 5, 5', 6 and 6' on the vermilion border or on the white roll is determined by the length of the pre-operative prolabium. If the length of pre-operative prolabium is clearly shorter than normal, points 5, 5', 6 and 6' are located on the white roll. The distance from point 6 or 6' to the vermilion border should be a little greater than the distance from point 5 or 5' to the vermilion border. If the length of pre-operative prolabium is not clearly shorter than normal, points 5, 5', 6 and 6' are located on the vermilion border. Points 7 and 7' are marked medially to the alar base and points 8 and 8' laterally to the alar base. Through the incisions connecting 7-8 and 7'-8', the alar base is completely released from the maxilla and moved medially. Extension of the lateral lip height is not the aim of the incisions 7-8 or 7'-8'. Incisions along 7-8, 7-6-5, 7'-8', 7'-6'-5' are made on the lateral lips (Fig. 9.4).

9.5 Surgical Procedures [3, 7]

The surgical procedures are described in the following sections.

9.5.1 Formation of the Prolabial Flap

After marking on the lips, 1 – 1.5 ml of 1% lidocaine with epinephrine 1:200,000 is injected along the cleft. Then, dissect the lateral lips: cut through the skin along the lines 7-6-5 and 7'-6'-5'. The orbicularis oris muscle is dissected free from both the skin and the mucosa just as for the cheiloplasty for unilateral cleft lip, and released from the alar base. The alar base is dissected from the maxilla and pulled to the midline (Fig. 9.5).

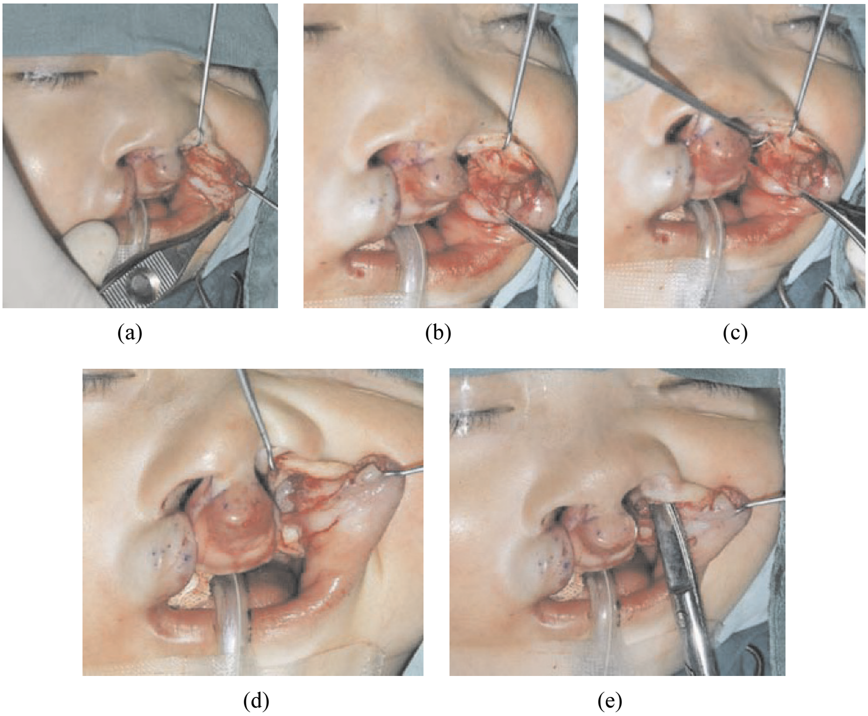


Fig. 9.5 (a) Incise along the white roll from the designed labial peak to nasal vestibule and connect with the incision of the hard palate; (b) Expose the nasal alar branch of the labial artery; (c) Free the nasal alar branch of labial artery and protect it. Cut off the deep muscle; (d) Expose anterior margin of the piriform foramen, dissect and separate the tissue attachments of the nasal floor; (e) Insert the scissors into the nasal base incision, creep under the superficial skin and detach its attachments to the nasal cartilage

9.5.2 Formation of the Lateral Upper Lip

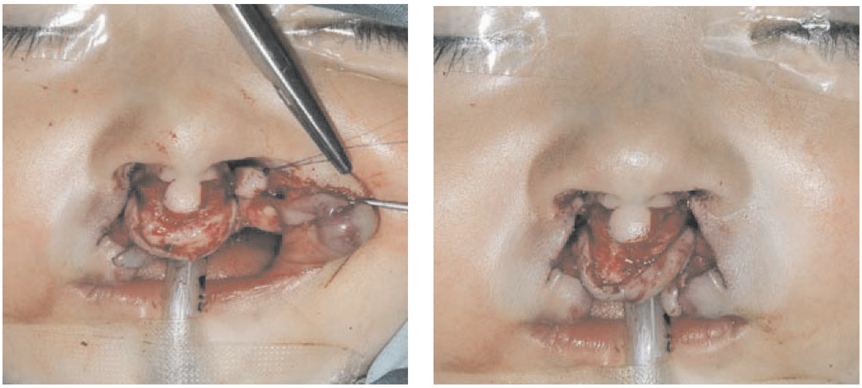
The skin lateral to the incisions along 2-3-4 and 2'-3'-4' is cut open and the medial triangular skin is removed. The vermilion of the prolabium is turned to the cleft edge. The skin and subcutaneous tissue enclosed by the incision along 3-2-1-2'-3' is dissected to the premaxillary periosteum. The dissection is extended to the columellar base and the prolabial skin flap is formed with the columella as the pedicle (Fig. 9.6).

(a) (b) (c)

Fig. 9.6 (a) Bilateral orbicularis muscles are degloveddissected; (b) Excise bilateral epidermis on the cleft edges of the prelabial flap; (c) Raise the prelabial skin flap upward to the nasal tip

9.5.3 Reconstruction of the Nasal Floor and the Nasal Sill

The orbicularis oris muscle sling is reconstructed and sutured to the anterior nasal spine on the maxilla. This suture can prevent the depression of the orbicularis oris muscle [8]. The junction between the alar base and the upper lip is horizontally cut open along the incisions 7-8 and 7'-8'. The skin flap medial to the alar base on the cleft side is turned over 90° and sutured to the skin flap of the columella to narrow the nasal floor and reconstruct the nasal sill. This procedure is similar to that in the cheiloplasty for unilateral cleft lip. One should take care to avoid making the nostrils too small in unilateral cleft lip, while in bilateral cleft lip repair the nostrils should be narrowed as much as possible and too wide a nasal base should be avoided [9, 10] (Fig. 9.7).

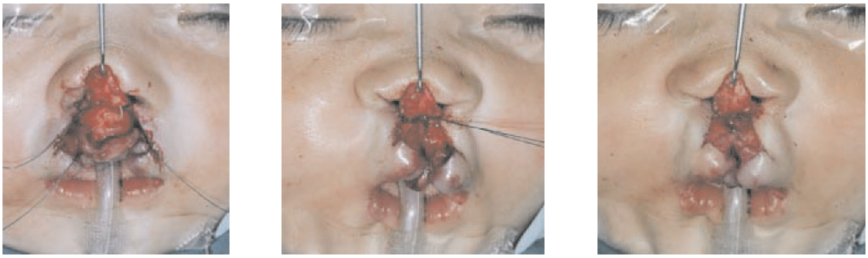


(a) (b)

Fig. 9.7 (a) Suture the vestibular layer of the nasal floor on one side; (b) Sutured bilateral nasal floors

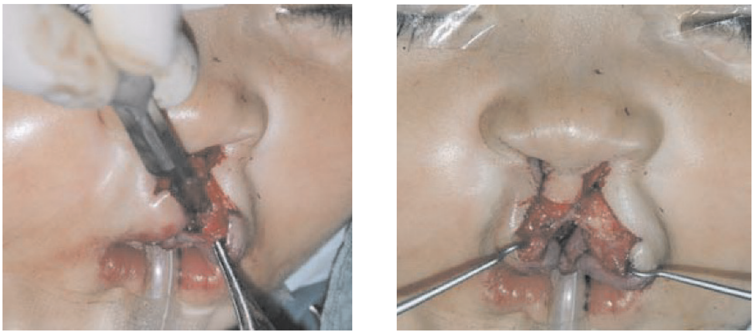
9.5.4 Sutures

The orbicularis oris muscles on the lateral sides are sutured above the premaxilla from the superior border beneath the columella base downwardly (Fig. 9.8). Cut through the skin, muscle and mucosa from points 5 and 5', extend superiorly to the alar bases across points 6 and 6'. Make sure the ends of the vermilion on the lateral lips involve enough orbicularis oris muscle (Fig. 9.9). The orbicularis oris muscle and the subcutaneous tissue is sutured to the opposite side with absorbable PDS. Points 6 and 6', points 5 and 2, points 5 and 2', points 1, 6, and 6', are sutured together respectively. Subcutaneous tissue is sutured before the skin. The lateral border with the higher peak point of Cupid's bow should be sutured first. Forceps are used to clip the superior end of the lateral lip throughout the whole suturing process. The lateral lip is carefully sutured to the prolabium and the redundant skin under the nasal floor is removed at the end. Attention should be paid to suturing the peak points of Cupid's bow on both sides at the same horizontal level. Thus, the distances from the alar base to the peak point of Cupid's bow on both sides are kept equal during the suture. The incisions on the lateral lips are adjusted to the length and shape of the prolabial lateral incisions [11, 12] (Fig. 9.10).



(a) (b) (c)

Fig. 9.8 (a) Pass the suture through the anterior nasal ridge when suturing the upper part of the orbicularis oris muscle; (b) Suture the orbicularis oris muscle end-to-end and fix it to the anterior nasal ridge; (c) Suture the upper 2/3 of orbicularis oris muscle end-to-end



(a) (b)

Fig. 9.9 (a) Cut the lower 1/3 of orbicularis oris muscle along the axis of muscular fibers and thus form two muscular flaps; (b) Use the muscular flaps to form labial pearl

(a) (b)

Fig. 9.10 (a) Suture the ends of bilateral muscular flaps; (b) The vermilion after suturing the muscles (view from below)

9.5.5 Repair of the Vermilion

In the repair of the vermilion for patients with bilateral cleft lip, the whistle deformity is a common abnormality because of the missing labial tubercle. However, the extreme pull of the vermilion on the lateral sides to form the labial tubercle will narrow the width of Cupid's bow too much. We should avoid both of the deformities during operation. When the bilateral ends of the vermilion are sutured at the midline, this can lead to asymmetrical thickness of the Cupid's bow on the two sides because the development of the vermilion is unbalanced. Small triangular flaps on the vermilion are designed and cross sutured to correct this asymmetry. A wide superior-based flap is designed on the side with the thicker vermilion and a narrow inferior-based flap is designed on the side with the thinner vermilion (Fig. 9.11).

(a) (b) (c)

(d) (e)

Fig. 9.11 (a) Sutured bilateral cleft lip (sketch map); (b) A patient with sutured bilateral cleft lip (frontal view); (c) A patient with sutured bilateral cleft lip (view from below); (d) One week after bilateral cleft lip repair (frontal view); (e) One week after bilateral cleft lip repair (view from below)

9.6 Tips on Cheiloplasty for Bilateral Cleft Lip

Keeping the pre-operative prolabium intact is a key factor of our technique. Thus, subcutaneous tissue lateral to the line 4-3-2-1-1'-2'-3'-4' remains on the prolabium, as introduced by Mulliken, especially in patients with complete cleft lip [1, 9]. The skin and mucosa is completely removed and a wing-shaped subcutaneous flap is formed with the prolabium as the pedicle, which is the lining when the lateral borders of the prolabium are sutured to the skin of the lateral lips. This procedure can promote healing and mimic the shape of the philtrum ridges (Fig. 9.4).

The orbicularis oris muscles on the lateral lips are dissected free from both the skin and the mucosa along the incisions, in the same procedure as in unilateral cleft lip repair (see Chapter 4). The uppermost end of the bilateral orbicularis oris muscles should be sutured with the periosteum of the frontal nasal ridge or the lower end of the nasal medial septum [13, 14, 15]. At the same time, suture of the orbicularis oris muscle is also adjusted according to the lip height differences between the prolabium and the lateral lip. When the lip height of the lateral labium is evidently greater than that of the prolabium, the most superior part of the orbicularis oris muscle can remain unsutured and be directly padded beneath the columella to support the columellar base.

The difference in orbicularis oris muscle reconstruction between bilateral and unilateral cleft lip repair is that only the superior two-thirds of the orbicularis oris muscle is sutured to form the muscle sling. The inferior one-third is transected and inferiorly rotated to form the labial tubercle. In theory, this will leave a rhombic defect in the inferior third of the upper lip (Fig. 9.9). However, our results show that the static and functional morphology of the upper lip is not affected after operation.

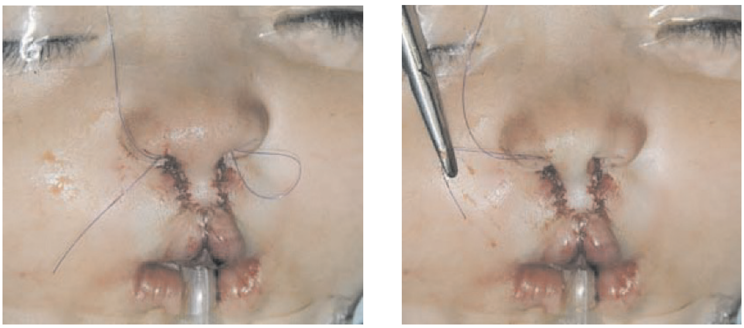
Rather than simply recover the lip bulkness, we should pay special attention to the distribution of the wet and dry vermilion in the reconstruction of the labial tubercle. After the dry mucosa is sutured, the wet mucosa of the bilateral vermilion is used with multiple Z-plasty [16, 17].

In primary rhinoplasty, the skin flap medial to the alar base on the cleft side is turned over 90° and sutured to the skin flap of the columella by cutting point 7 to point 8. Another important point is that the subcutaneous tissue underneath the bilateral nasal bases should be sutured under the columella end-to-end. This technique can obviously narrow the bilateral nasal bases and prevent excessive lateral extension of the nostrils (Fig. 9.12).

(a) (b) (c)

Fig. 9.12 (a) Pulling bilateral nostrils and observe the symmetry of bilateral alar bases; (b) Transfixing suture bilateral alar bases and fix to the surface of anterior nasal ridge; (c) Adduction of bilateral nasal bases and nasal floors

After completely dissecting the lower lateral cartilages from the above skin through the cut under the columellar base and the alar base, PDS II sutures are used to mold the ala and prolong the columella. The dissection of cartilages should be as thorough as that in unilateral cleft lip rhinoplasty. Any attachment that might brace the nasal base, the nasal bottom or the nasal tip should be released. The suture method is similar to that of unilateral cleft lip nasal correction [11, 12, 18] (Fig. 9.13).



(a) (b)

Fig. 9.13 (a) Prolong the columella with bilateral domes; (b) Columella was lengthened and nasal tip was lift up

Some of the bilateral cases repaired with this method are shown in Fig. 9.14.

(a)

(b)

Fig. 9.14 Before and after bilateral cleft lip repair

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10

Sommerlad's Technique of Bilateral Cleft Lip Repair

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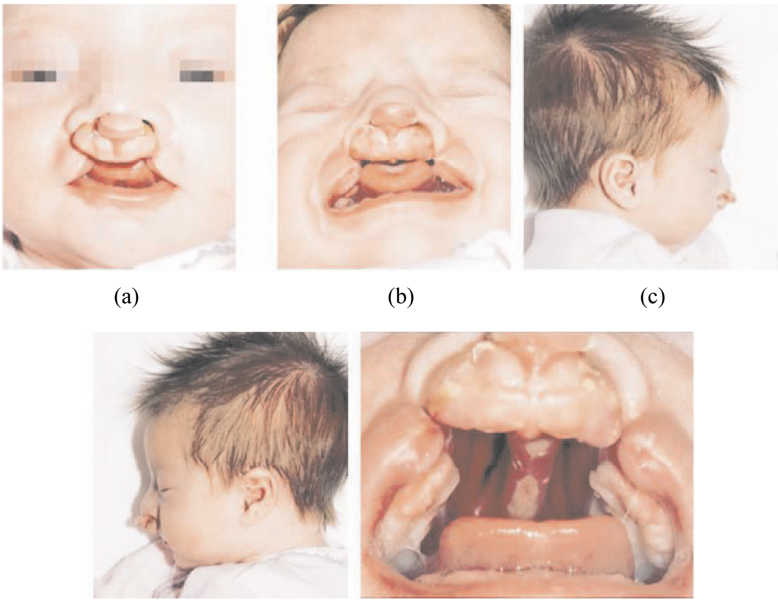
10.1 Introduction

Excessive tissue deficit and displacement make bilateral cheiloplasty more difficult for the surgeon [1]. At the same time, the absence of a normal opposite side as a reference allows the surgeon to freely adjust the bilateral symmetry and does not require accurate simulation of the non-cleft side. Compared with unilateral cheiloplasty, the most difficult part in bilateral cleft lip repair is the powerful tension of the upper lip, which is increased by the protruded premaxilla and the relatively great distance between the premaxilla and the rest of the maxilla [2]. Important tips for the surgical procedures include preventing a wide nasal base reconstruction [3], rebuilding, in the primary repair, the normal loop of the orbicularis oris as far as possible [4, 5], and restoring the oral vestibular groove to its normal depth and form. The fascinating charm of bilateral cheiloplasty lies in the completely different understanding among surgeons of the surgical principles, techniques and skills required. In this chapter, our techniques for bilateral cleft lip repair will be introduced in detail.

10.2 Design

The standard patient described in this chapter is a 3 month old baby, with a large premaxilla, as shown in below, which is a good sign of maxillary growth. The palatal view shows the vomer in the midline. It is symmetrical and so offers little difficulty. There is some deviation in the septum. Commonly, there is a prominent premaxilla. There is a natal tooth at the side of the premaxilla, which needs to be removed. The choice of surgical technique depends on the cleft. The technique we used in this case is a combination of surgical ideas from several surgeons, such as McComb [6], Mulliken [7], Millard [8] and Manchester [9], while Orthertin's vomerine flap closure for cleft palate was also used. We decided to use what we called the Mulliken-Millard technique in reconstructing the prolabial central vermilion mucosa from the lateral segment (Fig. 10.1).



(a) (b) (c) (d) (e)

Fig. 10.1 (a) The 3-month old baby with a complete bilateral cleft lip and palate; (b) Worms eye view; (c) Right side view; (d) Left side view; (e) Inside the mouth

Fig. 10.2 demonstrates the surgeon's view when sitting at the head side of the operation table. Landmarks on the centre of the prolabium and the midline of the columella were noted. In this case, the prolabial white roll is not well developed and the prolabial mucosa is not in perfect condition. The preserved C-flaps need not be too long since they are often too large: a small transverse incision at the alar base was made. There was no need to preserve mucosa to line the sulcus, as the junction area will be sacrificed. In the lateral segment, the junction area will also be sacrificed. The incision goes down to the interior surfaces of the maxilla. For the vomerine flap, the incision goes down the midline of the vomer and around the sulcus of the premaxilla on the oral side of the groove, which is between the premaxilla and the vomer. A lateral incision slightly above the sulcus was also adopted, and this will be the incision going through the periosteum on the anterior maxilla which will be elevated.

At the beginning of the procedure, the alveolus width, the gap in the lip and the length of the lips, particularly at the back of the hard palate, are usually measured and recorded (Fig. 10.3).

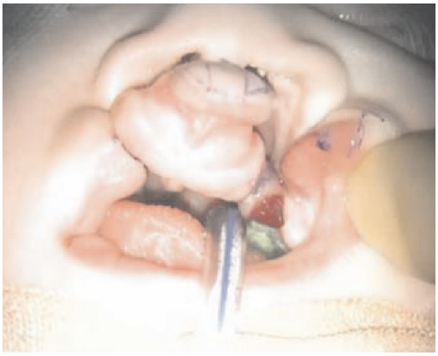


Fig. 10.2 Design of the lip incision

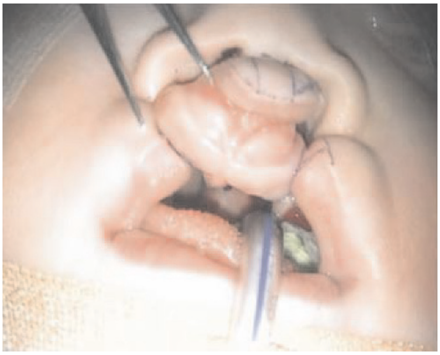


Fig. 10.3 Measurement before operation

10.3 Vomerine Flap for Hard Palate Cleft

Using a modified gadget, the palatal cleft and the total premaxilla can be exposed. In this patient, the cleft was a little wider on the left side and the vomer is closer to the right side. Fig. 10.4 shows the incision beginning in the midline of the vomer and going round the side of the premaxilla. Considering the vascularity of the premaxilla in the prolabial area, a one-sided rather than a two-sided vomerine flap was performed. The incision at the junction of the edge of the cleft in the lateral segment goes back into the soft palate at the junction of the oral-nasal layer which we used to do a little work around the oral side exactly where we would later match the incision for the soft palate closure. The groove and the incision would be made just on the oral side of the groove.

An incision would be made from the alveolar margin up to the lip, extending to the white roll inferiorly. The incision goes through just above the sulcus, above the fixed point of the gingiva, and down through the mucoperiosteum. The subperiosteal plane would then be elevated with a dental scalar to facilitate infraorbital nerve dissection. As it is not so easy to access the subperiosteal plane, the periosteum was released by cutting just below the nerve. Then, the periosteum would be released against the sulcus and turned right, down to the piriform aperture so that the periosteum is completely free. We suggest blocking the nerve with long-acting lidocaine before the periosteal incision (Fig. 10.5).

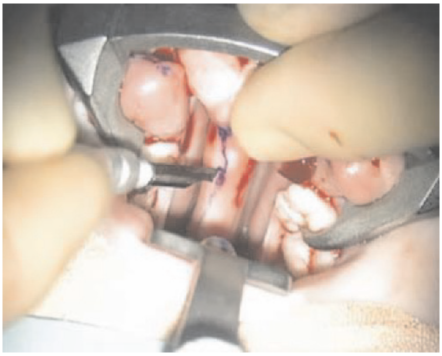


Fig. 10.4 Design of the vomer incision

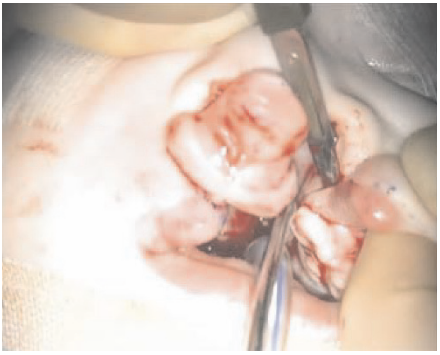


Fig. 10.5 Incision is made from alveolar margin to lip

10.4 Prolabium Incision

Stretching down the prolabium makes the incision easier. In this case, the prolabium is about 5 mm wide. The incision should be made just on the vermillion margin from the midline to the lateral points of the prolabium. Then, turn to the lateral incision on the lateral bulk of the prolabial flap and the lateral margin of the C-flaps. A short C-flap, lying horizontally in the floor of the nose, but not very thick, should be made to preserve the nostril seal. By being elevated down to the labial flap, the C-flap would be reasonably thin. Then, the junctional area of the prolabial mucosa would be sacrificed to keep a reasonable amount of it for the layer of the sulcus. It is important to make a good sulcus for the mobility of the lip (Fig. 10.6).

While performing on the right side, it is important again to remember to make the incision down to the junction of the nasal lining with the palatal mucosa, preserve the white roll, make a transverse incision in the alar base which will become the central part of the prolabial mucosa, and sacrifice the marginal strip. The incision should be just above the sulcus and the gingival on the right side. Again, the periosteum was elevated from the anterior maxilla with a dental scalar. Fig. 10.7 shows the extended subperiosteum up towards the piriform aperture and then towards the infraorbital nerve.

The periosteum of the premaxilla-vomer suture on both sides should be elevated completely By releasing it posteriorly by making a little V-incision, close the pharyngeal roof and more vomerine tissue would be provided for closure. The success rate of the vomerine flap in the unilateral cleft is very high. But in the bilateral cleft, it always ends in failure with a limited vomerine flap or even a more radical one (Fig. 10.8).

Fig. 10.6 Incision on the prolabium

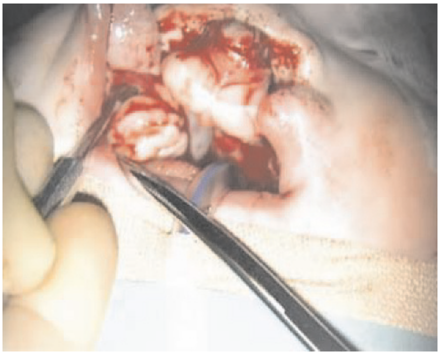


Fig. 10.7 Elevating the periosteum on right side

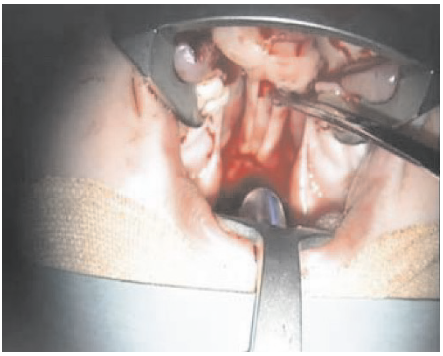


Fig. 10.8 Releasing vomer flap posteriorly with making V-incision

10.5 The Lateral Incision for the Vomerine Flap

The incision in the lateral segment: use a 69 beaver blade to make an incision in the lateral segment on the oral-nasal mucosa junction, right on the edge of the cleft. This would meet the incision already made, which runs through the periosteum at the piriform aperture before accessing the subperiosteal plane. The same incision should be made on the other side with a 169 beaver blade at the junction at the edge of the cleft. The logical place to insert the vomerine flap is the nasal layer, but it is better to overlap them. In other words, the vomerine flap should be inserted under the oral surface of the lateral segment. In addition, anteriorly, the flap becomes continuous with the incision of the piriform aperture at the sulcus on the anterior surface of the maxilla (Figs. 10.9 – 10.10).

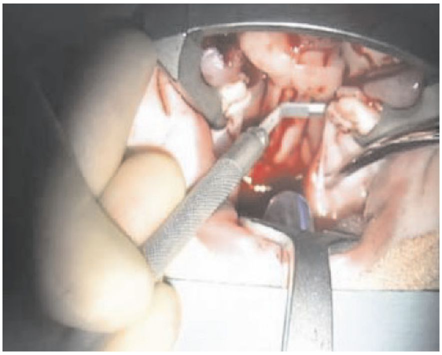


Fig. 10.9 Incision in the left segment

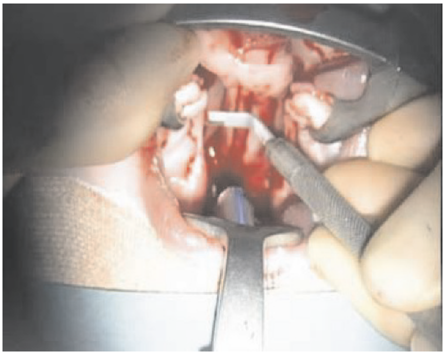


Fig. 10.10 Incision in the right segment

In this case, the choice of a left side radical vomerine flap of the nose is adopted. The incision goes around the groove and unites with the incision around the premaxilla. It is necessary to make sure that the incision goes deep into the periosteum. Using a dental scaler on the incision, the flap was made to be continuous with the lateral marginal C-flap at the edge of the prolabial dissection. The scaler can access the septum cartilages in order to completely free the vomerine flap (Fig. 10.11).

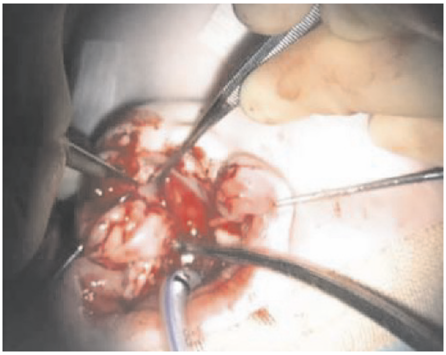


Fig. 10.11 Free vomerine flap completely

10.6 Closure of Vomerine Flap

The turbinate is divided after making sure that the oral and nasal mucosa are completely freed from the lateral nasal wall. A vertical cut is made initially, which comes forward superiorly and terminates at the piriform aperture. It will provide the lateral nasal wall part close to the anterior nasal wall. The lateral nasal wall flap is made, then sewn to the palatal flap. Then, the same lateral nasal wall is released on the right side. Just like the other side, the turbinate can be seen and the lateral nasal wall can be reached to again make sure complete separation of the nasal layer from the palatal shelf.

The key to the vomer flap sewing is to overlap it. The suture goes through the oral mucosa, and then the vomerine flap from inside. The earlier logical steps of anatomy are to sew the vomerine to the palatal mucosa, but that is a single-layer closure without overlap and the chance of its breaking down is much higher. Here, a 5-0 vicrol suture is used with a compound curved needle, which is very convenient for difficult areas: 3 or 4 stitches are enough. The overlap should be about 5 mm. Sometimes, a fine PDS suture can be employed to improve the apposition between the oral layer and the vomerine flap by just putting sutures through the edges of the mucoperiosteal flaps. We might employ two or three stitches to check the contacts between the flaps. Sutures around the piriform aperture must be done with great care and they should not be too tight. Choosing on which side to do the radical vomerine flap is usually based on the principal of width: the radical vomerine flap is usually on the wider side (Fig. 10.12).

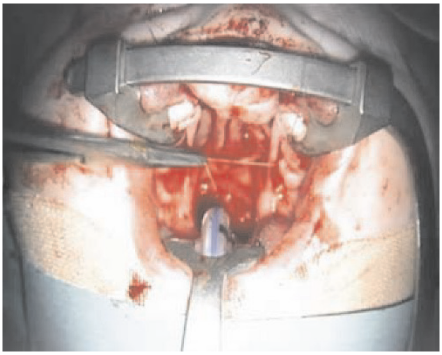


Fig. 10.12 Over lap suture of vomer flap

10.7 Dissection of the Lip

Dissection of muscle on the right side: use a curved knife to make sure that all the muscle is in one block. The dissection is extended to just a little beyond the alar base and divides the muscle from the alar base. The mucosa should reach at least to the midline (Fig. 10.13).

Then dissect the C-flap. Make sure this is freed from the top. Do not damage the blood supply to the prolabium and the process, given that this is quite a thin flap (Fig. 10.14).

Now mobilize the skin from the cartilage at the nose. It is easier to do this in the bilateral cleft because it is necessary to access the media crus skin plane to separate the skin and alar cartilages [10, 11]. Scissors are used to mobilize both the right and the left side. Then dissect the muscle on the left side and free the mucosa, and estimate how far it can approach the midline (Fig. 10.15).

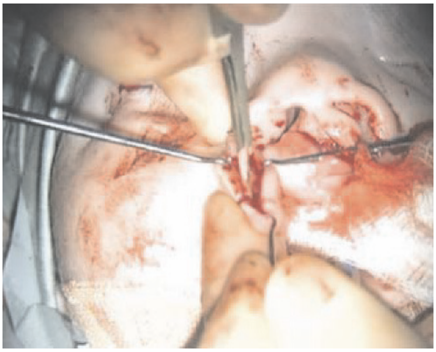


Fig. 10.13 Dissection of muscle on the right side

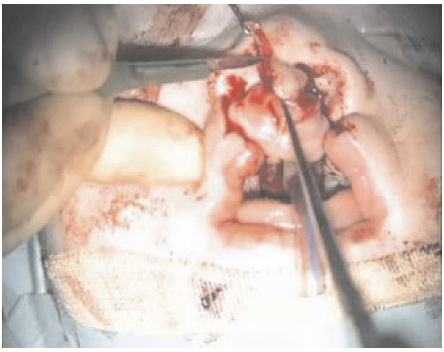


Fig. 10.14 Free the C-flap

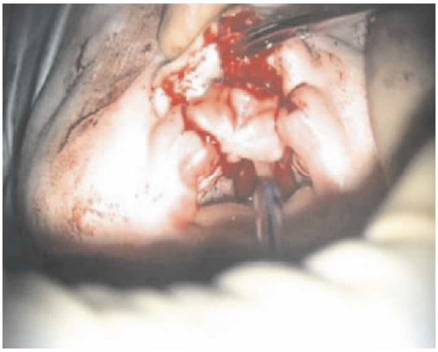


Fig. 10.15 Mobilization of the skin

10.8 Closure of Alar Base, Muscle, Mucosa and Skin

As closure of the vomerine flap up to the alveolar ridge beneath the mucoperiosteum has already been completed, the nasal floor now needs to be closed. In the foregoing steps, the vomerine flap is sutured to the least lateral nasal wall; the stitch goes through the vertical incision and then back to the vomerine flap. But now, three point stitches, through the alveolus, alveolar margin, through the lateral nasal wall and through the vomer, are needed. This is a vertical mattress stitch with a single-layer suture. Another vertical stitch is made to bring the alar base forwards (Fig. 10.16).

Fig. 10.17 shows the alar base stitch with a 4-0 or 5-0 nylon non-absorbable suture. It is a key stitch to narrow the nasal width and ensure the alar base at the right position and plane.

Fig. 10.16 Closure of the nasal floor

Fig. 10.17 Alar base stitch

Fig. 10.18 shows the mucosa closure. Make sure that the mucosa is of equal length on both sides, and insert one or two more vicrol sutures, and keep the same length on each side.

Then tighten the alar base suture. Bring the alar base into the best, ie. most symmetrical, position possible (Fig. 10.19).

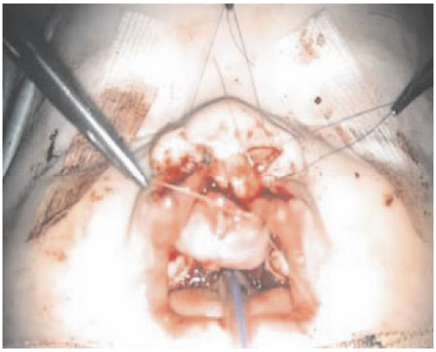


Fig. 10.18 Mucosa closure

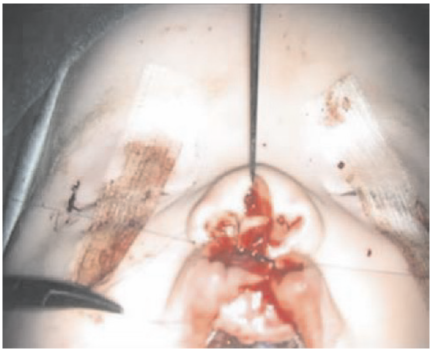


Fig. 10.19 Tighten the alar base suture together

A stitch aligning the mucosa from a point 3 mm from the vermillion margin on each side is inserted to make exact contact with each other. Then trim a little of the mucosa margin as necessary, leave the prolabium mucosa intact, and decide how high it will be inserted (Fig. 10.20).

Insert some inferior muscle stitches with 5-0 nylon sutures. In the unilateral cleft, the muscle is usually sutured overlapping, but for the bilateral cleft we simply pull the muscle together. These stitches began from inferior orbicularis muscle, which would be tied up by the end, and then muscles at about the level of the vermillion margin. Remember constantly to check the orientation of this muscle. Usually 4 to 5 muscle stitches are enough. Another stitch may be required close to the dermis covering the muscle. Tie the muscle sutures together from the inferior part (Fig. 10.21).

Fig. 10.20 A stitch align the mucosa

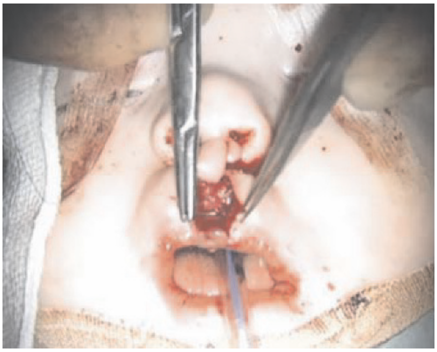


Fig. 10.21 Muscle stitches

Close the skin incision with an 8-0 nylon suture. A subdermal stitch is needed in the midline of the prolabium and at each corner of the vermillion margin to optimize the midline. Leave the suture end long enough to facilitate suture removal. It should not be surprising to find that the skin is as bulky as the mucosa, given that the mucosa and the muscle are under no tension and the skin is almost as abundant (Fig. 10.22).

Then trim the C-flap a little, and insert it into the nostril floor. In the bilateral cleft, the premaxilla becomes retro-planed, tips back, and the C-flap becomes visible as the nose is retracted. Fig. 10.23 shows the tip suture curved with the C-flap and the lateral nasal crus.

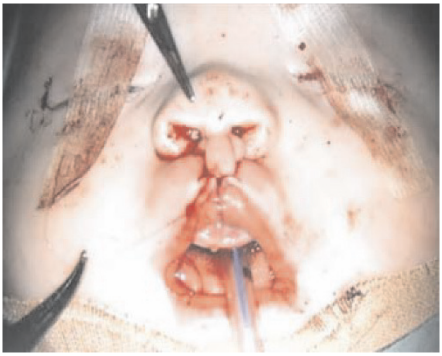


Fig. 10.22 Skin incision closure

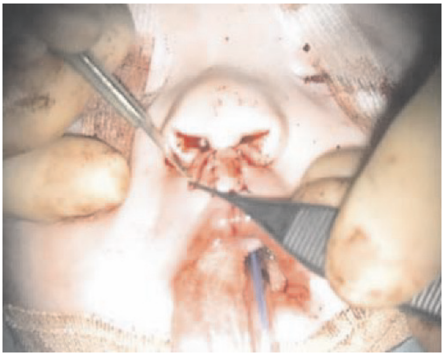


Fig. 10.23 Trimming the C-flap

For this patient, the C-flap is sewn on the left side. The back end of the C-flap is sutured to the lateral nasal wall, with the intention of turning down the nasal floor and ensuring it does not protrude. The same is done on the right. McComb stitches are suitable here by putting sutures through the dermis of the rims and tying for the boost [12]. The flap was inserted from the skin of the bridge of the nose, down to the nostril rim, and was curved manually in order to access the right plane and achieve the optimum position, with the bevel facing towards the concavity of the curve. As the principle of this technique is to support the nostril rim, the alar derm for 3 months, the key is to put in a PDS suture which will last for 3 months rather than the McComb stitch which would last for only 5 days, even though a sufficiently and significantly improved nose is not promised by this technique (Fig. 10.24).

Fig. 10.24 Suture of C-flap

10.9 Suture Technique of Nasal Deformity

Figs. 10.25 – 10.26 demonstrate the curved needle technique. The stitch was inserted from the right side of the bridge through the rim of the left alar. Then, a 5-0 PDS suture is threaded into the needle. The needle was withdrawn almost out through the skin and redirected back towards to a point next to that area, but through another wound. The aim is to take the pouch on the deep tissue, not the periosteum, and fix the deep tissue. Then the alar rim can be lifted. The same is then done on the other side to achieve symmetry of the nostril. In this case, the suture lasted almost until the patient came back for palate repair 3 months later. Even though the dome seemed quite satisfactorily placed, stitching from one dome to another using the same suturing material was still needed.

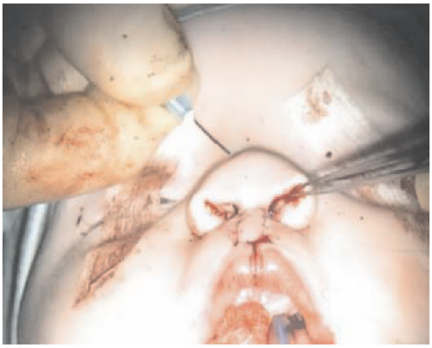


Fig. 10.25 Curved needle technique for alar lift

Fig. 10.26 Curved needle technique for alar lift

Fig. 10.27 shows the Noordhoff stitch [13] inserted from inside out, passing through the skin backwards in the same puncture mark, then going through the different grooves. Dimpling will only be temporary. Tubes were inserted in the nostril on occasion.

The side view of the nostril rim and a reasonable columella does not suggest a significantly lengthened columella [14]. The final columella is now located on the nose instead of the lip [15] (Fig. 10.28).

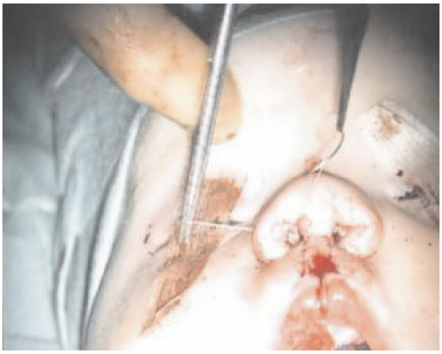


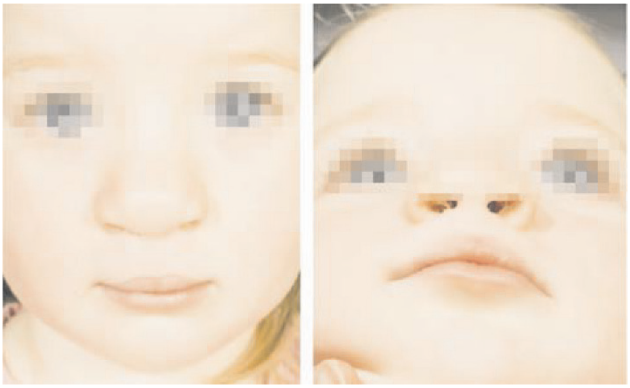
Fig. 10.27 Noordhoff stitch

Fig. 10.28 Side view of nostril rim

10.10 Follow-up

Fig. 10.29 show the little girl at the age of 2 with a typically broad lip and nose and prominent upper maxilla [16]. However, this can be regarded as a good sign at this stage. Clearly, she will require further surgery later, possibly lip and nose revision with columella lengthening [17, 18].

(a) (b) (c)



(d) (e)

Fig. 10.29 2 years after primary bilateral cheiloplasty

10.11 Conclusion

Presurgical orthopedics is routinely required in the bilateral cleft, for the prominent premaxilla. The prominent premaxilla is very common in bilateral cleft cases and in some of the most severe cases the prominence could be as much as 25 mm. A significantly prominent premaxilla is a great challenge for any surgeon. Presurgical orthopedics can stop collapse of segments and push the premaxilla back.

A bilateral cleft lip is always a great challenge for surgeons. Each technique has its own advantages and disadvantages, and many surgeons have tried various techniques to repair it satisfactorily but failed. In this chapter, the authors have employed and modified these techniques to repair bilateral cleft lip, and the long-term results are good.

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11

Cutting’s Technique of Bilateral Cleft Lip Repair

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The techniques of bilateral cleft lip and nasal repair have undergone a significant evolution in the past two decades. Modern techniques strive to concurrently and anatomically correct the nasal deformity at the time of lip repair. These methods have resulted from a better understanding of the anatomy of bilateral cleft nasal deformity, dismissal of the myth that manipulation of nasal cartilages during infancy is damaging [1-4], and the development of techniques that preserve the blood supply to the prolabium in conjunction with comprehensive anatomic repositioning of lower lateral cartilages (LLCs). The senior author’s technique is performed with presurgical nasoalveolar molding (NAM) whenever possible. Although we strongly believe that NAM will optimize the patient for the most predictable and reproducible reconstruction, variations of the senior author’s technique will be described for use in patients in which NAM is not possible.

11.1 The Upper Lip Deformity

A major deficiency of the bilateral cleft lip is the absence of muscle under the prolabium. In the unilateral cleft lip deformity, primary reconstruction of the orbicularis oris muscle can be accomplished in such a way as to concurrently reconstruct the philtral column. In bilateral cleft lip deformity, there is no consensus regarding how to address this deficiency, as the absence of orbicularis oris muscle in the prolabium precludes an anatomic reconstruction of the upper lip muscle in this patient population. Many surgeons do not advocate joining the muscle under the prolabium [5-8], citing decreased tension on the premaxilla after closure, possibly improving long-term midface projection [9-11]. However, lack of muscle repair under the prolabium results in widening of the prolabial skin. We advocate primary apposition of the orbicularis oris at the time of cleft lip repair. Presurgical retraction of the premaxilla facilitates primary reconstruction of the orbicularlis oris. Muscle reconstruction of the upper lip brings the alar bases into anatomic position and helps prevent lateral displacement of the ala postsurgically.

11.2 The Nasal Deformity

The primary insult resulting in formation of the bilateral cleft lip nasal deformity is a failure of migration of mesodermal cells into the primordial epithelial bilayer connecting the lateral maxillary and frontonasal process. Subsequently, the unrestrained premaxilla is thrust anteriorly and superiorly by the fetal tongue. The lateral palatal shelves, lacking the stability of an intact maxillary arch, collapse medially. Normally, the intact maxillary arch positions the premaxilla inferior to the quadrangular cartilage. In the bilateral cleft, the premaxilla is pushed anteriorly and rotated horizontally. The crural footplates are thrust forward with the premaxilla while the alar bases are displaced posteriorly by the collapsed lateral palatal shelves. The net result of these opposing vectors is a severe separation of the lateral and middle crura with a deposition of fibrofatty tissue (fibrofat) between the separated cartilages. The severe separation of the LLCs secondarily widens the skin envelope at the superior aspect of the columella, effectively shortening this structure. The elongation of the foreshortened columella by anatomic repositioning of the LLCs is at the core of the modern techniques of primary bilateral cleft lip rhinoplasty.

11.3 Presurgical Molding Options

One of the more challenging distortions associated with complete bilateral cleft lip deformity is the anterior and superiorly projecting premaxilla. Presurgical orthotopic repositioning of the premaxilla is critical to a high-quality primary nasal reconstruction and a tension-free lip repair. The earliest methods of addressing the projecting premaxilla included resection, which simplified lip repair but resulted in an iatrogenic and problematic dentofacial deformity [12]; therefore, this treatment modality should not be used. Partial resection of the vomer with preservation of the premaxilla at the time of lip repair will allow for repositioning of the premaxilla [13]; however, the premaxillary segment will be free-floating and therefore of little functional use to the patient as preferential use of the lateral dentoalveolar segments for chewing will lead to bone hypoplasia of the premaxilla.

Primary lip adhesion can be performed as part of a two-stage repair in an attempt to rotate the premaxilla towards an orthotopic position. In cases in which an orthodontist or prosthedontist is not available, this modality is a viable option. However, this intervention is limited by the uncontrolled fashion in which the premaxilla is retracted. Additionally, no presurgical nasal molding is performed in the process. Use of presurgical elastic traction also suffers from the same limitations of a lip adhesion; although the use of elastic traction is relatively simple, the uncontrolled rotation of the premaxilla associated with it can result in an overly rotated premaxilla in which the teeth are pointed posteriorly.

Active alveolar molding and premaxillary repositioning can be accomplished with a dental appliance that attaches to lateral palatal shelves and the premaxilla by the use of pins [14-16]. Active molding of the alveolar segments, which occurs over the course of approximately 2 weeks, adjusts the width of the lateral palatal shelves while rotating the premaxilla into anatomic position. This modeling device was extensively used and advocated by Millard, who performed gingivoperiostoplasty at the time of cleft lip repair [16]. The use of this device is controversial, as some believe long-term growth of the midface is adversely affected by this aggressive repositioning modality [17, 18].

11.4 Nasoalveolar Molding

Since 1998, our team has used NAM whenever possible to passively place the alveolar segments into anatomic position prior to bilateral cleft lip repair and to presurgically optimize nasal form [19-21]. This therapy commences shortly after birth and continues until the time of cleft lip repair, usually about 5 months later. The device is currently used by the authors consists of an alveolar molding plate with extensions brought out from the molding plate and into the nose. Through weekly adjustments, the alveolus and nose are gradually reshaped in preparation for surgery. A more detailed description of the NAM technique is given in Chapter 1.

11.5 Alveolar Molding and Gingivoperiosteoplasty

The alveolar molding plate of the NAM device widens the maxillary arch and sets the premaxilla into anatomic position. Orthotopic repositioning of the premaxilla enables the surgeon to perform gingivoperiosteoplasty on at least one side at the time of lip repair, stabilizing the premaxilla and preventing downward descent over time. The goal of gingivoperiosteoplasty is to avoid bone grafting to the alveolus while causing minimal additional disturbance to midface growth. Anatomic alignment of the alveolar segments prior to the time of lip repair allows for a limited subperiosteal repair of the alveolar gap. However, the use of gingivoperiosteoplasty in the cleft patient remains controversial. If a significant retrusion of the midface is found to be associated with NAM combined with gingivoperiosteoplasty, the benefit of this technique may be questionable. By performing gingivoperiosteoplasty only when the alveolar segments are within a 1 mm distance, dissection can be limited to the medial and distal faces of the alveolar segments [22]. Avoidance of subperiosteal dissection across the lingual and buccal faces of the alveolar segments avoids restriction of midface growth by midterm follow-up [23, 24]. Analysis of midface projection after full facial maturation is pending. Without optimal presurgical alveolar alignment, gingivoperiosteoplasty will require wide undermining over the face of the maxilla, as described by Skoog [25], whose originally described technique caused concern for long-term facial growth [26]. Although other surgeons have advocated use of primary bone grafting soon after the time of cleft lip repair, this has been associated with long-term restriction of midface projection, likely due to the wide amount of subperiosteal undermining required to place the graft combined with a degree of resorption of partially necrotic graft. Our experience with unilateral cleft deformity has shown that secondary alveolar bone grafting is not required 60% to 73% of the time after gingivoperiosteoplasty [22, 27]. In cases of bilateral cleft lip and palate deformity, bilateral gingivoperiosteoplasty completely avoids the need for alveolar bone grafting in 41% of patients [28].

It should be stressed that success of gingivoperiosteoplasty even on one side of the premaxilla is still of therapeutic and functional benefit to the bilateral cleft patient [28]. Once the premaxilla has been secured to the lateral alveolar segment by unilateral bony fusion, the premaxillary segment gains function. The future teeth growing in the premaxillary segment can be used and stressed during mastication, promoting healthy bony development in the premaxillary segment. Furthermore, inferior descent and posterior rotation of the premaxilla, a sequela seen after bilateral cleft lip repair without alveolar reconstruction, is avoided, as the premaxilla is secured to the lateral alveolar segment [28]. This will preclude the need for premaxillary repositioning at the time of secondary bone grafting.

11.6 Nasal Molding

Adjustments of the nasal extensions in the NAM device lengthens the columella, relocates the alar bases to an anatomic position, increases nasal lining, and shapes the LLCs into a more convex form. The sum of these changes, combined with anatomic repositioning of the premaxilla, results in decreased tension of the lip at the time of reconstruction and a more limited and predictable primary rhinoplasty. The benefit of an elongated columella cannot be overstated. NAM can presurgically elongate the columella. This length has been stable over time and not found to be statistically different from the normal [21]. Previous surgical techniques used to lengthen the columella involved transposing tissue from the prolabium, resulting in a significantly scarred columella, wound contraction and, ultimately, a degree of loss in columellar length in the long-term. Limitations of these techniques will be discussed later in the chapter. Tissue expansion of the nasal lining allows the domes of the LLCs to be brought together at the time of primary rhinoplasty with minimal tension and limits the need for a piriform aperture incision and dissection of the lateral lip and cheek from the face of the maxilla. Finally, the nasal molding device alters the shape of the typically concave LLC to a more esthetic convex shape.

11.7 Early Principles of Lip and Nasal Reconstruction

Earlier techniques of bilateral cleft lip repair focused on rearrangement of prolabial skin to correct the major deformities of the upper lip and nose. In these "skin paradigm" techniques, the wide prolabial skin was used to lengthen the vertically deficient columella. The most popular of these techniques was the "banked forked flap" [29, 30]. Although the technique appears logical (the excess width of prolabial skin is used to lengthen the foreshortened columella), recruitment of prolabial skin into the deficient columella suffers many short-term and long-term consequences. First, an unesthetic scar is placed on to the midline of the columella. Second, the combination of a horizontal scar across the base of the columella, an absent anterior nasal spine, and tension across the horizontal scar due to medialization of the alar base results in retraction of skin over the area of the absent anterior nasal spine, creating a characteristically acute lip-columella angle. In the long-term, the elongation of the columella by recruitment of redundant prolabial skin results in upward displacement of the crura footplates and further widening of the alar domes [31]. This nonorthotopic repositioning of the nasal cartilages reveals a major deficiency of the skin paradigm repairs: they are non-anatomic. The upward displacement of the crural footplates, in fact, accentuates the deformity of the domes, separating them further. During subsequent growth, the nasal domes are further separated, resulting in widening of the nasal tip. Because nasal tip projection does not increase with facial growth, over time the nasal tip becomes characteristically broad, flat and under-projected. Although later correction of the cartilaginous deformity is not difficult, the overlying soft tissue envelope is challenging to mold [32]. The nasal tip skin tends to have a 'memory' of its original form and resists the shape of the newly constructed cartilaginous framework. The result is recurrence of the broad, flat tip deformity despite dramatic refinement in the LLCs.

11.8 Current Principles of Lip and Nasal Reconstruction

The era of modern bilateral cleft lip nasal repair commenced when Harold McComb introduced his technique of bilateral lip reconstruction [2] which focused on correcting the position of the aberrantly displaced LLCs. In contrast to the previous skin paradigm techniques, McComb addressed the columellar length deficiency by bringing the LLCs into anatomic position instead of recruiting skin from the prolabium. His conceptual shift from focusing on skin rearrangement to anatomic repositioning of the nasal cartilage to increase columellar length inspired the development of the modern bilateral cleft lip repair techniques [20, 33-35].

McComb's two-stage operation consisted of wide exposure of the LLCs through a wide "V" incision across the base of the nasal tip. The fibrofat is elevated from between the domes and the LLCs are sutured together into anatomic position. The V-incision at the base of the nasal tip is closed as a Y, elongating the columella. As the branches of the anterior ethmoid arteries are disrupted from reaching the prolabium, nasal repair is performed with a lip-adhesion only and formal lip reconstruction is performed at a second stage.

Following the description of McComb's two-stage repair, Mulliken introduced a single-stage bilateral cleft lip repair which followed McComb's principle of anatomic repositioning of the LLCs to attain optimal nasal form and as a primary means of elongating the columella [33, 36]. Rather than using a V-incision at the nasal base to expose the LLCs, paired nostril rim incisions were used in concert with a midline incision at the nasal tip. As the blood supply to the prolabium from the external branches of the anterior ethmoid are not entirely violated by this approach, a concurrent comprehensive lip reconstruction could be performed with little risk of ischemia to the prolabium. The operation was later modified by Mulliken, who eliminated the midline incision on the nose [31]. Two limitations of the Mulliken repair are the use of nostril rim incisions and failure to reposition the retro-displaced medial footplates of the nose [35].

Following the introduction of Mulliken's single-stage repair, Trott and Mohan described a single-stage procedure utilizing an extended open rhinoplasty technique to access the LLCs. In this technique, a standard open rhinoplasty incision is extended inferiorly into the prolabial skin such that a prolabial skin flap is raised in continuity with a cutaneous columellar and nasal tip flap. Although exposure to the LLCs is excellent with this technique, the external branches of the anterior ethmoid artery are violated by the columellar incision, compromising the blood supply to the prolabial flap. In addition, the straight line incision from the prolabium into the nostrils can cause a problematic contraction deformity [35].

Cutting subsequently developed a single-stage repair technique which incorporates a retrograde approach to the LLCs [20]. A transfixion incision is made superiorly toward the septal angle and inferiorly through the deep tissue of the prolabium. The prolabial flap is then elevated with the composite flap of columella, medial crura and nasal lining. By elevating the composite flap superiorly, the domal cartilages can be approached in "retrograde fashion", from the underside of the composite nasal/prolabial flap, dissecting anteriorly and laterally. A mattress suture is placed through the nasal lining on one side, through the LLCs and through the nasal lining on the opposite side. Care is taken to protect the fibrofat from being incorporated into the mattress suture. As the external branches of the anterior ethmoid artery are preserved in this procedure, the blood supply to the prolabial flap remains robust. The retrograde technique of bilateral cleft lip repair requires NAM to set the premaxilla into anatomic position, lengthen the columella, stretch the nasal lining and mold the LLCs into a convex shape in preparation for surgery. Performing the retrograde technique without NAM can result in an inadequate nasal reconstruction [35]. In cases when NAM is not possible, the retrograde approach to the nose is combined with Mulliken's nostril rim incisions [35]. This combined approach facilitates elongation of the columella and the placement of domal sutures for anatomic repositioning of the LLCs.

The retrograde technique has the advantage of preserving a robust blood supply to the prolabium while providing good exposure to the LLCs. No incisions are made on the nasal skin. In addition, the retro-displaced crural footplates can be anatomically repositioned as part of the repair. After the orbicularlis oris is primarily reconstructed at the midline, the crural footplates are placed on top of the superior aspect of the orbicularis oris reconstruction, in a more anterior (and anatomic) position, increasing nasal tip length [35].

11.9 Technique

The Cutting technique of bilateral cleft lip repair follows the classic markings of Millard [37]. The vermillion is constructed with bilateral vermillion turn-down flaps taken from lateral lip elements (Fig. 11.1). We feel that this is an improvement over the Manchester repair [6, 38] in which a turn-down flap of buccal mucosa is used to recreate the midline tubercle. The Manchester technique is limited by volume deficiency at the reconstructed central vermillion, color and texture mismatch, as well as drying out and desquamation of the buccal mucosa flap [31, 39].

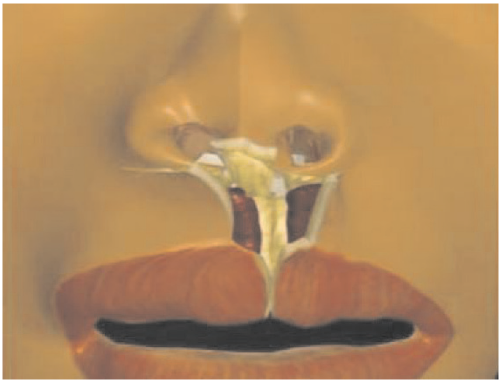

Fig. 11.1 Bilateral turn-down flaps are used to reconstruct the vermillion at the midline

The midline point on the white roll of the prolabium is marked. Two additional marks are then made on the white roll, 2.5 mm lateral to each side of the first mark. The lateral marks denote the width and height of the philtral columns. The heights of the prolabial lateral marks are measured and this vertical distance is used to determine the white roll mark on the lateral lip elements. In this measurement, the alar base denotes the superior border of lip height and the white roll point denotes the inferior height. All five white roll marks are tattooed.

Draw two 1/4 hemi-circles on the prolabium connecting the three white roll points to create a "bird in flight" pattern over the white roll. These hemi-circles will create the new Cupid's bow. The philtral columns are drawn on the prolabium with care to slightly bow out the inferior aspect of the column. The marked philtral line should pass just laterally to the lateral tattoo points on the prolabium. On the lateral lip elements, a line is drawn lateral to medial along the alar base crease, traveling slightly inferiorly to the medial border of the white lip, approximately 1 mm inferior to the alar crease. A line is then drawn, from this point to the tattoo point on the lateral lip element, following the border of the mucosa with the white lip. Lateral turn-down flaps are then marked on the lateral lip elements to match the length of the premarked hemi-circles. A 2.5 mm distance is marked from the lateral lip element point to a superior point along the junction of the mucosa and white lip. If a combined Cutting/Mulliken reconstruction is planned, draw a Tajima inverted-U incision on each nostril.

After all markings are incised, sharply dissect a thick prolabial flap away from the underlying mucosa and periosteum of the premaxilla. If Tajima inverted U-incisions are marked, they are dissected at this time. Dissection scissors are placed through the Tajima incisions and the soft tissue of the dome is carefully separated from the underlying LLCs. The dissection pockets created through each Tajima incision are connected at the midline. Care is taken not to damage the fibrofat deposited between the domes. A transfixion incision is then made in continuity with the prolabial flap. Carefully dissect the composite flap of prolabial tissue, columellar skin and medial crura up to the septal angle (Fig. 11.2). The oral mucosa remaining of the premaxilla is sutured to the premaxillary periosteum using a horizontal mattress technique, setting the new height of the gingivobuccal sulcus on the premaxilla. Excess mucosa is then trimmed.

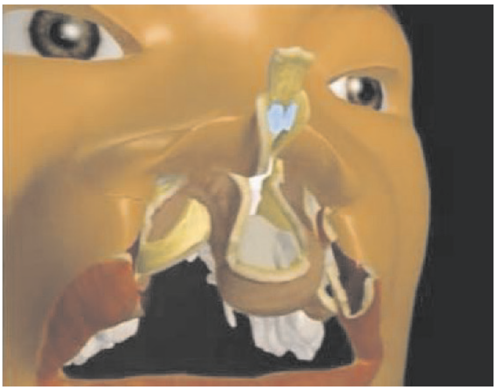

Fig. 11.2 By extending the prolabial flap incision superiorly into a membranous septum incision, the medial crura are elevated with the columella and prolabium as a single unit. The lower lateral cartilages may then be approached in a retrograde fashion

Thin nasal floor flaps are sharply dissected from the dermomuscular pennants below the alar base. The L-flaps are then sharply dissected from the lateral lip element from distal to proximal. As the gingivobuccal sulcus is approached, the depth of the dissection changes from a submucosal to a subperiosteal plane. A vertical incision is made intranasally at the piriform aperture at the junction of the squamous epithelium and the nasal mucosa. The inferior aspect of the piriform aperture incision should meet the superior border of the L-flap. Completion of this incision will pedicle the L-flap on the lateral nasal wall (Fig. 11.3). A periosteal elevator is then inserted into the piriform aperture incision to mobilize the L-flap from the inferior aspect of the lateral nasal wall. An incision is made through the base of the lateral nasal wall just inferior to the mobilized L-flap. This L-flap/lateral nasal wall mucoperiosteal flap will be used to close the nasal floor. A corresponding vomer flap is raised. If indicated, a gingivoperiosteoplasty is performed at this time.

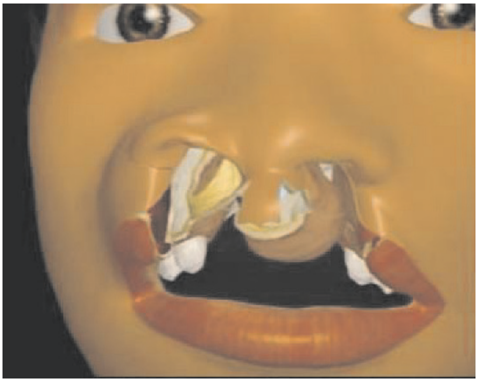

Fig. 11.3 The underside of the L-flap is depicted in yellow in the patient's right nostril. Note the flap is pedicled on the lateral nasal wall, not the alveolus as originally described by Millard

The fully mobilized L-flaps are then tucked into the nose. A gingivobuccal sulcus incision is made bilaterally and this incision is connected with the piriform aperture incision. The L-flaps, now placed within the nose, should not be damaged by this incision. The upper lip and cheek composite flap is widely undermined from the face of the maxilla both superiorly and laterally. This dissection may be extensive if no presurgical orthopedics is performed and should proceed until a tension-free midline apposition of the alar bases can be accomplished. The L-flap is then inset into the piriform aperture defect created by mobilization of the lateral cheek element. Suture the base of the L-flap to the inferior aspect of the alar base. Then trim the L-flap as needed and inset into the piriform aperture defect of the lateral nasal wall. The nasal floor defect is closed by suturing the vomer flap to the inferior border of the lateral nasal wall/L-flap in vertical mattress fashion.

The lateral lip elements are then repaired at midline. Starting from the lateral aspect of the gingivobuccal sulcus incision, the oral mucosa is closed with obliquely oriented sutures which advance the lateral lip elements to midline. As closure proceeds towards midline, tension is progressively taken off the lateral lip elements such that when the midline is reached, minimal tension will be used to unite the lateral lip elements. When the midline is reconstructed, a suture is placed through the periosteum of the premaxilla to strengthen the closure. Close the remainder of the upper lip mucosa. The orbicularis oris is then primarily repaired. Care is taken to affix the superior aspect of the muscle to the substance of the anterior nasal spine to prevent elongation of the upper lip.

Attention is then drawn to the rhinoplasty portion of the procedure. In all cases, a retrograde dissection of the LLCs is performed. The prolabial flap is retracted posteriorly and superiorly, exposing the underside of the dome. The LLCs are approached from below, by inserting the dissection scissors directly over the nasal tip cartilages in a superior and lateral trajectory (Fig. 11.4). Careful blunt dissection directly over the LLCs separates the fibrofat from the middle and lateral crura. Care is taken not to damage the fibrofat as this tissue contains the blood supply to the prolabial flap. If Tajima inverted U-flaps were previously mobilized, these dissection pockets are connected with the dissection pocket created through the retrograde approach. Once the fibrofat has been separated from the LLCs, the prolabial flap is placed back on to the upper lip and the nose is inspected. The location of the nasal tip suture is sighted on the superior edge of the nostril and marked. This is usually about 3 mm lateral from the columellar border. Once marks are made on each nostril, a long-lasting suture is passed through the nostril point, just within the border of the nasal mucosa with the tip skin, and out through the transfixion incision posterior and inferior to the domes. A Ragnell retractor is used to protect the fibrofat from the passage of the needle. The suture is then passed through the transfixion incision, over the opposite dome and through the contralateral nostril mark. Again, the fibrofat is protected from the needle using a Ragnell retractor. The suture is then returned to the ipsilateral nostril by reversing the path of the needle. On the return pass, the suture is placed 2 mm posterior to the original passage. Tying this horizontal mattress suture will unite the separated LLCs and elongate the columella (Figs. 11.5 – 11.6).

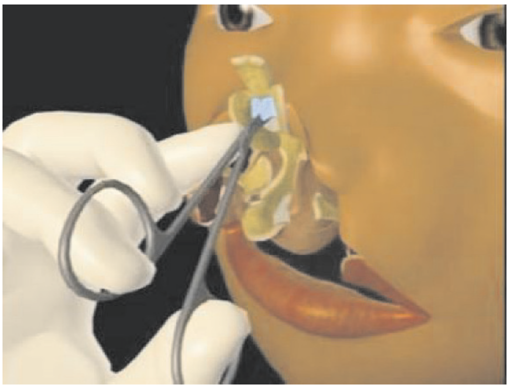

Fig. 11.4 Dissection scissors are inserted from the underside of the lower lateral cartilages to approach the domes through a "retrograde" approach

Fig. 11.5 A horizontal mattress suture passed through both lower lateral cartilages will simultaneously increase nasal tip definition and increase columellar length

Fig. 11.6 A transparency of Fig. 11.5 demonstrating the suture passing through both lower lateral cartilages of the nasal tip

In cases where the Tajima inverted U-incision is combined with a retrograde approach, the domes are sutured together as described in the retrograde technique. However, instead of passing the needle through the transfixion incision, the suture is easily passed through the Tajima incisions, facilitating suture placement. Greater mobilization of the LLCs allows for greater elongation of the columella through this technique.

After the domal sutures are placed using either the retrograde or combined retrograde/Tajima technique, the membranous septum incision is closed with horizontal mattress sutures. Care is taken to advance the crural footplates onto the superior aspect of the orbicular oris reconstruction to increase nasal tip length. If Tajima inverted U-incisions were made, the flaps are thinned and inset into the nostril rim using a semi-buried horizontal mattress technique. After the membranous septum incision is closed, another horizontal mattress suture is placed just inferior to the soft triangle to further support and shape the columella.

The lateral skin flaps on the prolabium, traditionally used in the banked fork flap technique, are de-epithelialized. This dermal tissue is trimmed and used to add bulk to the upper lip incision line, reproducing philtral columns at the time of closure. The prolabial skin is also undermined slightly to aid in eversion of the skin along the philtral line. The tattoo points of the prolabial flap are sutured to the tattoo points of the lateral lip elements and the lip is closed. Excess skin of the alar base is excised and the nostril floor is closed. Excess mucosa of the lateral turn-down flaps are trimmed as needed, preserving the muscular tissue. As the vermillion is reconstructed at the midline, a full tubercle should be appreciated. Vestibular web obliterating sutures are then placed using a long-lasting absorbable suture. Pass the needle behind the vestibular web and out through the alar/facial groove externally. Return the needle back into the nostril through the same skin puncture at the alar/facial groove however the needle enters the nostril anterior to the vestibular web. Tying the stitch has the dual effect of obliterating the vestibular web and accentuating the alar/facial groove. Two to three such sutures are usually required on each side.

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12

Chang Gung Technique of Bilateral Cleft Lip Repair

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12.1 Introduction

The objective of surgical correction of the bilateral cleft lip is to reconstruct a symmetrical, balanced lip and nose with good proportions. The traditional approach is a two-stage correction with columella elongation as a secondary procedure at different ages [1-10]. With the help of presurgical nasoalveolar molding (NAM) to balance the skeletal base and elongate the columella, the more recent approaches are trying to achieve good results in both lip and nose in one stage. Mulliken [11, 12], Trott [13], and Cutting [14] have reported different techniques to achieve a more satisfactory one-stage repair in the past 15 to 20 years. Most of the recent techniques which achieve a better result in a one-stage repair use the technique of presurgical orthopedics or NAM to stretch the columella before operation [15-17]. The technique used in the Chang Gung Craniofacial Center has undergone a continuous evolution over the past thirty years [18-23]. The present technique is an integrated approach with presurgical management, surgical refinements and postsurgical maintenance.

12.2 The Integrated Approach

The key deformities of a bilateral cleft lip are 1) protruding/deviated premaxilla with relatively retro-positioned lateral maxillary segments 2) wide/asymmetric alveolar gaps with wide nasal width and 3) shortness of the columellar height with nasal tip tethered to the prolabium (Figs. 12.1 – 12.2). To approximate the orbicularis muscles in front of the protruding premaxilla is not only technically difficult but it also places excessive tension on the premaxilla, which will eventually cause premaxillary/maxillary retrusion or twisting of the premaxilla. The typical nasal shape after primary lip repair in a bilateral cleft lip patient with protruding premaxilla is a wide and flat nose with inverted nostril axes and broad nasal tip due to the short columella and skeletal imbalance between the premaxilla and lateral maxillary segments (Figs. 12.3 – 12.4). The purpose of the presurgical orthopedics or NAM is to lengthen the columella, enlarge the prolabium, restore normal shape of the cartilaginous framework and balance the skeletal base [15-17, 24].

For surgical refinements, besides reconstruction of the nasal floor with various mucosal flaps, anatomical restoration of the orbicularis muscle, and reconstruction of Cupid's bow with tissue from the lateral lips, surgery itself emphasizes nasal correction with alar base repositioning, cartilage repositioning, lengthening of columella and restoration of good nasal height/width ratio.

The postsurgical maintenance uses micropore tapes and silicone sheet for scar care and modified silicone nasal conformers to maintain the surgical results on nasal correction.

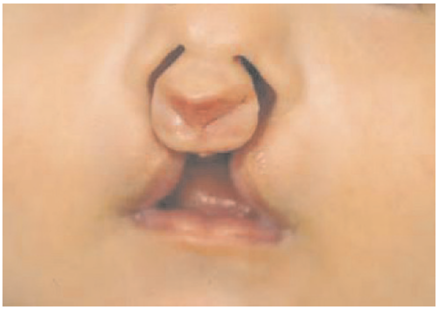


Fig. 12.1 A one month old baby with bilateral complete cleft lip and palate. There is protruding premaxilla with retro-positioned lateral maxillary segments. The columella is very short with nasal tip tethered to the prolabium

Fig 12.2 A 2 weeks old baby with bilateral complete cleft lip and palate. The premaxilla is twisted and deviated to right side with wider alveolar gap on the left side. The columella is short

Fig. 12.3 A 4 years old girl with bilateral complete cleft lip and palate. Lip repair with banked forked flaps was done at 3 months old. The columella is short and the nose is wide. The nostril axes in inverted compared to those in normal persons. The vermilion on prolabium is used for reconstruction of the Cupid's bow. Note the uneven suture line on the central vermilion

Fig 12.4 A 5 years old boy with bilateral complete cleft lip and palate. Lip repair with banked forked flaps was done at 3 months old. The columella is short and the nose is wide. The nostril axes in inverted compared to those in normal persons. Note the uneven forked flaps on nasal floor

12.3 Presurgical Management

The following presurgical management has been used in the Chang Gung Craniofacial Center for the past twenty years. This has included very simple and very sophisticated techniques, all of which need to be started in early infancy, i.e., 4 to 6 weeks after birth.

12.3.1 Presurgical Orthopedics

The protruding premaxilla can be gradually pushed back by applying Micropore tapes across the lip with or without traction rubber bands (Fig. 12.5). It is suggested that the patients sleep in a prone position or on their side to increase pressure on the cheeks. An acrylic dental plate keeps the tongue out of the cleft to prevent the force from tongue movements widening it. It also stabilizes the alveolar segments from collapse [19, 24]. This simple technique is effective in expanding the prolabial tissue and places the premaxilla in a better position. The technique is easy and the patient needs only 2 – 3 visits before the operation. However, nasal shape cannot be corrected with this technique.

Fig. 12.5 A 2 months old boy with bilateral complete cleft lip and palate.Presurgical orthopedics was performed with micropore tapes with rubber band traction

12.3.2 Nasal molding with Silicone Nasal Conformers

A silicone nasal conformer can be used as a tool for presurgical nasal molding when the patient has incomplete cleft lip [25]. The nostril height and columellar length can be increased by gradually adding some soft resin or flat silicone sheets on the nasal stent (Fig. 12.6). It is effective in lengthening the columella and reshaping the deformed alar cartilage [22, 23]. It only needs one or two pre-operative visits. However, it can only be applied to incomplete clefts.

Fig. 12.6 Modification of the silicone nasal conformer by adding silicone sheet on top of the conformer for presurgical lengthening of the columella in incomplete bilateral cleft lips

12.3.3 Nasoalveolar Molding

12.3.3.1 Grayson's Technique

A passive type of orthopedic appliance is used together with taping of the lip for premaxilla and alveolar molding. Alveolar molding is started first. When the alveolar gap is narrowed down to less than 5 mm and the arch is better aligned, a nasal molding device is added to the orthopedic appliance to increase the columellar height as well as to reshape the alar dome [15, 17] (Fig. 12.7).

Fig. 12.7 Presurgical nasoalveolar molding with Grayson's technique. *Upper left*: 2 weeks old at first visit. *Upper middle*: 1 month old under alveolar molding. *Upper right*: 2.5 months old after a period of nasolaveolar molding. Note the better arch alignment and better columellar length. *Lower left*: dental cast at first visit. *Lower middle*: the nasolaveolar molding device. *Lower right*: dental cast at 2.5 months

12.3.3.2 Figueroa's Technique

Alveolar molding and nasal molding are performed simultaneously using an acrylic plate with rigid acrylic nasal extension. Rubber bands are connected to the acrylic plate for gentle retraction of the premaxilla. A soft resin ball attaching to the acrylic plate across the prolabium is sometimes used to maintain the nasolabial angle [16].

12.3.3.3 Liou's Technique

The NAM device is composed of a dental plate, nasal molding components and several micropore tapes for premaxillary retraction. The dental plate is held to the palate with dental adhesives. Micropore tapes are placed across the clefts to minimize the alveolar cleft, retract the premaxilla, and pull both alar bases medially. The nasal components are made up of curved stainless steel wires projecting forwards and upwards from the anterior part of the dental plate. The top portion contains a kidney-shaped soft resin molding-bulb that fits underneath the nasal cartilages for nasal molding. The columella is lengthened by pushing the premaxilla backwards as well as pushing the nasal tip forwards. Retraction of the premaxilla, lengthening of the columella and shaping the cartilages are performed all at the same time [22, 23] (Fig. 12.8).

Fig. 12.8 Presurgical nasolaveolar molding with Liou's technique. *Upper left*: 2 weeks old at first visit. *Lower left*: worm eye's view at first visit. *Upper middle*: the nasolaveolar molding device. *Lower middle*: during nasoalveolar molding. Lip taping is emphasized to approximate the alar bases as well as providing the counteracting force for columellar lengthening. *Upper right:* 4 months old before surgery. *Lower right*: worm eye's view at 4 months old

Grayson's technique emphasizes approximating the alveolar clefts before nasal molding, while in both Figueroa's and Liou's techniques alveolar and nasal molding are performed at the same time. A study comparing the results in these three techniques in unilateral clefts showed that the latter two techniques tend to result in a larger diameter in the cleft-side nostril postoperatively. However, both the latter two techniques are easy, less expensive and less time consuming [26]. Lip taping is therefore emphasized in Liou's method to approximate the alar base during nasal molding in order to prevent over-stretching of the ala.

The key point of nasal molding in bilateral clefts is to push the alar domes forward in the sagittal direction for columellar lengthening instead of pushing the domes upwards in the cephalic direction to produce an up-turned nasal tip. Most of the NAM techniques require regular patient follow-up over a period of one to two weeks, which is disadvantageous in terms of time and cost, as well as being a burden of care for the parents. A new device using a spring mechanism is a useful tool as it can provide a continuous force to lengthen the columella. It needs fewer visits during the molding period, thus greatly reducing the burden of care for the parents.

12.3.4 Evaluation and Recording of Pathology

There is a wide variation in the quality and amount of tissue in different elements, i.e. bone, cartilage, skin muscle and mucosa [27-31]. All bilateral clefts have some degree of asymmetry in their horizontal, vertical or sagittal dimensions. Documentation of the extent of the cleft and any pre-existing asymmetry prior to surgery is very important in order to assess post-operative results more accurately. Kernahan's "striped Y" method [32] cannot fully illustrate the range and diversity of the asymmetric cleft. The double-Y numbered classification, reported by Noordhoff in 1990, is a more accurate method for recording as well as being a more suitable system for computer database documentation [19].

12.3.5 Surgical Principles in Repairing Bilateral Cleft Lips

There are several surgical principles that need to be emphasized in bilateral cleft lip repair. They are as follows: 1) keep the width of the central lip segment narrow without compromising the blood supply, 2) advance the columella prolabium complex superiorly to allow reconstruction of the orbicularis oris muscle in front of the premaxilla, 3) reconstruct the nasal floor with different mucosal flaps, 4) adequately dissect the muscle on the maxilla, 5) deepen the prolabial buccal sulcus with tissue from the prolabium, 6) reconstruct the orbicularis oris muscle sphincter and anchor it to the nasal septum, 7) reconstruct the Cupid's bow, vermilion and lip tubercle by tissue from the lateral lips, 8) balance the height of both lateral lips without any incision around the ala, 9) preserve the columellar length and further lengthen it by reverse U-incisions, 10) release and reposition the lower lateral cartilage in an over-corrected position, and 11) maintain the presurgical nasolabial angle.

12.4 Surgical Refinements

12.4.1 Markings and Measurements of the Central Lip

The landmarks of the lip are marked out on the prolabium and both lateral segments and various measurements are taken (Figs. 12.9 – 12.10). On the prolabium, the width between the proposed peaks of the Cupid's bow (CPHR and CPHL) is chosen as 4 mm (Fig. 12.11). The width of the central segment is gradually narrowed to 3 mm at the base of the columella. The height of the central segment is determined by the original height of the prolabium. The incision lines of the prolabium are kept straight, not curvilinear.

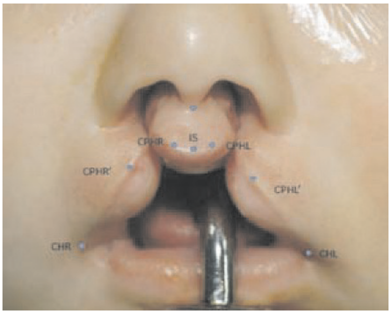


Fig. 12.9 The landmarks in bilateral cleft lip. IS: center of Cupid's bow; CPHR: right side peak of the Cupid's bow; CPHL: left side peak of the Cupid's bow; CPHR': the right side base of the philtral column; CPHL': the left side base of the philtral column; CHR: right side commissure; CHL: left side commissure

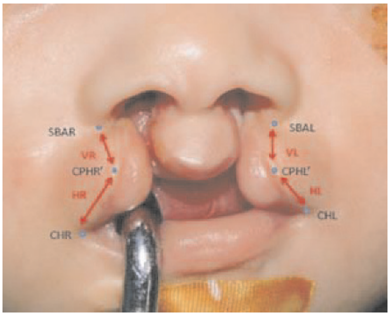


Fig 12.10 The landmarks and measurements. SBAR: right side alar base; SBAL: left side alar base; VR, VL: lip height from alar base to the base of the philtral column; HR, HL: lip length from commissure to the base of the philtral column

12.4.1.1 Discussion of the Markings and Measurements in the Central Segment

The width and height of the central lip vary widely in bilateral clefts owing to the great variation in their soft tissue condition. The post-operative width and height of the central lip also vary widely with different techniques. The central lip tends to become horizontally wide but remains vertically short in the technique without muscle approximation. With muscle approximation, the central lip will have less width but more length. Noordhoff[33], in attempting a primary elongation of the columella by interdigitation of forked flaps into a transverse incision in the nasolabial junction, found two vessels running from the columella to the prolabium. A width of 3 mm at the columellar base will include both these columellar vessels, providing good blood supply to the prolabium.

Two forked flaps are designed on the sides of the base of the columella. The incision line of the forked flaps is initially perpendicular to the vertical limbs of the prolabium flap, then extends down to the skin-mucosal junction on the premaxilla (Figs. 12.11 – 12.12). This incision then turns upwards along the skin-mucosal junction behind the columella up to the alar dome. The forked flaps are much smaller than in the original design by Millard.

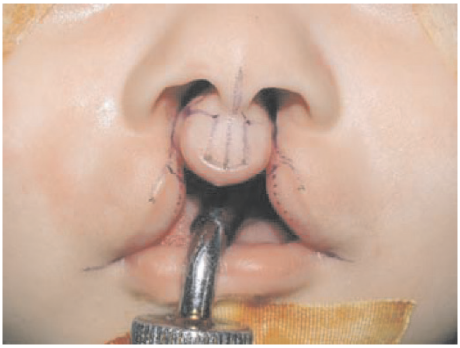


Fig. 12.11 The incision lines. On the prolabium, the central segment is 4 mm wide between the points CPHR and CPHL. The width is narrowed to 3 mm at the columellar base. The forked flaps are cut perpendicular to the central segment. The incision lines on lateral lips are along the free margin above the white skin roll

Fig. 12.12 Oblique view of the incision lines of the forked flap. The incision line goes downward to the deepest point of the skin/mucosal junction then turns back along the skin/mucosal junction behind the columella

12.4.1.2 Discussion on Forked Flaps

Millard suggests banking the forked flaps on the nasal floor. These banked forked flaps will be used for columellar lengthening in secondary revisions. In Oriental patients, a nose with disproportionately long columella and short dome components is quite often the case after a columellar elongation procedure using banked forked flaps from the nasal floor [22, 23]. The banked forked flaps will also end up with unsightly scarring on the nasal floor and nasolabial junction. Instead of banking these forked flaps to the nasal floor, the author's preference is to design a smaller forked flap and suture the tip backwards toward the septum to restore the nasolabial angle.

The lower margin of the prolabium incision is placed above the indistinct white skin roll (WSR) with the points CPHR and CPHL higher than the point IS for the shape of a Cupid's bow (Fig. 12.11). The vermilion and mucosa below this incision will be designed into an inferiorly based mucosal flap for deepening the central sulcus and two laterally based prolabium mucosal flaps (PM flaps) for reconstruction of the nasal floor.

12.4.2 Markings and Measurements of the Lateral Lips

The proposed base of the lateral philtral column on the lateral lips (points CPHR' and CPHL') are marked at the point where the vermilion first becomes widest and is usually 3 – 4 mm lateral to the converging junction of the red line and WSR (Fig. 12.11). The horizontal length from this point to the commissure is usually 13 – 15 mm. The vertical and horizontal lengths of the lips on both sides are measured to identify any asymmetry in vertical and horizontal dimensions. The incision line on the lateral lips is extended along the free margin of the lip, at the upper margin of the WSR, leaving the WSR to the free border to form a WSR-free border flap for later Cupid's bow reconstruction.

12.4.3 Markings for the Mucosal Flaps in Lateral Lips

A L-mucosal flap (L-flap) based on the alveolus of the cleft margin is marked out for lateral reconstruction of the nasal floor (Fig. 12.13). The upper incision line of the L-flap is continued along the skin-mucosal junction to the piriform area and to the base of the inferior turbinate to include a superiorly based inferior turbinate flap.

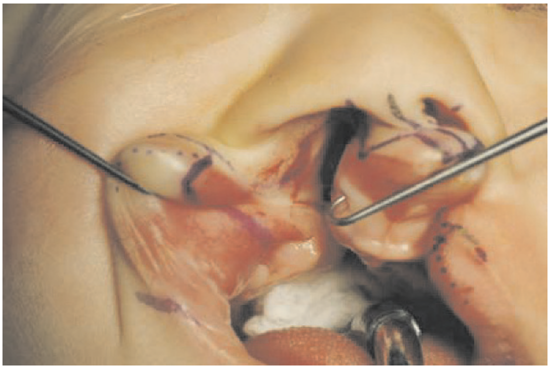


Fig. 12.13 The L-flap is based on the alveolus. The upper incision line of the L-flap is along the free margin of the lateral lip to the deepest point medial to the alar base then turns 90° along the skin/mucosal junction on piriform rim to the base of inferior turbinate

12.4.4 Incisions on the Central Segment

A double hook is used to retract the columella up while a small single hook is placed at the vermilion below the point IS to stretch the prolabium (Fig. 12.14). The central segment is developed by a No. 11 blade to give straight cuts. The two forked flaps are extended laterally behind the columella up to the alar domes. The lower margin of the prolabium incision is designed to give the appearance of the Cupid's bow. This incision should be placed above the indistinct WSR. The central prolabium, the forked flaps and the columella are raised as one unit and advanced cephalically with traction by a double hook (Figs. 12.15 – 12.16). and sutured to the membranous septum at their new position (Fig. 12.17). This creates a space between the prolabial skin and the premaxilla for later reconstruction of the orbicularis muscle in front of the premaxilla.

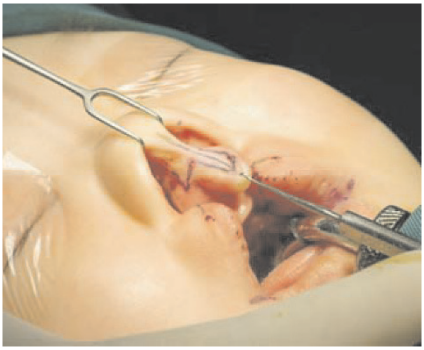


Fig. 12.14 The prolabium is stabilized by applying a double hook on the alar rims and a single hook at the vermilion for accurate incisions

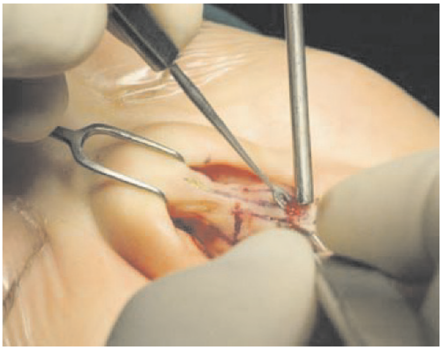


Fig. 12.15 Initial cuts are made with No. 11 blade for straight cuts. The central segment is then raised from the premaxilla

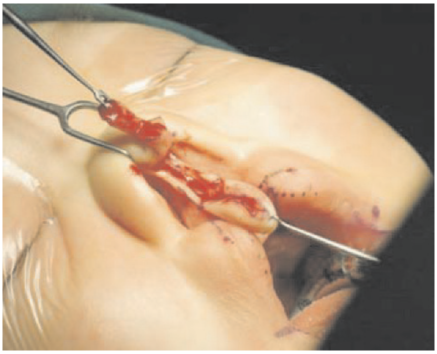


Fig. 12.16 The central prolabium, the forked flaps and the columella are raised together to the upper columella. This creates a space between the prolabial skin and the premaxilla allowing for muscle reconstruction in front of the premaxilla

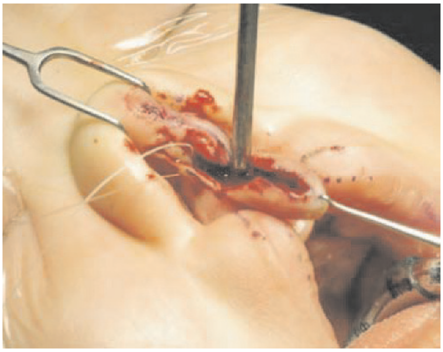


Fig. 12.17 The central prolabium, the forked flaps and the columella are advanced in a cephalic direction and fixed to their new position with 5-0 polyglactin

Discussion on the Columella-prolabium Complex

To dissect the prolabium and columella as one unit and advance the whole complex in the cephalic direction is important, as anatomically the prolabium does not have a muscle component under the skin. If the surgeon wants to restore the oral sphincter, a space has to be created in front of the premaxilla and behind the prolabial skin. To reconstruct the orbicularis muscle in front of the premaxilla with the nasolabial junction still attached to the anterior nasal spine will result in an extremely acute angle and an unnatural appearance.

12.4.5 Deepening of the Upper Buccal Sulcus

The vermilion and mucosa of the prolabium is divided into three parts (Fig. 12.18). The central part is used for the lining of the raw surface on the premaxilla (Fig. 12.19). The lateral parts of the prolabial mucosa flaps will be used for nasal floor reconstruction.

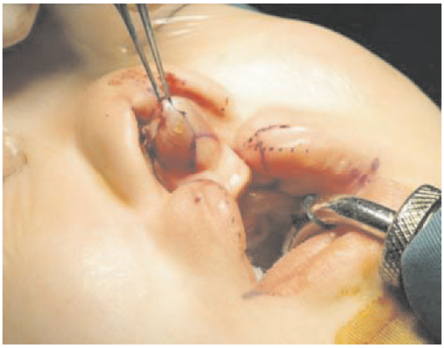


Fig. 12.18 The vermilion and mucosa of the prolabium are divided into 3 parts: the central one is used for deepening of the upper buccal sulcus and the lateral two flaps (PM flaps) are used for nasal floor reconstruction

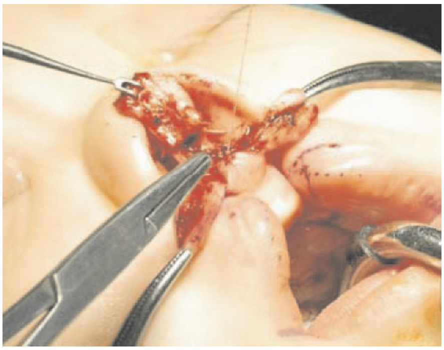


Fig. 12.19 Suturing the central mucosal flap to the periosteum of the premaxilla for deepening of the upper buccal sulcus

Discussion on the Upper Buccal Sulcus on the Premaxilla

Instead of using all the vermilion and mucosa for deepening the buccal sulcus on the premaxilla, only part of the tissue is used. An extremely deep central sulcus, though preventing the central lip from adhering to the premaxilla, might cause some problem in terms of blood supply during the alveolar bone grafting procedure. Only part of the tissue is needed to deepen the central sulcus to the same height as in the lateral maxillary segments.

12.4.6 Incisions on Lateral Segments

The incision is made from the proposed base of the philtral column (CPHR' and CPHL') along the cleft edge down to the alveolar margin. The incision is placed right above the WSR (Fig. 12.20). An L-mucosal flap based on the alveolus is raised along the cleft edge (Figs. 12.21 – 12.22). The incision is then continued along the skin-mucosa junction on the piriform rim and then around the inferior turbinate to raise an inferior turbinate flap based on vestibular skin. The inferior turbinate flap is dissected in a retrograde fashion using tenotomy scissors. The dissection is continued on the maxilla in a plane above the periosteum (Fig. 12.23). The cleft edge is then opened to develop the WSR-free border flap (Fig. 12.24). This flap is developed with the blade beveled to the labial mucosa to include more orbicularis marginalis muscle in the flap for reconstruction of the Cupid's bow, free border and lip tubercle. There is no skin incision the on nasal floor or incisions around the alar bases.

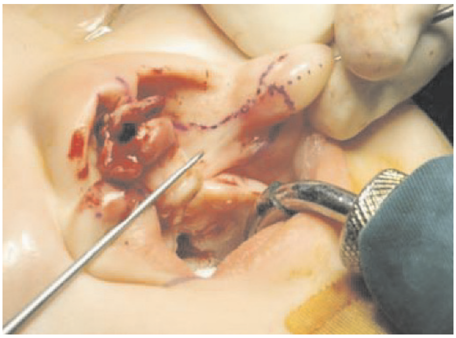


Fig. 12.20 The lateral lip is stabilized with a single hook and fingers for accurate incisions. The white skin roll is included with the vermilion for later reconstruction of the Cupid's bow

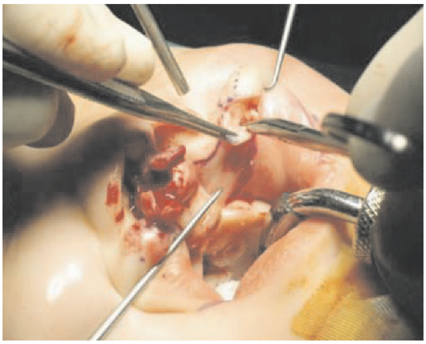


Fig. 12.21 The L-flap is raised with a tenotomy scissors. A thin layer of muscle is included in the flap for better blood supply

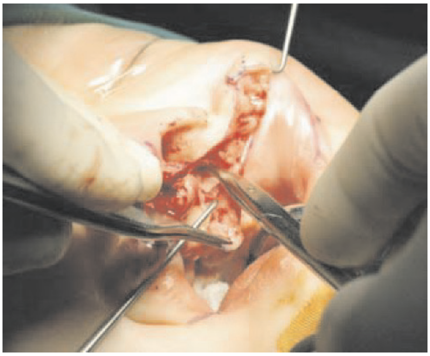


Fig. 12.22 Dissection of the L-flap to its base at the alveolus. The dissection is continued on the maxilla

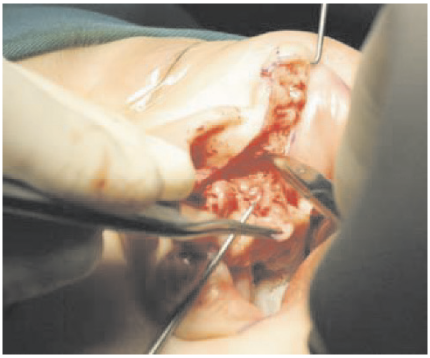


Fig. 12.23 The dissection plane on maxilla is above the periosteum

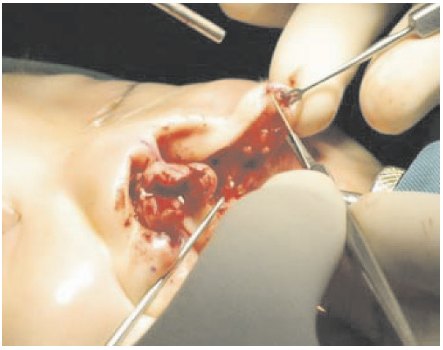


Fig. 12.24 Raising the orbicularis marginalis flap. The blade is beveled to the mucosa side to include more muscle in the flap which will be used for central lip tubercle in the reconstruction of the Cupid's bow

Discussion on the Necessity of a Horizontal Incision on the Lateral Lips

From the experience in unilateral cleft lip repair, the horizontal incision below the nasal floor is usually unnecessary. Nevertheless, the ala-facial groove will have a better appearance if the skin is kept intact. The only situation when the horizontal incision is necessary is in the presence of a vertical discrepancy between the central lip and lateral lips when shortening of the lateral lips is indicated. However, these horizontal incisions should be kept as short as possible.

12.4.7 Dissection of the Orbicularis Peripheralis Muscle

The dissection is carried above the periosteum on the maxilla (Fig. 12.24). The muscle dissection plane is above the periosteum, which gives a better chance of releasing all the abnormal muscle insertions to the maxilla. The dissection on the mucosal side is limited to 2 mm while the dissection on the skin side is quite extensive to separate the abnormal muscle insertion from the skin. The dissection is also carried lateral to the alar base to release the abnormal muscle component that inserts to the alar base (Fig. 12.25). The angular artery is used as a landmark to ensure the extent of dissection is lateral and superior to the alar base. The muscle is released until the muscle of the lateral segments can be brought medially and joined in front of the premaxilla without tension (Fig. 12.26).

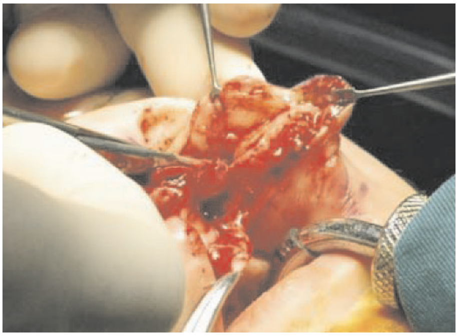


Fig. 12.25 Release of the abnormal muscle insertion around the alar base. The Angular artery is used as a landmark for the extent of the dissection

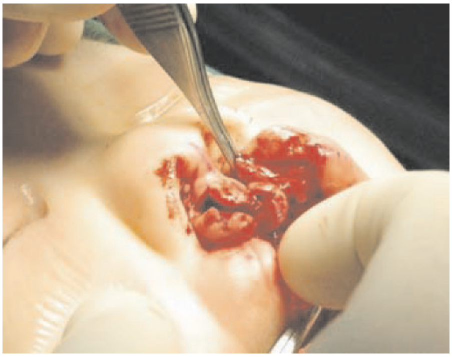


Fig. 12.26 Checking the adequacy of muscle dissection by pulling the muscle to see if it can reach the midline

Discussion on the Muscle Dissection Plane

Though Delaire[34] suggested wide subperiosteal dissection on the maxilla to achieve a functional closure, there is still a controversy about whether a subperiosteal or supraperiosteal muscle dissection is better in terms of function or subsequent facial growth. Supporters for subperiosteal dissection advocate that this will leave less scarring and, subsequently, less growth disturbance. However, there are no scientific data supporting the contention that a subperiosteal dissection will produce less scarring and better facial growth. A muscle dissection above the periosteum seems to offer a better release of the abnormal muscle insertion around the alar base from both the skin side and periosteal side. It is very important to release all the abnormal muscle insertions to the alar base to prevent the continuous pulling force causing the lateral and downward displacement of the alar base seen in secondary cleft deformities. The technique presented here emphasizes minimal but adequate dissection of muscle allowing its approximation at the center. This should create minimal scarring in front of the maxilla.

12.4.8 Nasal Floor Reconstruction

The inferior turbinate flap is not necessary in cases of a narrow cleft. For moderate to wide clefts, the turbinate flap is an essential part of providing lining on the lateral part of the nasal cavity. The inferior turbinate flap is transposed 90° with its superior margin sutured to the lower margin of the piriform incision. The L-flap is brought across the cleft and sutured to the perichondrium of the septal incision to reconstruct the nasal floor (Figs. 12.27 – 12.28). The inferior margin of the inferior turbinate flap is then sutured to the superior margin of the L-flap in cases of moderate to wide clefts. In case of a narrow cleft, when only the L-flap is used for the nasal floor, the superior margin of the L-flap is directly sutured to the piriform margin (Fig. 12.29). The PM flap is sutured caudally to the L-flap (Fig. 12.30).

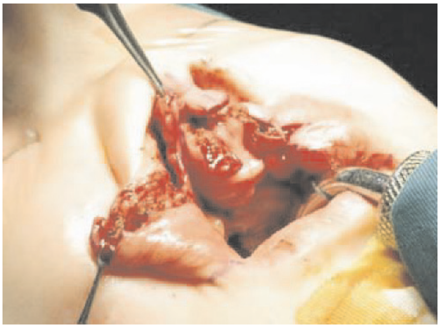


Fig. 12.27 Reconstruction of the nasal floor in a case with narrow cleft width. Only L-flap is used for reconstruction of the nasal floor. The tip of the L-flap is sutured to the incision on columella

The inferior turbinate flap, the L-flap and the PM flaps provide adequate tissue for coverage of the nasal floor and lateral nasal wall. These flaps can reconstruct a nasal floor with adequate height. Excess tissue on the PM flap is trimmed off to avoid any redundancy on the upper sulcus. The vestibulum of the alar base is then advanced with the upper margin of the piriform incision sutured to the upper margin of inferior turbinate flap and L-flap, with special attention focused on the width of the nostril to be around 8 – 10 mm (Figs. 12.31 – 12.33).

Fig. 12.28 Suturing of the L-flap to the columella and the base of the PM flap

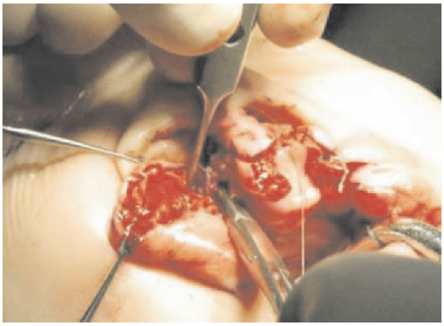


Fig. 12.29 As the cleft width is narrow; the upper edge of the L-flap is sutured to the piriform margin for complete mucosal closure in nasal floor

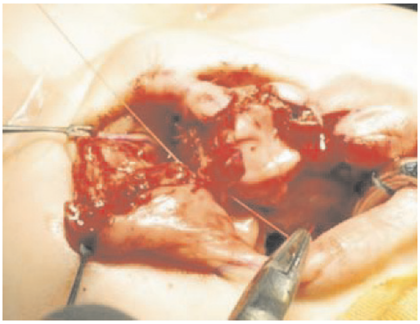


Fig. 12.30 Suturing the L-flap to the PM flap for the lower part of the mucosa on the nasal floor. The lower edge of the PM flap will be the upper buccal sulcus

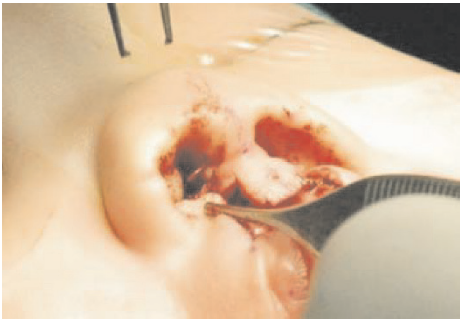


Fig. 12.31 Advancement of the alar base and the nasal vestibulum. The lower margin of the vestibulum is sutured to the upper edge of the L-flap

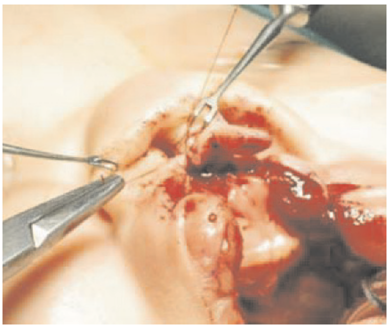


Fig. 12.32 The deepest point medial to the alar base is advanced and sutured to the columella. The nasal floor wound is completely closed

Fig. 12.33 Same procedure is performed on the other side. Great care must be taken for the symmetry of the nostril width

Discussion on the Mucosal Flaps used in Nasal Floor Reconstruction

Even with presurgical NAM, it is still not uncommon to see relatively retro-positioned maxilla and alar bases. Mobilization of the alar base will leave a raw surface in the piriform area. Noordhoff described the use of a buccal mucosal flap folded on itself filling in the inter-cartilaginous incision to facilitate cartilage repositioning as well as decreasing scarring in this area. The technique has been modified to using an L-flap for better flap orientation. Although the necessity of these flaps remains a controversial issue, the inferior turbinate, the L and the PM flaps do provide ample tissue for nasal floor reconstruction, especially in restoration of a nostril with adequate height in its nasal floor.

12.4.9 Muscle Reconstruction

The orbicularis muscles are approximated with 4-0 polyglactin sutures. The muscle and mucosa are approximated in one layer with mattress sutures in the lower part of the orbicularis muscle (Fig. 12.34). The muscle above the upper buccal sulcus is stitched with simple sutures. The upper edge of the orbicularis muscle is anchored to the nasal septum to prevent drifting down of the lip. It usually takes 4 sutures to complete the muscle reconstruction. There is no muscle interdigitation. The skin on the lateral lips should be approximated very closely after these muscle sutures (Fig. 12.35). Another cinch suture is placed under the alar base skin for further approximation of the lateral lips (Fig. 12.36).

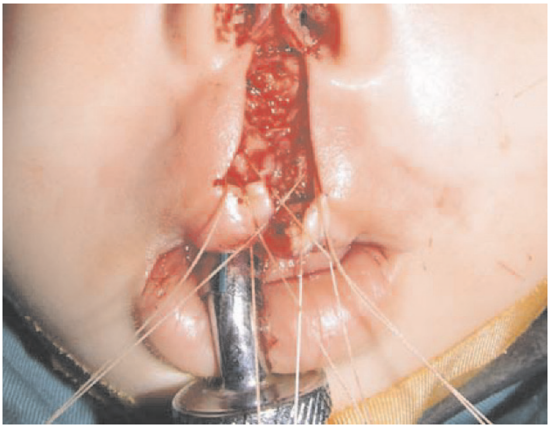


Fig. 12.34 Muscle reconstruction is performed by using mattress sutures on the lower half of the lip. The suture passes the muscle and mucosa on one side. The sutures then catch the mucosa on the other side, back to catch the mucosa on the initial side and finally catch the muscle and the mucosa on the second side. The upper two sutures are above the buccal sulcus thus only simple sutures are needed for muscle approximation

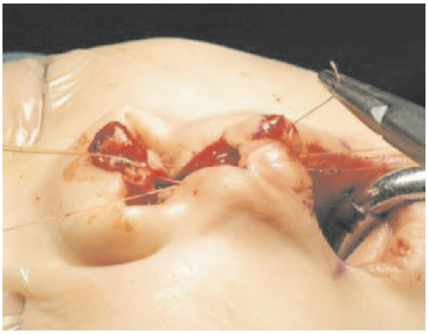


Fig. 12.35 The skin on the lateral lips should be able to be approximated very closely after the muscle reconstruction

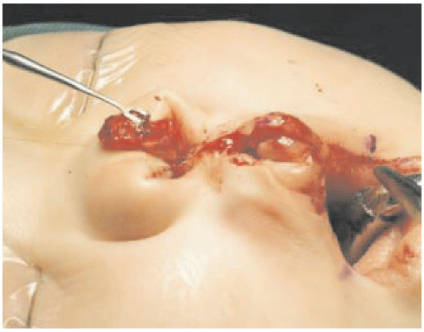


Fig. 12.36 The skin is further approximated by a cinch suture below the alar base. This can reduce the wound tension to the central prolabial segment

Discussion on the Muscle Reconstruction

Manchester [35, 36] felt the orbicularis muscle should not be reconstructed, as it would cause too much tension and growth disturbance. Nagase et al. [37], however, showed that there was no significant growth disturbance after muscle reconstruction. There is a definite difference in the appearance of the bilateral lip repair with or without muscle reconstruction. Muscle reconstruction produces a much better result both functionally and esthetically and also helps to restore a more natural-looking alar-facial groove. The author will not attempt to reconstruct the philtral column in repairing bilateral clefts unless it is an incomplete cleft with pre-existing philtral columns. From the literature, there is no good technique for philtral column reconstruction in bilateral clefts.

12.4.10 Cupid's Bow Reconstruction

The skin flap of the central segment is then sutured to the lateral lip. It is important to make as accurate approximation as possible of points CPHR and CPHL to their counterpart points CPHR' and CPHL' with subcuticular sutures (Fig. 12.37). The full thickness WSR-free border flaps are brought together below the central segment to reconstruct the central lip (Fig. 12.38). The WSR-free border flap is made longer than the skin part to create lip pout and the central tubercle (Figs. 12.39 – 12.42). The orbicularis marginalis muscle at the tip of the WSR-free border flap is preserved to form the central tubercle. The skin is closed with a 7-0 polyglactin suture.

Fig. 12.37 Approximation of the points CPHR and CPHR' with 5-0 polydioxanone subcuticular suture

Fig. 12.38 The Cupid's bow will be reconstructed by the white skin roll-free border flaps from lateral lips

Fig. 12.39 The white skin roll-free border flap is made longer than the width of the central segment. The redundancy in the white skin roll-free border flap will create the lip pout and central lip tubercle

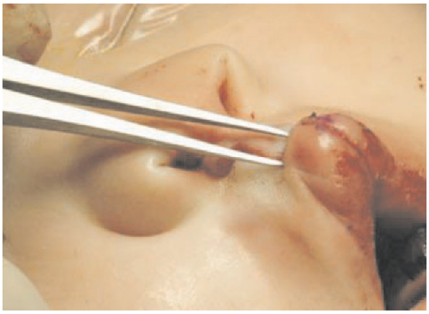


Fig. 12.40 The lip pout and lip tubercle

Fig. 12.41 The orbicularis marginalis muscle at the tip of the white skin roll-free border flap is preserved for the central lip tubercle. The muscles are sutured with 5-0 polydioxanone to prevent the central whistling deformity due to inadequate muscle approximation

Fig. 12.42 The point IS is sutured to the tips of the two white skin roll-free border flaps with 7-0 polyglactin sutures

Discussion on the Cupid's Bow

The techniques using the WSR and the vermilion on the prolabium to reconstruct the Cupid's bow often result in a Cupid's bow with abnormal peaking, indistinct WSR at the central lip, and an irregular vermilion with a depressed scar at the central lip (Fig. 12.43). The quality of the WSR from the lateral lips is much better compared with the WSR from the prolabium. Reconstruction of the central lip by advancing the WSR- free border flaps from the lateral lips will result in a Cupid's bow with a much better appearance [6, 18, 22, 23, 38, 39].

Fig. 12.43 The technique using the vermilion on the prolabium for central lip reconstruction will often leave an uneven suture line in this area

12.4.11 Adjustment of the Lateral Lip Height and Nostril Width

If there is any height discrepancy between the lateral lips after muscle approximation, this can be dealt with by adjustment of the muscle sutures or placement of some subcuticular sutures for fine adjustment. Any significant discrepancy between the two lateral lips can be adjusted by vertical shortening of the lip along the nasal floor on the longer side. If there is a significant discrepancy between the height of central lip and lateral lips, the lateral lips should be vertically shortened along the nasal floor to prevent pulling the columella-prolabium complex downwards. The nostril width should be measured again after muscle reconstruction. Any asymmetry in nostril width should be adjusted at this moment. A nostril wider than 10 mm should be narrowed by excising nasal floor tissue and advancing the alar base.

Discussion on the Vertical Dimension in Central Versus Lateral Lips

A vertically short prolabium, though difficult to stretch on the operating table, will always lengthen vertically after muscle approximation and produce a satisfactory appearance later if its height matches the height of both lateral lips. The problem is when there is a marked discrepancy in a short central lip and long lateral lips. In this situation, the surgeon should vertically shorten the lateral lip along the nasal floor to match the vertical height of the central prolabium. Direct approximation of central and lateral lips without shortening the long lateral lips will pull the columella and the nasal tip downwards, resulting in a nose with a very short columella and a tethered nasal tip. The Veau technique, using tissue from the long lateral lips placed below the short central prolabial segment to achieve lip lengthening, will result in an abnormally long and tight upper lip, and eventually results in severe maxillary retrusion (Fig. 12.44).

Fig. 12.44 The Veau technique using tissue from lateral lip placed below the central lip for lip lengthening will always results in a tight and bad looking lip

12.4.12 Nasal Reconstruction

Bilateral reversed U-incisions are made on both alar rims (Figs. 12.45 – 12.46). The caudal edge of the lower lateral cartilages (LLCs) can be easily seen through this incision. The LLCs are dissected by eye to release all the fibrofatty tissue of the nasal tip from the LLCs (Figs. 12.47 – 12.48). The separated LLCs are approximated by mattress sutures using 5-0 polydioxanone sutures (Figs. 12.49 – 12.55). The fibrofatty tissue on the nasal tip is brought to the top of the approximated LLCs. The tissue on the lower edge of the reversed U-incisions is turned into the nasal lining of the columella and excessive tissue is carefully trimmed off (Fig. 12.56). The wound is closed with 5-0 polyglactin sutures. The medial crura are further reinforced by another mattress suture (Fig. 12.57). Through-and-through alar transfixion sutures using 5-0 polydioxanone are placed on the alar-facial groove to close the dead space above the alar base, tack down the webbing in the nasal vestibulum, provide further support to the LLCs and restore the alar-facial groove (Figs. 12.58 – 12.60).

Fig. 12.45 The reverse U-incisions for nasal reconstruction

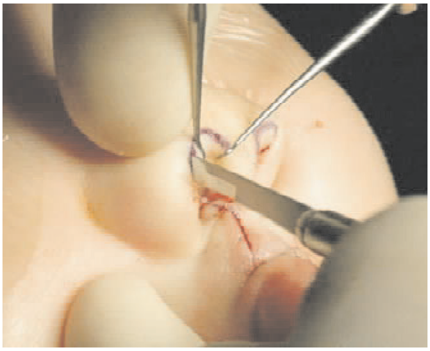


Fig. 12.46 The incisions are cut with No. 67 blade with two single hooks to stabilize the alar rim

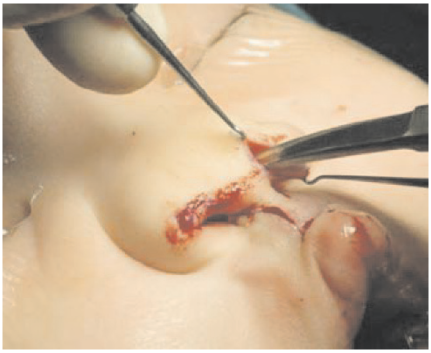


Fig. 12.47 Sharp dissection is performed with tenotomy scissors to separate the fibrofatty tissue from the lower lateral cartilages under direct vision

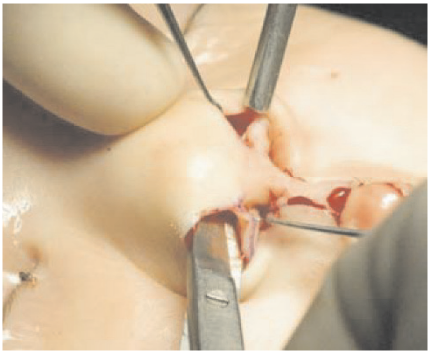


Fig. 12.48 The fibrofatty tissue should be completely separated from the cartilage that the scissors can be passes from the incision on one nostril to the other one

Fig. 12.49 Markings are made on the dome area for accurate placement of the stitches for cartilage approximation

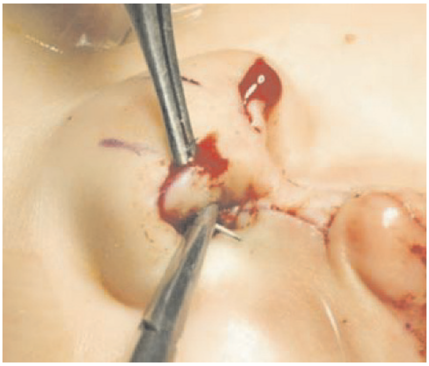


Fig. 12.50 The suture is passed through the cartilage at the point lateral to the alar dome for better approximation of the cartilages

Fig. 12.51 The needle is passed through the subcutaneous tunnel then catching the cartilage on the other side. The needle is also passed at the point lateral to the alar dome

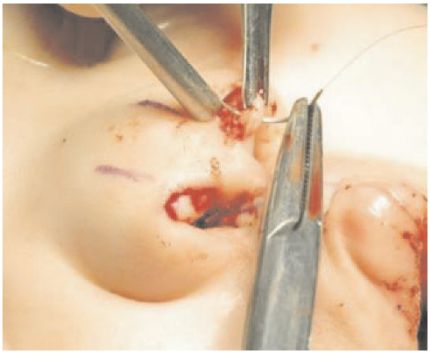


Fig. 12.51 The needle is passed through the subcutaneous tunnel then catching the cartilage on the other side. The needle is also passed at the point lateral to the alar dome

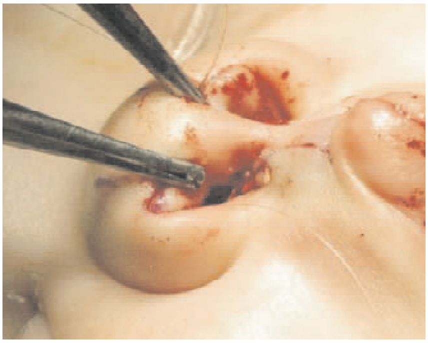


Fig. 12.53 Passing the needle through the subcutaneous tunnel again with the tip of the needle pointed backward to prevent catching the tip soft tissue

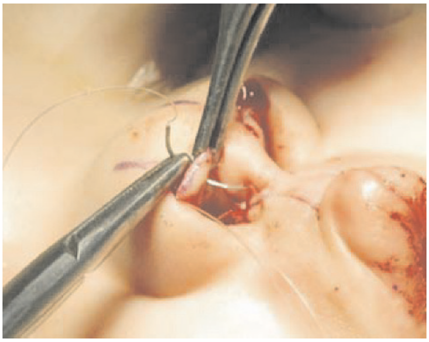


Fig. 12.54 Passing the needle through the symmetrical point as the other nostril

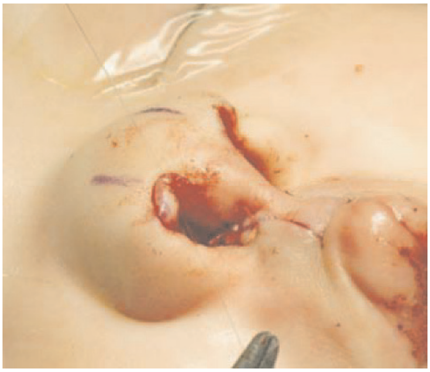


Fig. 12.55 Approximation of the LLC's by this mattress suture. Note that some skin below the reverse U-incision is now moved to the upper part of the columella after cartilage approximation

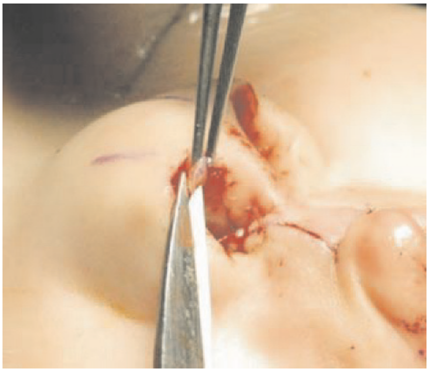


Fig. 12.56 Trimming of the excessive skin with sharp scissors

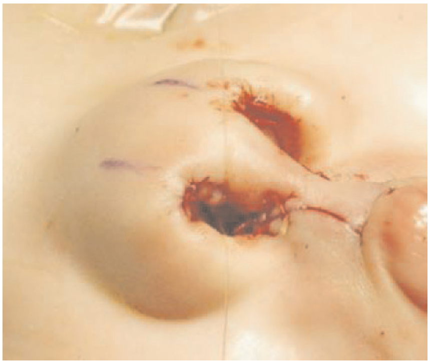


Fig. 12.57 Reinforcement of the medial crura by another mattress suture

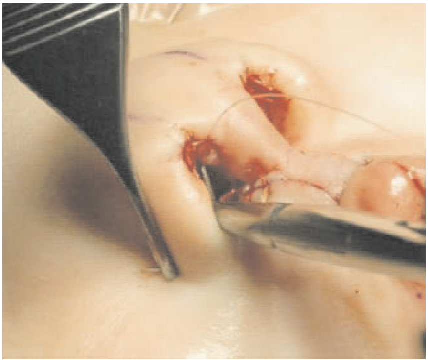


Fig. 12.58 The alar transfixion suture. Passing the needle from nasal vestibulum and come out of skin at alar-facial groove

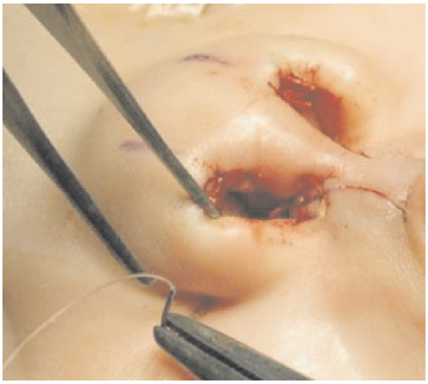


Fig. 12.59 The needle is passing through the same puncture hole back to the vestibulum

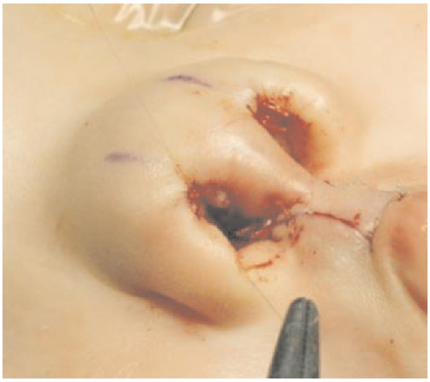


Fig. 12.60 This alar transfixion suture helps to close the dead space in this area after releasing the alar base from the maxilla

12.4.12.1 Discussion on Open, Semi-open and Closed Rhinoplasty

The approximation of the LLCs can be achieved through either an open, semi-open or closed rhinoplasty. All these three techniques have been used in the Chang Gung Craniofacial Center. The closed rhinoplasty was used in the late 1980s and the open rhinoplasty was used in the 1990s. Semi-open rhinoplasty has been the technique used in our institute since the early 2000s. The closed rhinoplasty, with cartilage dissection through the inter-crural space under the prolabium-columella and through the alar bases, has less chance of adequate release of the cartilage from the skin and higher risk of iatrogenic injury to the cartilage. The open technique has been used in author's institute since the 1990s. Though it can provide a better result than the closed technique, it was replaced by the semi-open technique for the following reasons: 1) Technically, a semi-open rhinoplasty with bilateral reverse U-incisions is simpler compared with the open rhinoplasty through a Trott's incision. 2) Separate septal incisions behind the medial crura and reverse U-incisions above the alar rims tend to have less risk of leaving visible contracted scar bands behind the columella compared with the open technique [40]. 3) Adams [41] reviewed the nasal tip support in open versus closed rhinoplasty, and showed the mean loss of tip projection was higher after an open rhinoplasty, which is another benefit for the semi-open rhinoplasty with reverse U-incisions.

12.4.12.2 Discussion on the Alar Transfixion Sutures

Dissection of the LLC from the skin will leave a dead space between the skin and cartilage. Mobilization of the alar base on the cleft side will accentuate the vestibular webbing inside the nostrils. The author uses alar transfixion sutures instead of bolster sutures to solve these problems and help to define the alar-facial groove. Two sutures are usually required. The lower suture is used to close the dead space and tack the vestibular webbing. The upper suture catches the leading edge of the LLC and helps to support the LLC [42].

12.4.13 Restoration of Nasolabial Angle and Nasal Floor

The forked flap is trimmed and sutured backwards towards the nasal septum to tighten and restore the nasolabial angle (Figs. 12.61 – 12.62). The excess tissue on the nasal floor is trimmed and the closure of the nasal floor is completed, care being taken to adjust the nostril width to around 8 – 10 mm (Fig. 12.63).

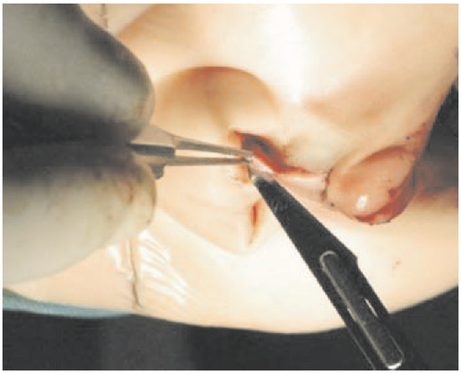


Fig. 12.61 Trimming of the excessive forked flap

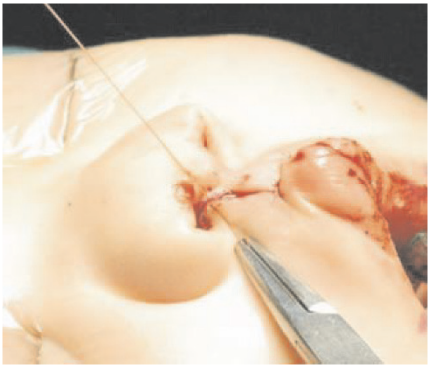


Fig. 12.62 Suture the forked flap backward to the septum helps to restore the nasolabial angle

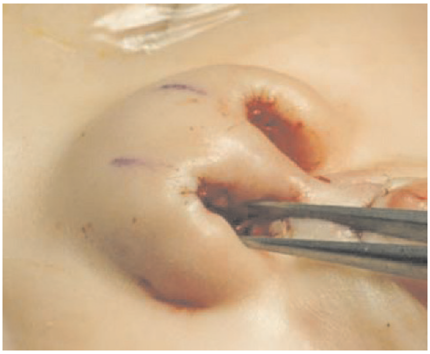


Fig. 12.63 The nostril width is re-checked for any asymmetry or inappropriate width, i.e., larger than 10 mm

Discussion on the Nasolabial Angle

The nasolabial angle is maintained by a ligament from the subcutaneous tissue to the anterior nasal spine [42]. Whenever the columella-prolabium complex is raised, the nasolabial angle tends to be reduced after operation. As restoration of the ligament by a tack-down suture from the skin to the anterior nasal spine may compromise blood supply to the prolabium, suturing the tips of the forked flaps backwards to the septum is a more practical way to restore the nasolabial angle [43].

12.4.14 Final Skin Closure

The lip skin is approximated with 7-0 polyglactin sutures. The vermilion is approximated with 7-0 polyglactin mattress sutures above the red line and 5-0 polyglactin sutures below it (Figs. 12.64 – 12.67).

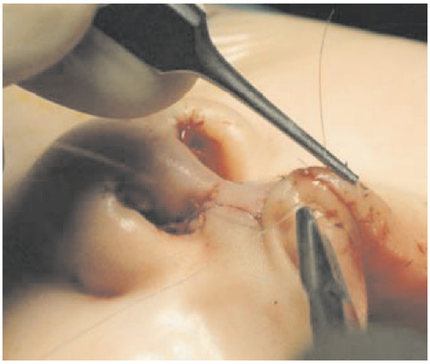


Fig. 12.64 The central vermilion is closed with mattress sutures for eversion of the wound edges

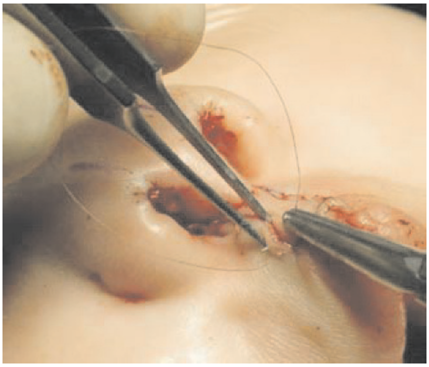


Fig. 12.65 Skin closure with 7-0 polyglactin sutures

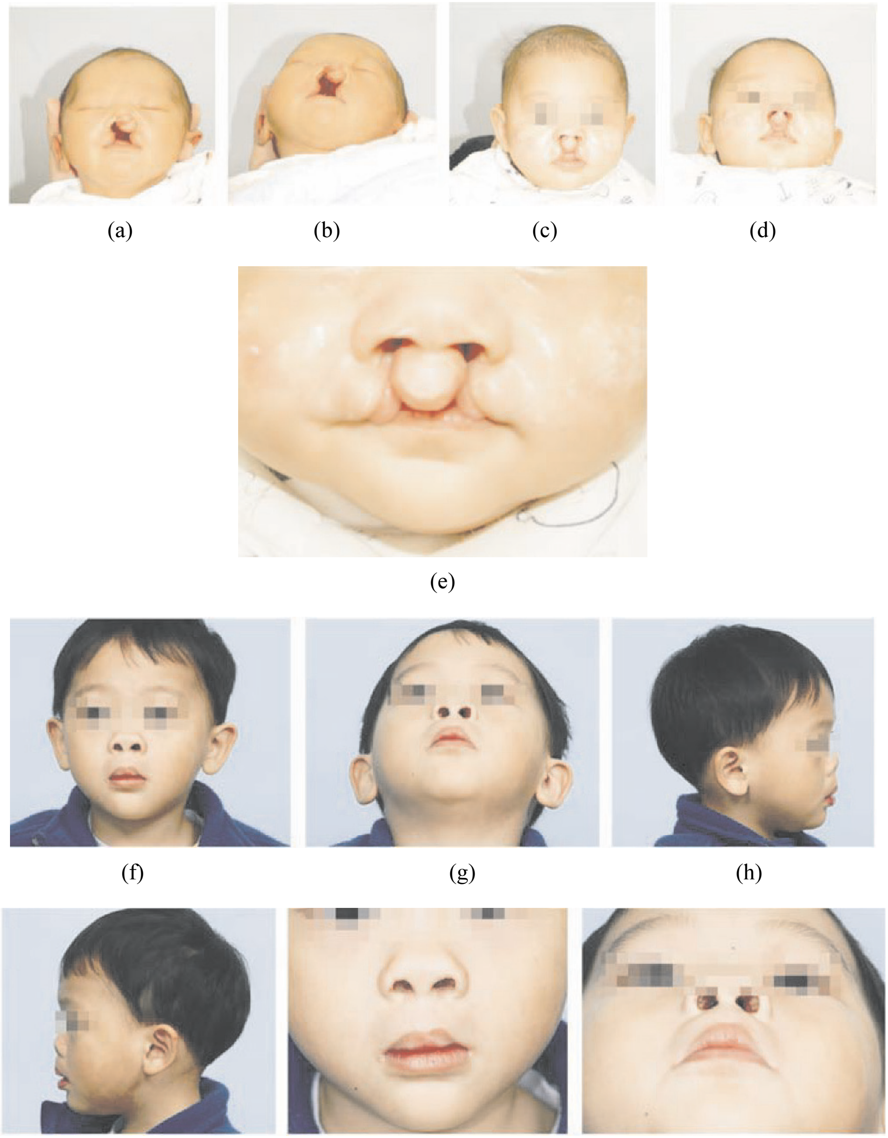
Fig. 12.66 Final appearance, front view

Fig. 12.67 Final appearance, worm eye's view

12.4.15 Post-operative Care

The wounds on the lip and nose are covered by antibiotic ointment. If there is excessive oozing or swelling, the wounds can be covered by sponges soaked in normal saline. The sutures are removed 5 to 7 days after surgery at the out-patient clinic under oral chloral hydrate sedation. The lip scars are supported by Micropore tapes as well as silicone sheets for 6 to 9 months. For that period, a silicone nasal conformer is also needed. Though the child grows throughout this period, changing a larger silicone splint is not recommended as it tends to widen the nostrils. The parents are taught to increase the height of the conformer gradually by adding silicone sheets (1 mm in thickness) to the domes of the conformer every two weeks. Usually 3 to 4 layers of silicone sheeting can be added. This helps to maintain or even increase the columella height after operation.

The results of this technique are shown in Figs. 12.68 – 12.69.



(a) (b) (c) (d) (e) (f) (g) (h) (i) (j) (k)

Fig. 12.68 A boy with bilateral complete cleft lip and palate. (a), (b): at first visit; (c), (d), (e): after nasoalveolar molding; (f) – (k): at 3 years old

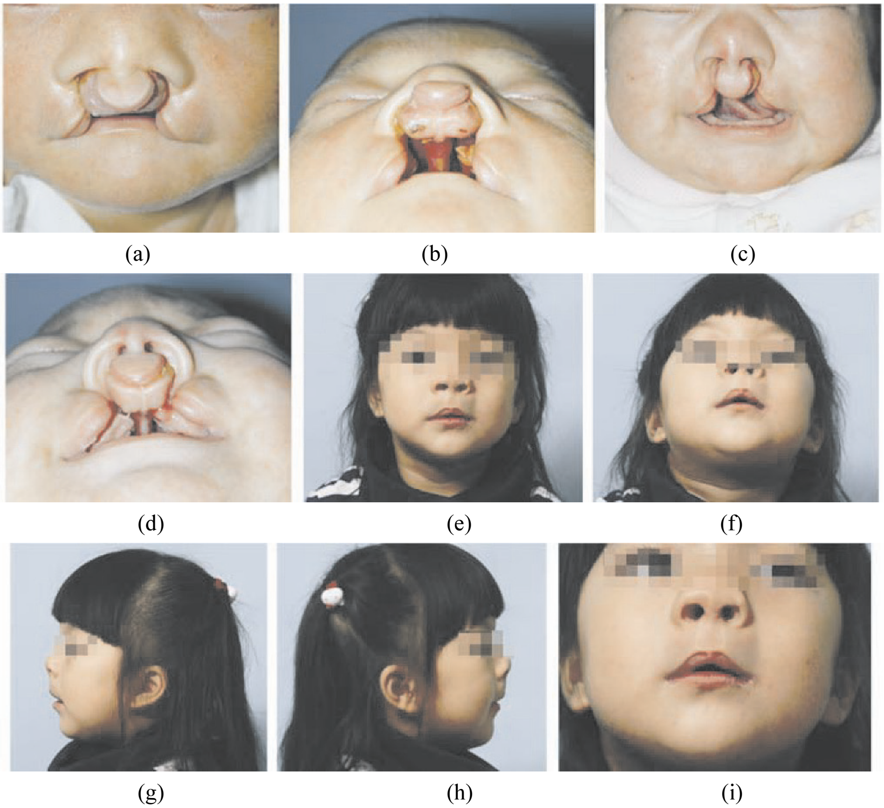


Fig. 12.69 A girl with bilateral complete cleft lip and palate. (a), (b): at first visit; (c), (d): after nasoalveolar molding; (e) – (i): at 3 years old

12.4.16 Complications

54 patients subjected to bilateral cheiloplasty in the Chang Gung Craniofacial Center from 2006 to 2008 were evaluated for post-operative complications. One patient suffered wound dehiscence which healed with wound care without further surgical intervention. There was one minor separation of the nasal floor, and one minor separation of the Cupid's bow at the IS point. There were 3 stitch abscesses. Four patients had noticeable asymmetry in their lip height, and 10 patients had some degree of nasal asymmetry.

12.4.17 Satisfaction of Patients

The satisfaction of patients or their parents is mainly dependent on their psychosocial adaptation. The experience in the Chang Gung Craniofacial Center revealed that almost every bilateral cleft patient was asking for revision of their lip or nose before school age during the 1980s. The percentage decreased to about one third in the early 2000s and almost no patient had revision surgery before school age in the last 5 years. This is a result of the integrated approach and the improvement in expertise and technique after primary repair.

12.4.18 Long-term Results in Nasal Reconstruction

The long-term results in nasal reconstruction usually give an impression of relapse of the nasal shape. A study was performed in 2004 in the Chang Gung Craniofacial Center to evaluate the changes in nasal morphology in complete bilateral clefts 3 years after lip repair [44]. The results were evaluated by photometric measurements with life-size photographs. The study included 22 patients. All of them had had Liou's method for NAM. The surgical technique is similar to the aforementioned technique except there was no nasal incision, no cartilage dissection and no cartilage repositioning. All the nasal results were the effect of NAM. The results showed that there was a significant increase in nostril width, significant increase in nasal tip height and nostril height, while columellar height remained the same. These changes give an impression of relapse of the pre-operative deformity as the nasal width increased and columellar height remained the same. Another study evaluating a different group of patients having Grayson's method for NAM and open rhinoplasty showed an improved result. However, the trends for post-operative changes were similar to the previous study. These studies showed the importance of over-correction of nostril height and width during surgery and the need to maintain nostril shape in an over-corrected position post-operatively. There are no scientific data suggesting the extent of over-correction during surgery. The post-operative maintenance can be achieved by gradually adding silicone sheets or soft resin to the nasal splint to increase the nostril height. Usually the patients can tolerate 3 to 4 layers of additional silicone sheeting.

12.5 Conclusion

Presurgical orthopedics and NAM provide the surgeon with a much better skeletal foundation for reconstruction of the bilateral cleft lip. The goal is to restore all the displaced tissue, reconstruct the dynamic sphincter, reconstruct the Cupid's bow with tissue from the lateral lips, overcorrect the nasal width, maintain and further elongate the columella during surgery and maintain the columellar height post-operatively. With these modifications, the author has been able progressively to improve his results over the past twenty years [45].

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Part IV

Primary Repair of Cleft Palate

13

Biological Basis and Geometry in Cleft Palate Repair

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Congenital cleft palate is one of the most common birth defects in the craniofacial region. Patients with cleft palate may experience maxillary growth retardation as well as dysfunctions in speech and feeding. Over the past centuries, management of cleft palate has evolved from simple closure of the cleft, although now surgical reconstruction of the palatal structures is one of the most important treatment steps. The optimal palatoplasty should achieve velopharyngeal competence (VPC) in order to develop normal speech, while causing the least growth disturbance to the maxilla and occlusion. This requires not only the closure of the cleft, but also restoration of palatal functions. It is a widely accepted concept that functional reconstruction of the intravelar muscles, particularly the levator veli palatini muscle (LVP), is an essential component in palatoplasty. The levator muscle plays an important role in raising the soft palate, which is critical to achieving adequate velopharyngeal closure. In patients with cleft palate, the origins of the levator muscle on the cranial base are approximately normal, but its course and palatal insertions are abnormal. The levator muscle fibers do not intermingle with fibers from the opposite side to form a sling; by contrast, they course anteriorly within the velum, merge with the other velopharyngeal muscles, and attach to the posterior edge of the palatine bone. Accordingly, modern palatoplasty emphasizes retro-positioning and reconstruction of the levator sling to optimize palatal functions after surgery. Meanwhile, it is necessary to minimize or even eliminate the relaxing incisions and denuded bone surface to avoid excessive scar formation and interference with maxillofacial growth after surgery.

13.1 Exploit the Maximum Muscular Potential in Velopharyngeal Closure

The levator veli palatini muscle plays a primary role in elevating the soft palate that contributes to velopharyngeal closure. Structural abnormalities and functional incompetence of this muscle result in velopharyngeal inadequacy (VPI) in individuals with cleft palate, sometimes even in children with repaired palate. A number of magnetic resonance imaging (MRI) investigations carried out at our center in collaboration with the University of Maryland provide insights into the abnormalities related to VPI [1-3].

We compared velopharyngeal structures including the LVP muscle using high-resolution MRI scans in three matched groups of young children: 1) children with repaired cleft palate and post-operative VPI; 2) children with repaired cleft palate and adequate velopharyngeal closure; and 3) children without cleft palate [1] (Figs. 13.1 – 13.4). It was noted that the children with VPI have less retro-positioning of the levator muscle, and therefore a longer distance for the soft palate to travel in order to reach the posterior pharyngeal wall during velopharyngeal closure (Figs. 13.5 – 13.6). Nonetheless, there are few differences in structural parameters between the two groups with statistical significance. Greater differences are found between the children with and without cleft palate (Fig. 13.5, 13.7 – 13.8). This result suggests that primary palatoplasty cannot restore the levator muscle and velopharyngeal anatomy to "normal", but the better restoration is associated with better velopharyngeal function.

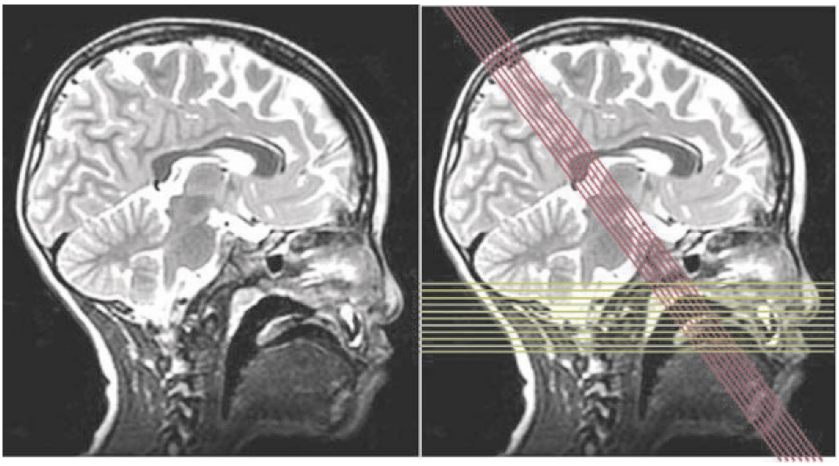

Fig. 13.1 Planes of MRI scans. The image on the left is a midsagittal slice of a 6-year-old boy with right complete cleft lip and palate and VPI following palatal repair. In addition to a multislice sagittal scan covering the whole head, there were a transverse scan covering the whole velopharyngeal mechanism and an oblique scan covering the entire course of the levator muscle sling. The orientations of the transverse and oblique scans are demonstrated in green and red lines in the image on the right

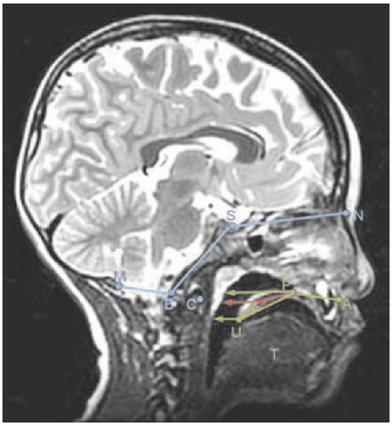

Fig. 13.2 Measurements on the sagittal plane. This graph demonstrates the landmarks and measurements on the sagittal plane of the same child as in Fig.13. 1. The red dot in the middle of the velum stands for the center of the palatal muscles (M). The distance between the posterior nasal spine (P) and M is the effective velar length, whereas that between the uvular tip and M is the posterior velar length. The red arrow stands for the muscle pharyngeal depth. The two other green arrows are the pharyngeal depth and uvular pharyngeal depth. N: nasion, S: sella, B: basion, M: magnum, C_1: anterior border of the first cervical vertebral arch, A: anterior nasal spine (anterior border of the hard palate), P: posterior nasal spine (posterior border of the hard palate), T: tongue

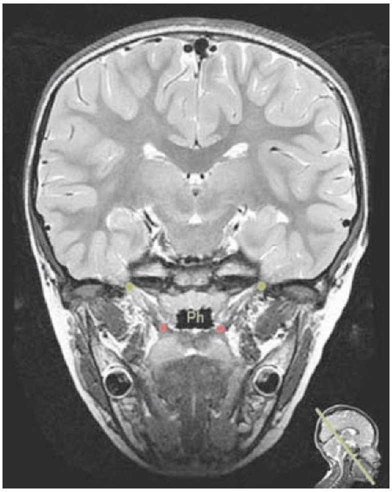

Fig. 13.3 Measurements on the levator veli palatini muscles. This image presents the landmarks used to measure the levator veli palatini muscles (LVP). The orientation of the scan is indicated by the green line at the lower right corner. The two green dots mark the origin of the LVPs, while the two red dots represents where the LVPs insert into the velum. The distance between the green and red dots on either side is the length of the extravelar portion of the LVP. Ph: pharynx

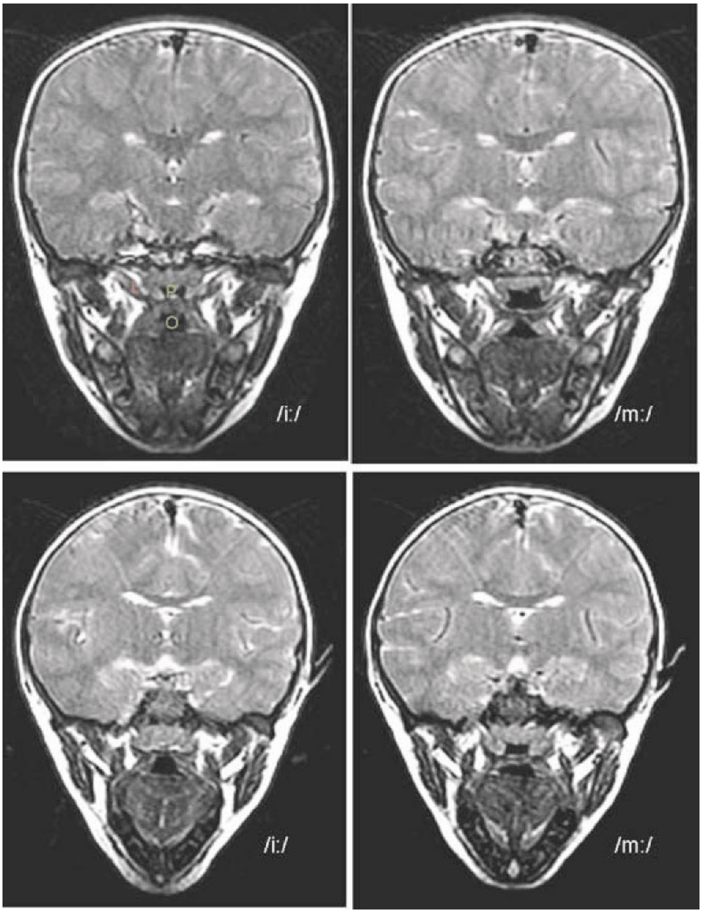

Fig. 13.4 Levator veli palatini muscles during sustained phonation. The four oblique coronal slices above show the contraction of the levator veli palatini muscles (LVPs) during sustained phonation. The levator muscles are reconstructed by the radical dissection technique and form a continuous sling (hypointense area marked by "L"). The upper two images come from a 7-year-old girl with right complete cleft lip and palate and VPI. The lower two images are from her twin brother with left complete cleft lip and palate and adequate velopharyngeal closure. In both cases, there is still a velopharyngeal gap during phonation of /m:/, whereas the adequate closure is demonstrated in the lower left image during phonation of /i:/, but not in the upper left image. L: levator veli palatini muscle, P: pharynx, O: oral cavity

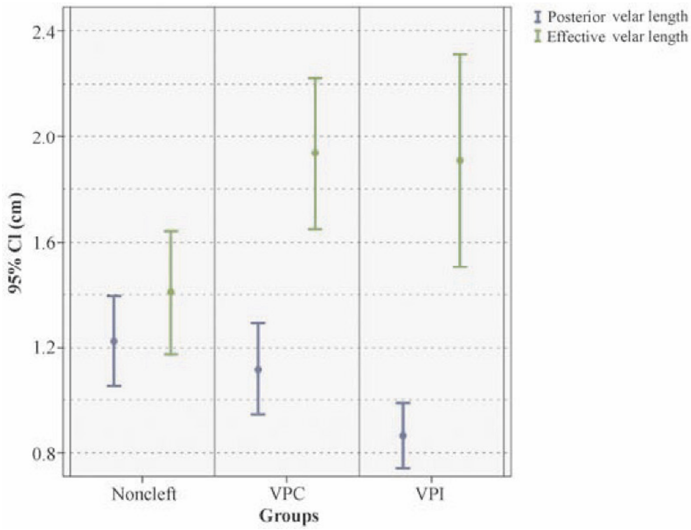

Fig. 13.5 Effective and posterior velar length in the three groups. The two groups with cleft palate have significantly longer anterior (effective) velum than the Noncleft group due to anteriorly located posterior border of the hard palate, which implies more work load in order to pull the velum toward the posterior pharyngeal wall during speech. The posterior velar length is the shortest in the VPI group, followed by the VPC group and Noncleft group

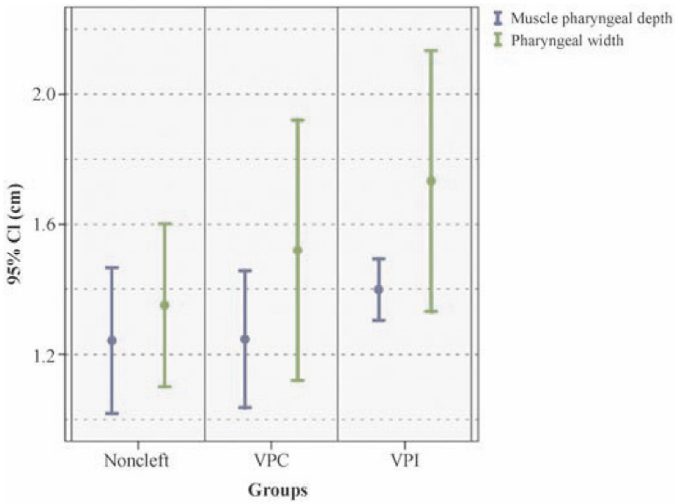

Fig. 13.6 Functional pharyngeal dimensions in the children with repaired cleft palate. The VPC group tends to have narrower and shallower pharynx than the VPI group, although the overall differences between these two groups are not significant ($p>0.05$)

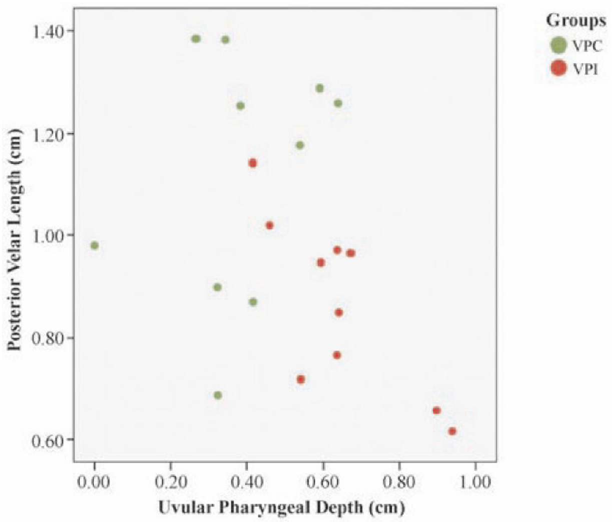

Fig. 13.7 Scatter plot of the uvular pharyngeal depth and posterior velar length in the children with repaired cleft palate. The VPC group has significantly shorter posterior velum and longer uvular pharyngeal depth compared to the VPI group. However, there is no clear distinction between these two groups

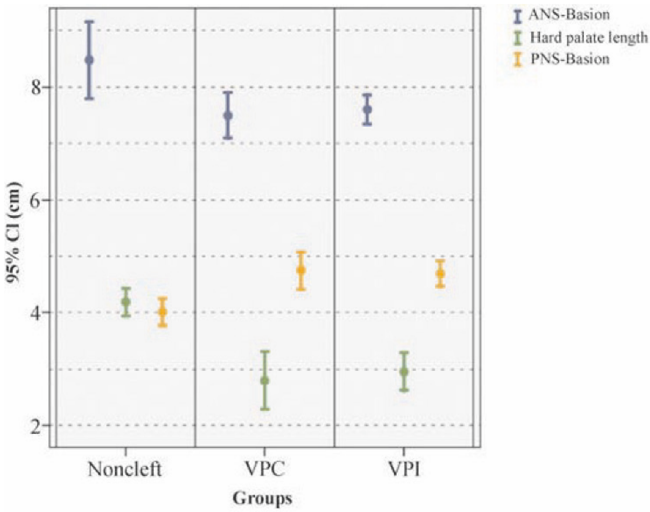

Fig. 13.8 Cranial base depth, hard palate length, and pharyngeal depth in the three groups. The two groups with cleft palate have significantly shorter hard palate and cranial base (ANS-Basion) than the Noncleft group because of the retruded and underdeveloped maxilla in the presence of cleft palate. As a result, the posterior border of the hard palate is more anteriorly located in the two groups with cleft palate compared to that in the Noncleft group as evidenced by the significantly longer pharyngeal depth (PNS-Basion)

Further comparison was made to investigate the extent of maximum velopharyngeal movement and levator muscle shortening during sustained phonation of non-nasal sounds in the three groups [2]. The VPI group had the least maximum velar stretch, lowest maximum velar height, smallest maximum pharyngeal constriction, lowest maximum velopharyngeal ratio (anterior velar length/pharyngeal depth), and least pharyngeal constriction ratio followed by the VPC group (Figs. 13.9 – 13.12). The effective velopharyngeal ratio at rest was found to have a strong positive correlation with the extent of maximum velopharyngeal closure in the antero-posterior dimension during sustained phonation (Fig. 13.13), which suggests a predictive value of the structural ratio between the anterior soft palate length and the pharyngeal depth for VPC. The anterior soft palate originates from the posterior border of the hard palate and ends at the center of the palatal muscles. Its length is determined, in part, by retro-positioning of the LVP muscle in primary palatoplasty.

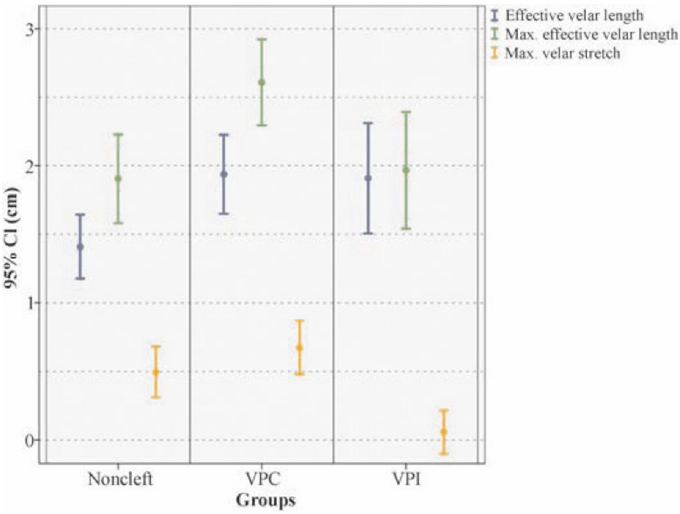

Fig. 13.9 Effective velar lengths at rest and during sustained phonation. The effective velar length at rest is similar in the VPI and VPC group, whereas the velum of the VPC group is stretched significantly more than that of the VPI group during sustained phonation (p<0.0001). As a result, the VPC group has significantly greater maximal effective velar length (p =0.041) than the VPI group. The Noncleft group has the second greatest velar stretch, whereas the VPI group demonstrates almost no velar stretch on average. The central circle stands for the mean value, whereas the line represents the 95% confidential interval of the variable

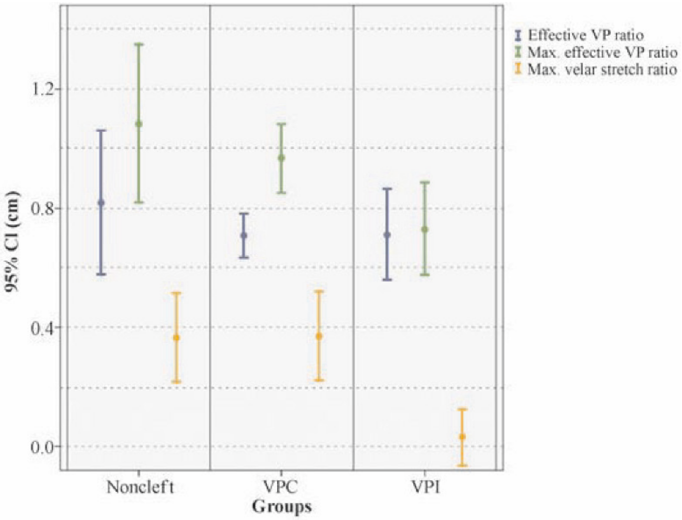

Fig. 13.10 Effective velo pharyngeal (VP) ratios at rest and during sustained phonation. The effective VP ratio at rest is similar among three groups, but the Noncleft group has the greatest maximal effective VP ratio, followed by the VPC and VPI groups respectively. This can be explained by the fact that the Noncleft and VPC groups having significantly greater maximal velar stretch ratio than the VPI group. The central circle stands for the mean value, whereas the line represents the 95% confidential interval of the variable

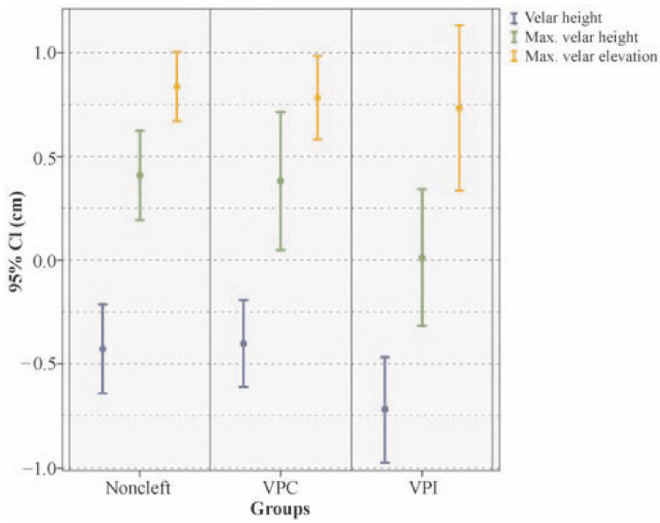

Fig. 13.11 Velar heights at rest and during sustained phonation. The VPI group's palatal muscle center is located the lowest at rest and at its maximal height, although it elevates the similar amount during sustained phonation to those of the Noncleft and VPC groups. Despite the consistent trend, the difference between groups is not statistically significant. The central circle stands for the mean value, whereas the line represents the 95% confidential interval of the variable

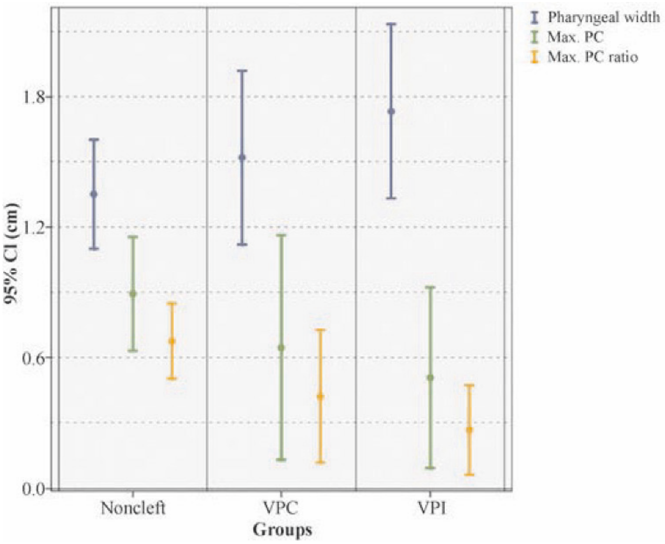

Fig. 13.12 Pharyngeal widths at rest and during sustained phonation. The VPI group has the widest pharynx at rest, but the least maximal pharyngeal constriction (Max.PC) and maximal pharyngeal constriction ratio (Max.PC ratio). The difference between the Noncleft and VPI groups is significant for the maximal pharyngeal constriction ratio (p =0.009). The width measurements are in the unit of centimeter. The central circle stands for the mean value, whereas the line represents the 95% confidential interval of the variable. All width measurements are in the unit of centimeter

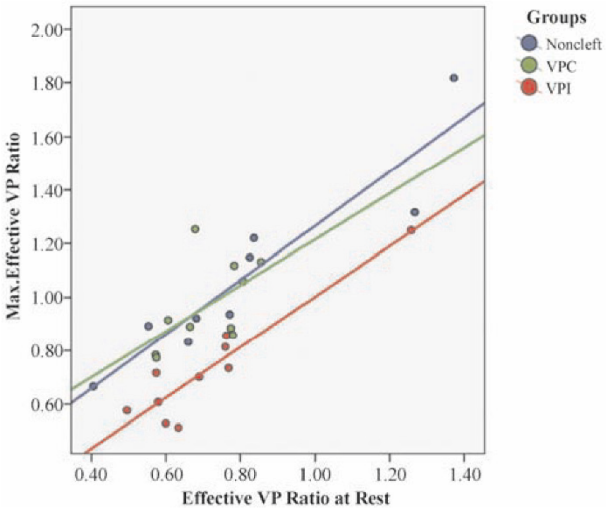

Fig. 13.13 Correlation between the effective VP ratios at rest and during sustained phonation. Regardless of the cleft condition and velopharyngeal function, the maximal effective VP ratio is strongly and significantly correlated to the effective VP ratio at rest (*Spearmanρ* =0.709 – 0.798, p<0.001 – 0.05). The three colored oblique lines stand for different correlation coefficients for the three groups

Interestingly, a strong linear correlation is found between the maximum velar stretch and the maximum pharyngeal constriction ratio in the VPI group (Fig. 13.14), which may imply that velopharyngeal closure movements in the antero-posterior and medial-lateral directions are correlated. It is a matter for further investigation and clarification as to whether the procedures enhancing velar stretch may also improve pharyngeal constriction.

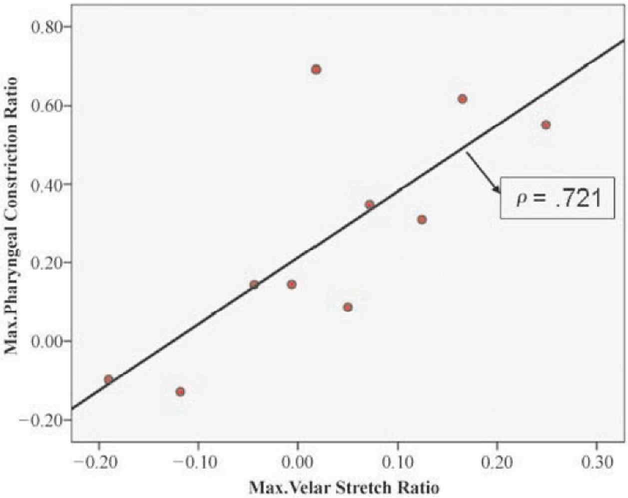

Fig. 13.14 Correlation between the maximal velar stretch and pharyngeal constriction ratio in the children with repaired cleft palate and VPI. In the VPI group, there is a strong and significant correlation between the maximal velar stretch ratio and the maximal pharyngeal constriction ratio (*Spearmanρ* =0.721, *p* =0.019). Although not presented in this graph, the maximal velar stretch is also strongly correlated to the maximal pharyngeal constriction in this group (*Spearmanρ* =0.709, *p* = 0.022). The slope of the oblique line represents the correlation coefficient

Contrary to the previous hypothesis that different length and orientation/angulation of the LVP muscle is associated with cleft palate and VPI, our studies did not find any significant differences between the three groups. Neither did we detect any significant difference in levator muscle shortening ratio during phonation. These results suggest that the primary cause of VPI is not the morphology or contractibility of the levator muscle. Rather, retro-positioning of the levator muscle helps to improve biomechanic competence of the velopharyngeal system. Our results in turn highlight the critical value of thoroughly reconstructing the mal-positioned levator muscle in primary palatoplasty.

13.2 Histological Changes of the Levator Veli Palatini Muscle Caused by Reconstruction in Primary Palatoplasty

Different surgeons may have different understanding of the extent to which the

LVP should be dissected. Some suggest that the LVP should not be dissected too extensively; otherwise muscle function will be compromised by the damaged blood supply resulting from dissection. However, this is merely a theoretical inference and has not been proven by scientific experimentation or is supported with strong evidence. Few researchers to date have studied whether the LVP dissection would lead to muscular fibrosis or whether there would be a strong correlation between extent of dissection and muscular injury.

Animal experimentation was conducted (on cats) to investigate the histological changes of the LVP after different extents of dissection [4]. Extending from the midline to the pterygoideus hamulus, one half of the soft palate was divided equally into three parts: inner, middle and outer part. Based on the different extent of muscular dissection, the subjects were divided into three groups: LVP dissected within the inner part in group 1) LVP dissected within the inner and middle part in group 2) and LVP dissected throughout the entire width of the soft palate in group 3) The LVP muscle in the opposite half palate was left intact to serve as the control. The results were as follows.

13.2.1 Histological Changes of the LVP Following Muscle Dissection

It is widely agreed that the LVP should be dissected and reconstructed in primary palatoplasty. However, the concern that LVP reconstruction might damage the muscle by destroying its blood supply still prevails. If this concern were true, the function of the LVP would be weakened by muscular fibrosis. Our study [4] found that there was no histological change of the dissected LVP muscle in group 1. The arrangement of muscle fibers was orderly and cross-striations were observed one and three months post-operatively. No hyperplasia of fibrous connective tissue was present in this group (Figs. 13.15 – 13.17). These findings confirm that mild muscular dissection does not cause structural changes to the muscle.

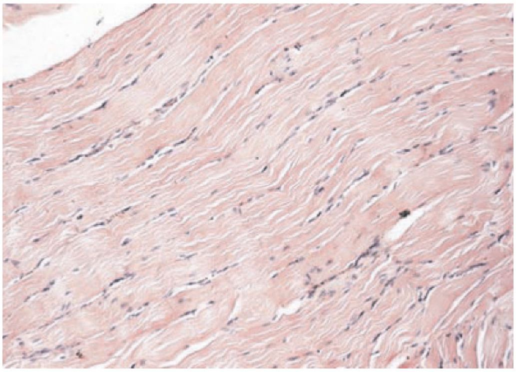

Fig. 13.15 Group normal: The muscle fibers are orderly and tightly arranged. The cross striations are clear (HE stain, ×200)

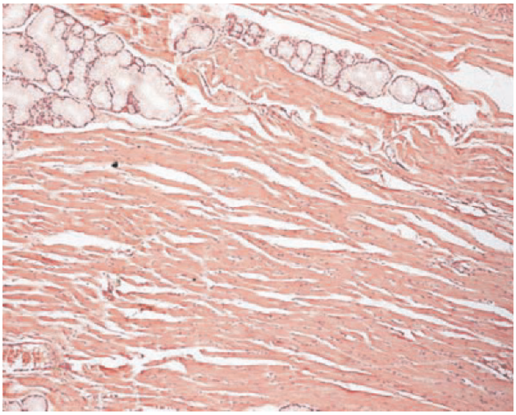

Fig. 13.16 Group 1: one month after surgery. The muscle fibers are almost orderly and a little loosen (HE stain, ×100)

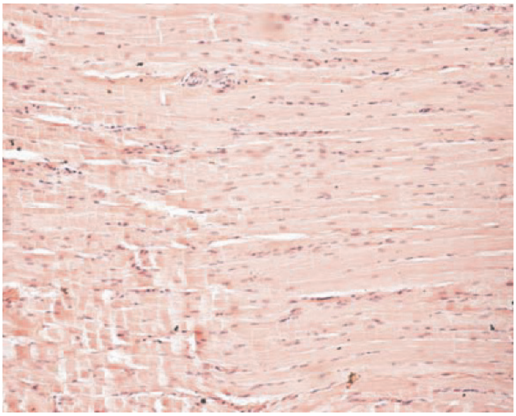

Fig. 13.17 Group 1: three months after surgery. The LVP fibers return to orderly and tightly arranged. The cross striations are clear. No proliferation of fiber tissues in mesenchyme (HE stain, ×200)

The levator muscle in group 2 exhibited mild damage during the first month after surgery (Fig. 13.18). Histological sections showed disordered muscle fibers whereas the blood vessels supplying the muscle were still normal. The muscle fibers were rearranged in an orderly fashion three months post-operatively. No hyperplasia of fibrous connective tissue or infiltration of inflammatory cells was observed (Fig. 13.19). These findings indicate that moderate dissection does not cause irreversible damage to the LVP muscle: there is a transient disturbance but this subsides spontaneously after operation.

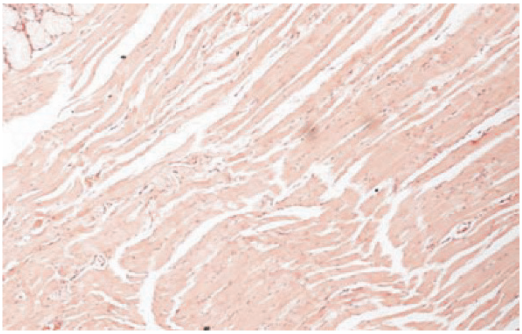

Fig. 13.18 Group 2: one month after surgery. The muscle fibers loosen a little (HE stain, ×100)

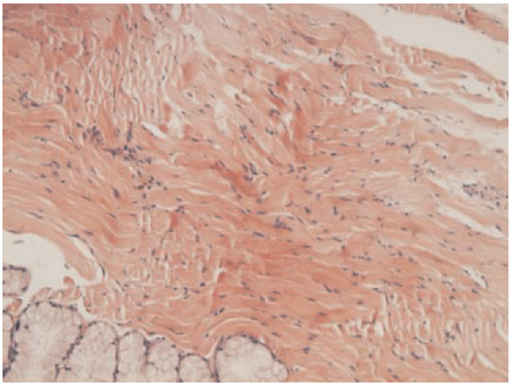

Fig. 13.19 Group 2: three months after surgery. The muscle fibers are orderly. No inflammatory cells infiltrate. No collagen fibers formed (HE stain, ×100)

On the other hand, the arrangement of the LVP muscle fibers in group 3 was disrupted and cross-striations were indistinct at one month after operation. Some muscle fibers were even disconnected and infiltrated by inflammatory cells. Some newly formed muscle fibers with centralized round nuclei were found. No collagenous fibers were formed at this time (Fig. 13.20). Two to three months later, the arrangement of the muscle fibers was restored to their normal condition and the newly formed fibers appeared to have matured. The number of inflammatory cells was significantly reduced and no fibrous connective tissue was present (Fig. 13.21). These observations suggest that extensive dissection can cause noticeable damage to the muscle at an early stage following operation; however, the muscular structure repairs and is restored to its normal condition within three months.

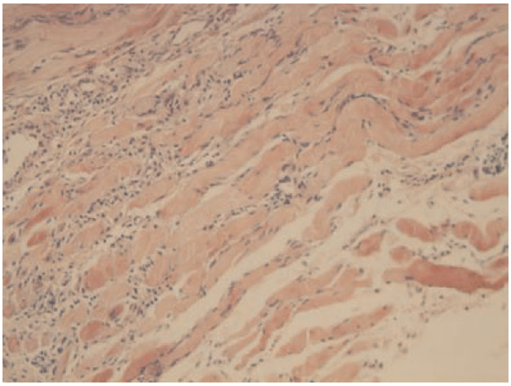

Fig. 13.20 Group 3: one month after surgery. The muscle fibers are almost tightly arranged. Many inflammatory cells infiltrate. Some new formed muscular fibers with centralized round nuclear (HE stain, ×100)

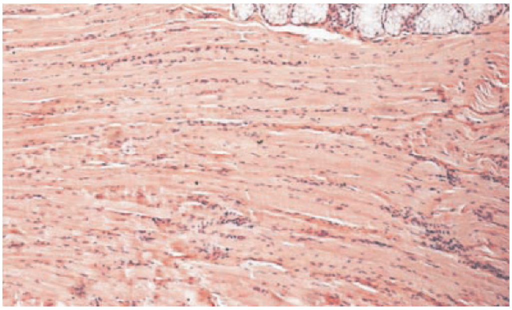

Fig. 13.21 Group 3: three months after surgery. The muscle fibers are orderly and tightly arranged. No proliferation of fiber tissues (HE stain, ×200)

13.2.2 Ultrastructural Changes of the LVP Following Muscle Dissection

Mitochondria exist in all aerobic eukaryotic cells. Their major function is to supply energy in the form of adenosine triphosphate to support functions such as contraction and transport. As the centre of energy production, cellular respiration and metabolism, mitochondria are sensitive to all kinds of detrimental factors and can be regarded as an indicator of cell injury. The progression of muscle injury and the extent of tissue repair after dissection of the palatal muscles can be detected by observing changes in the ultrastructures of mitochondria.

By electron microscopy, it was found that the mitochondria underwent no change, either at the early or late stage after operation when the dissection of the LVP was of mild extent (Figs. 13.22 – 13.23). There was also neither infiltration by inflammatory cells nor hyperplasia of fibrous connective tissue. The myofibril Z lines were distinct and the sarcomeres normal. Therefore, the ultrastructure of muscle fibers was not altered by mild dissection. When the dissection was extended to the middle part of the soft palate in group 2, increasing mitochondrial cristae and dilated sarcoplasmic reticulum were observed at the early stage after operation (Fig. 13.24). Nevertheless, the myofibril Z line was still distinct and the sarcomeres appeared normal. At the later stage of repair after operation, the number of mitochondrial cristae and the extent of the sarcoplasmic reticulum gradually returned to normal, which implies muscular self-repair over time (Fig. 13.25).

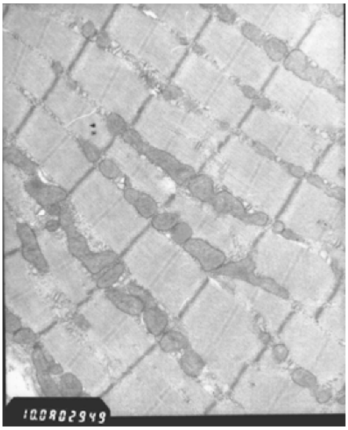

Fig. 13.22 Group 1: one month after surgery. The myofibrils are aligned. The Z lines are clear and the sarcomere was normal (×10000)

Fig. 13.23 Group 1: three months after surgery. The myofibrils are aligned. The Z lines are clear and the sarcomere was normal (×10000)

Fig. 13.24 Group 2: one month after surgery. The Z lines are clear and aligned. More mitochondrial cristae are observed (×10000)

Fig. 13.25 Group 2: three months after surgery. A few enlarged mitochondria. The Z lines are clear and aligned (×15000)

With more extensive dissection, more severe damage was apparent. Mitochondrial cristae and glycogen particles were typical findings in group 3 at the early stage after operation (Fig. 13.26). In addition, the myofibril Z line was indistinct and the arrangement of the muscle fibers was irregular. However, there was no reduction of mitochondrial cristae or any vacuolated change in the mitochondria. By three months after operation, all the structures had returned to normal (Fig. 13.27). In conclusion, extensive dissection of the LVP does not lead to permanent pathological changes of the muscle if the dissection is implemented accurately to carefully protect the deep fascia and the muscle's blood supply.

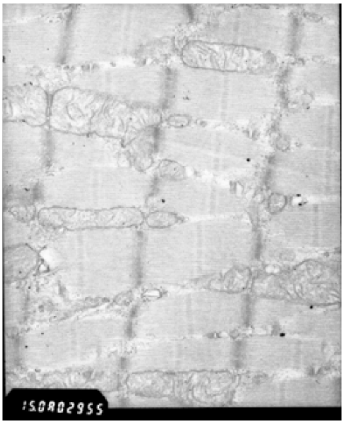

Fig. 13.26 Group 3: one month after surgery. The number of mitochondrial cristae is reduced. The Z lines are not quite clear (×15000)

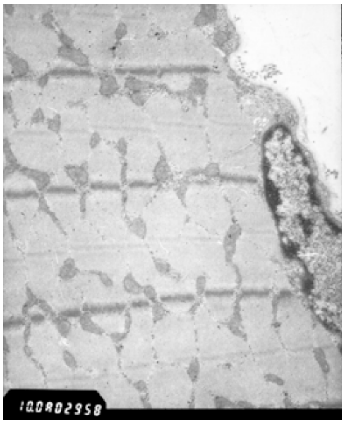

Fig. 13.27 Group 3: three months after surgery. The number of mitochondria is increased. The Z lines turn clear (×10000)

13.3 Geometrical Basis of Using Palatal Mucoperiosteal Flaps to Close the Cleft without Leaving a Denuded Surface

Many surgeons assume that one of the pre-requisites for successful closure of the palatal cleft is that the width of the cleft must be less than the gross width of the bilateral palatal flaps (shown in Fig. 13.28 as $C \leqslant A'+B'$). Based on this opinion, relaxing incisions are made to reduce the occurrence of fistula in classic two-flap palatoplasty. This, however, can be criticized because the palatal flap is not flat and it can in fact supply more tissue than earlier thought (Figs. 13.29 – 13.30). The diagram in Fig. 13.31 helps explain our theory. $\angle\alpha$ and $\angle\beta$ are defined as the angles between the horizontal plane and the individual palatal flap. A and B are the real width of the palatal flap while A' and B' are the visual width. The relationships between these measurements are: $A' = A \times \cos(\alpha)$, $B' = B \times \cos(\beta)$. If $(A - A') + (B - B') \geqslant C$, which means that we can use the palatal flaps to close the cleft without resorting to relaxing incisions: the greater the angles α and β, the wider cleft we can close without relaxing incisions. Further, the palatal mucoperiosteal flap has a degree of flexibility and extensibility. If we extensively free and stretch the palatal mucoperiosteal flaps, based on our theory in palatoplasty, we can achieve a much wider coverage. The space between the palatal flap and the nasal layer will disappear soon after operation provided no significant post-surgical hemorrhage occurs.

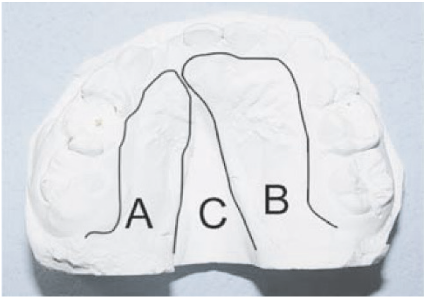

Fig. 13.28 The two dimensional projected view of cleft palate

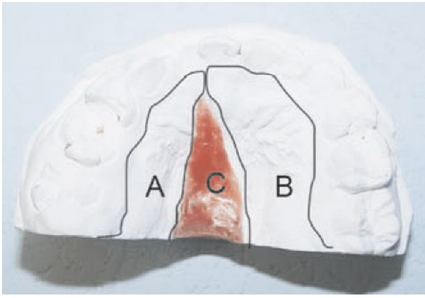

Fig. 13.29 The correlation between the cleft (C) and the real available palatal flaps (A, B)

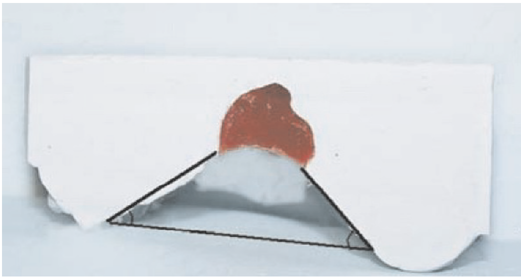

Fig. 13.30 The correlation between the palatal plane and the real available palatal flaps

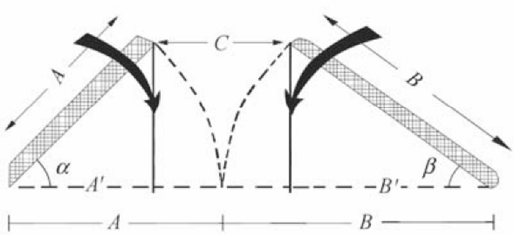

Fig. 13.31 Geometrical basis of using palatal mucoperiosteal flaps to close the cleft without leaving any denuded surface geometric in Sommerlad's reconstruction of LVP

Thus, the palate cleft can be closed without leaving any denuded surface and less scar tissue is formed (Figs. 13.32 – 13.34).

Fig. 13.32 Before palate repair

Fig. 13.33 One month after palatoplasty, no release incision

Fig. 13.34 Two months after palatoplasty, the scar was quite mild

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14

Sommerlad's Technique of Cleft Palate Repair

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14.1 Introduction

The aims of palatoplasty are to improve feeding, to achieve normal speech, and to minimize maxillary growth restriction. The technique of palate repair may also have an impact on middle ear function and hearing. Cleft palate repair is the most important component of cleft surgery, not only in that it determines the outcome as far as speech and communication is concerned, but also in that it potentially has the greatest impact on maxillary growth and the dental arch relationship. But the evolution of palatoplasty has been relatively slower than cheiloplasty. Most of the frequently used techniques nowadays are derived from the early 1900s [1-5]. Though surgeons have started to highlight the reconstruction of the levator veli palatine (LVP) the anatomic restoration has never been accomplished [6-8]. On the other hand, the success of velopharyngeal closure (VPC) can be influenced by a number of factors, such as patient age [9, 10], the surgeon's expertise and width of cleft [11]. Therefore, it is difficult currently to assess the significance of velo palatine levator reconstruction in palatoplasty. In addition, VPC is the result of multiple factors, and muscular reconstruction is only a technique affecting the soft palate. However, the operative anatomic restoration of LVP is definitely an ideal worth pursuing. The authors have persisted in practising this technique in different countries during the past decades and have achieved better results than traditional techniques [12]. The better results include both a higher post-operative VPC ratio and maximizing development of the maxilla and maxillary dental arch [13], since there is less use of releasing incisions and therefore reduced scarring [14]. These results make us firmly convinced that complete anatomic reconstruction of the LVP is a promising technique, which has radically changed the techniques and conceptualization of palatoplasty.

14.2 Design

The complete cleft palate became narrower after vomer flap repair of the hard palate during primary cheiloplasty. The hard palate was covered by new epithelial tissue, leaving only the soft palate to be closed [15] (Fig. 14.1).

Fig. 14.1 Only left soft cleft palate is left after vomer flap repair

The incision is designed along the cleft, and nasal mucosa should be conserved a little more. The uvula will be reconstructed respecting the parents' requirements though it is of no use for phonation. In front of the cleft, a triangular flap is designed comprising new epithelial tissue which will be turned over to help close the nasal mucosa (Fig. 14.2).

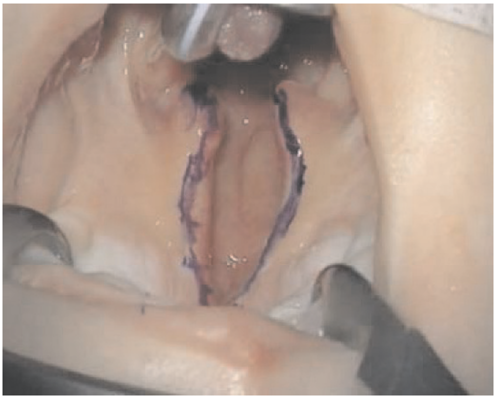

Fig. 14.2 Design of incision

Injection of 1∶200,000 adrenaline normal saline in the operative area helps to minimize bleeding (Fig. 14.3).

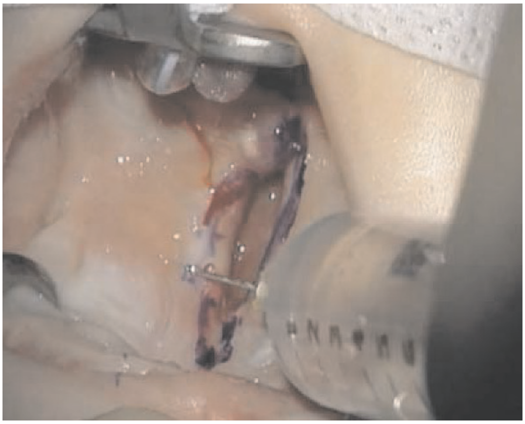

Fig. 14.3 Injection of 1∶200000 adrenaline NS

14.3 Closure of Nasal Mucosa

Cutting mucosa along the design line: the triangular flap should be carefully prepared and turned over to join the nasal mucosa. The muscle and gland layer will be separated using the elevator (Fig. 14.4).

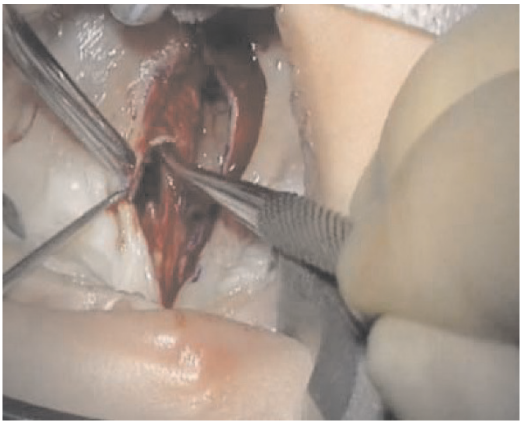

Fig. 14.4 Cutting mucosa along the design line

Using a single hook, the oral mucosa and gland layer is separated from the muscle layer. The muscle should be kept intact (Fig. 14.5).

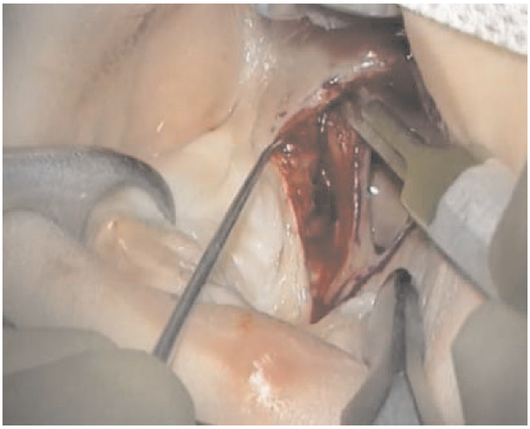

Fig. 14.5 Separating mucosa from muscle on left side

Separating around the greater palatine nerve-vessel bundle reveals the white bone around the root of the bundle. The periosteum here should be cut to release the palatal flap. There is a little hard connective tissue that restricts the flap from moving the bundle and this tissue can be seen through the releasing incision outside the bundle (Fig. 14.6).

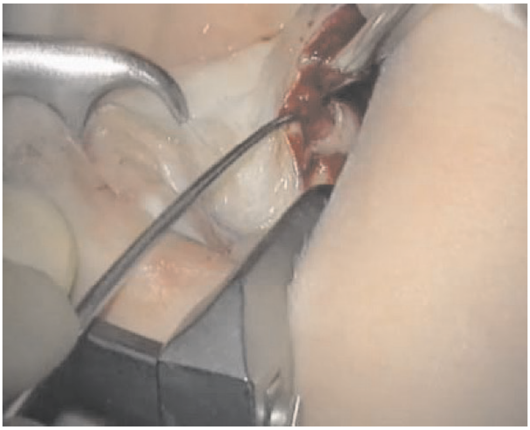

Fig. 14.6 Separation around the greater palatine nerve-vessel bundle

Dissection of the greater palatine nerve-vessel bundle: the degree of dissection depends on the cleft width. It should not be too thorough in the narrower cases (Fig. 14.7).

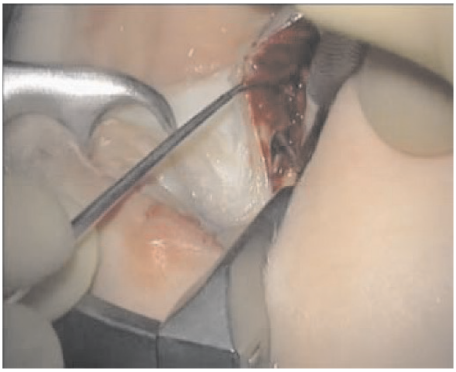

Fig. 14.7 Dissection of the greater palatine nerve-vessel bundle

The anterior triangular flap is prepared to be turned over to close the cleft together with nasal mucosa (Fig. 14.8).

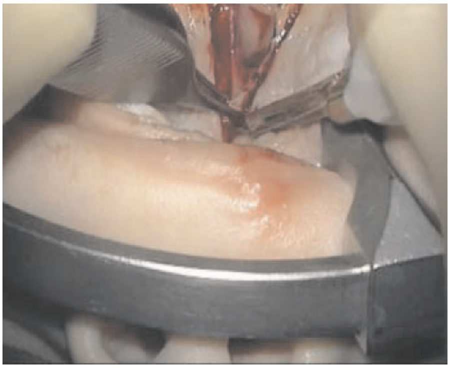

Fig. 14.8 Preparing the triangular flap

The same technique is used on both sides. Here the muscle is attached to the nasal mucosa (Fig. 14.9).

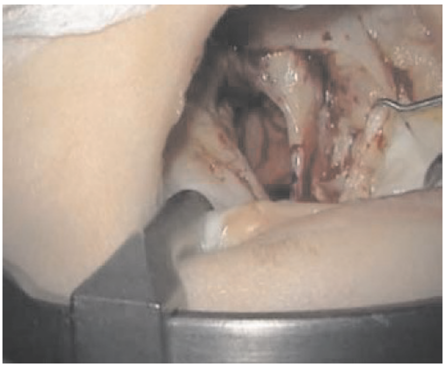

Fig. 14.9 Separating mucosa from muscle on right side

The anterior palatal flap is raised by a curved elevator, which makes suturing the cleft easier (Fig. 14.10).

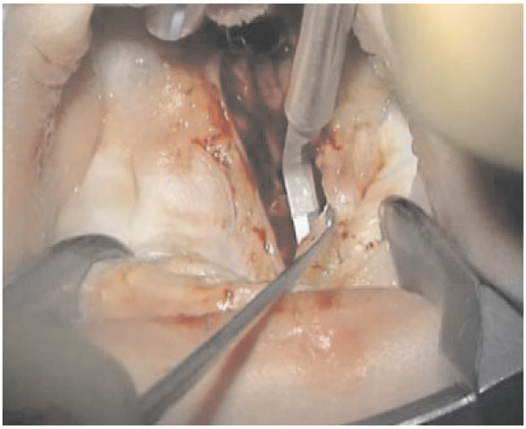

Fig. 14.10 Elevating the palate flap

Stent suturing is used on both sides, and the nasal mucosa and muscle is exposed and prepared to be closed (Fig. 14.11).

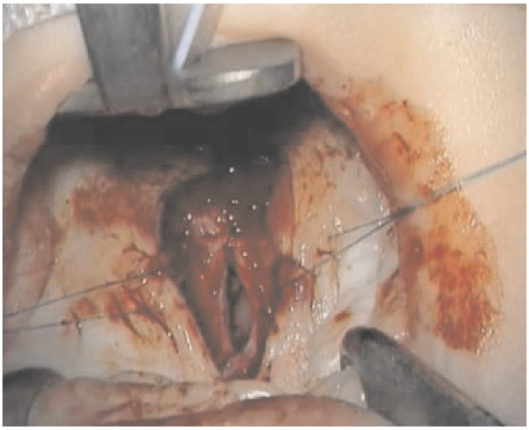

Fig. 14.11 Exposure of the nasal mucosa and muscle

The closure of the nasal mucosa and muscle is completed. Note that the triangular flap has been turned over. The wider the cleft is, the larger the flap required. There is still considerable tension here, so the suture of the flap is important [16] (Fig. 14.12).

The muscle can be seen clearly after nasal closure (Fig. 14.13).

Fig. 14.12 Closure of nasal mucosa

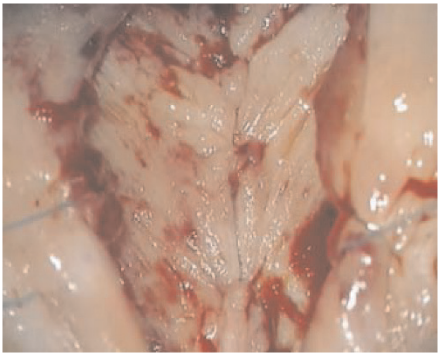

Fig. 14.13 The fiber of muscle

14.4 Dissection of Velo Palatine Levator

Dissection begins from the posterior rim of muscle and 5 mm from the midline. One must take care to keep the nasal mucosa intact. From back to front, the incision is made from far to near (Fig. 14.14).

The LVP does not attach to the back boundary of the hard palate but goes into the cleft rim in front of the middle part of soft palate. The rear boundary of the hard palate is attached to the palatopharyngeus muscle (Fig. 14.15).

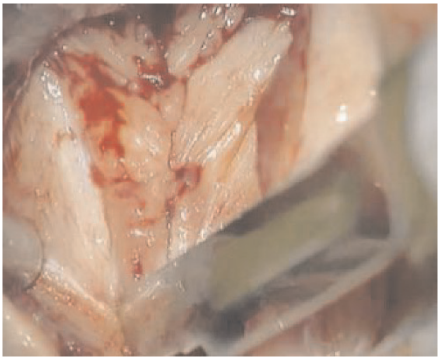

Fig. 14.14 Beginning of dissection of muscle

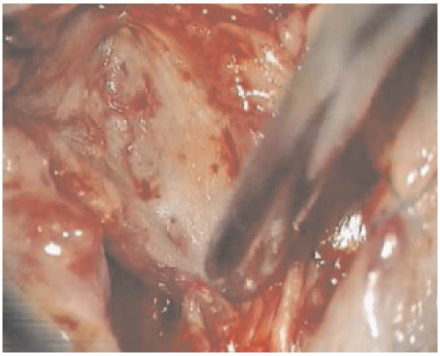

Fig. 14.15 Fiber of levatorveli palatine

Separate the LVP and nasal mucosa as far as the Eustachian tube. Mark the position of the LVP on the nasal mucosa. This should be done on both sides (Fig. 14.16).

The white tissue that becomes apparent is the palatine aponeurosis, which attaches to the posterior boundary and should be separated (Fig. 14.17).

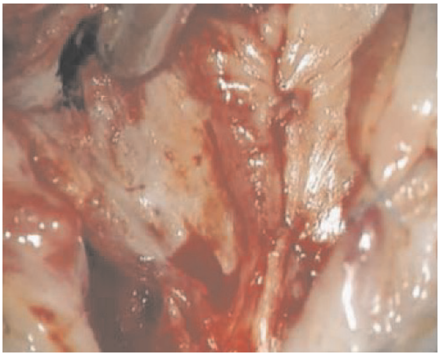

Fig. 14.16 Mark the position of levator veli palatine on nasal mucosa

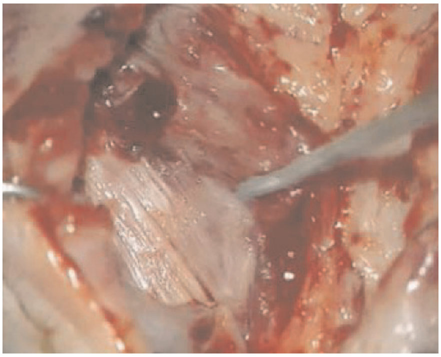

Fig. 14.17 Palatine aponeurosis

After separation of the palatine aponeurosis, the incision turns backwards to separate the tensor veli palatine from the hamulus. The palatopharyngeal muscle should be separated from the nasal mucosa at the same time. The inner side of the hamulus can be seen when the tendon of tensor veli palatine moves backwards (Fig. 14.18).

A small horizontal vessel can be seen during dissection of the LVP, and this vessel should be conserved (Fig. 14.19).

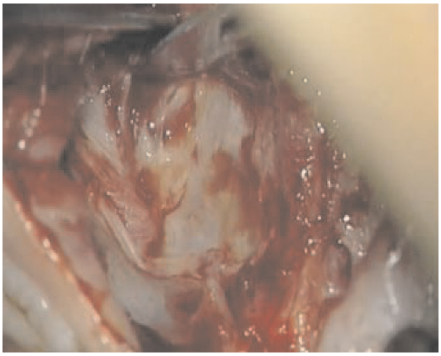

Fig. 14.18 The inner side of hamulus

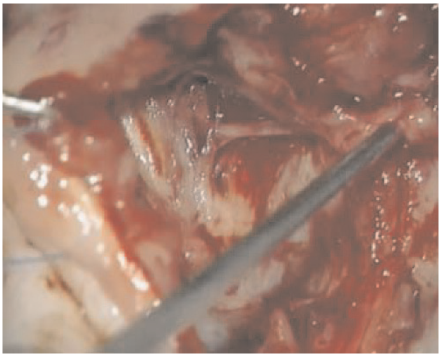

Fig. 14.19 Small horizontal vessel

Muscle dissection completed: the nasal mucosa can be seen from this angle together with the relaxed LVP (Fig. 14.20).

Forceps can help to show the LVP on the left side (Fig. 14.21) and on the right side (Fig. 14.22).

4-0 or 5-0 nylon is used to suture the muscle. This kind is not absorbable so the suture can be kept for a long time. Both the LVP and the palatopharyngeus should be sutured. The knot should be put on the nasal side to minimize discomfort or exposure (Fig. 14.23).

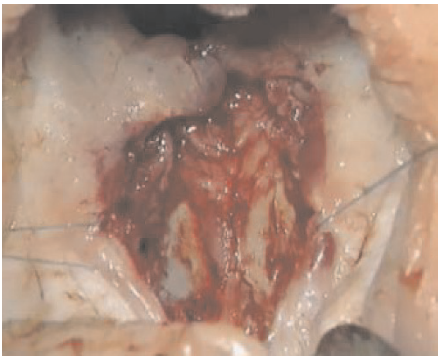

Fig. 14.20 Muscle dissection finished

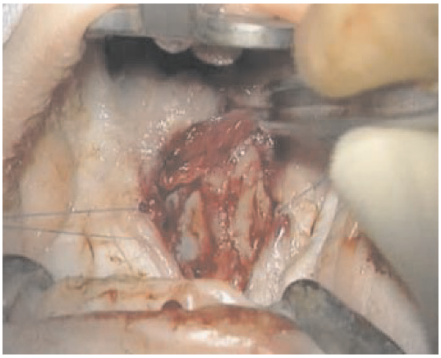

Fig. 14.21 Levator veli palatine on left side

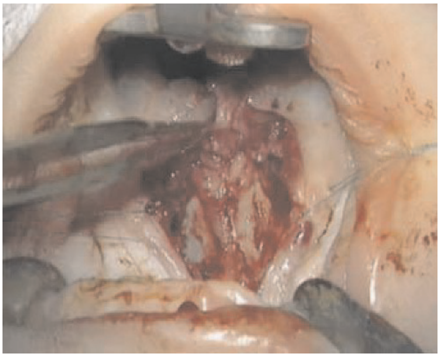

Fig. 14.22 Levator veli palatine on right side

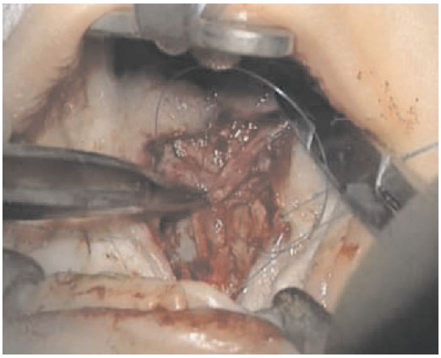

Fig. 14.23 Suture the muscle

Finally, close by suture the anterior part of the LVP and make it protrude downwards. The reconstructed muscle sling now clearly moves to the posterior part of soft palate (Fig. 14.24).

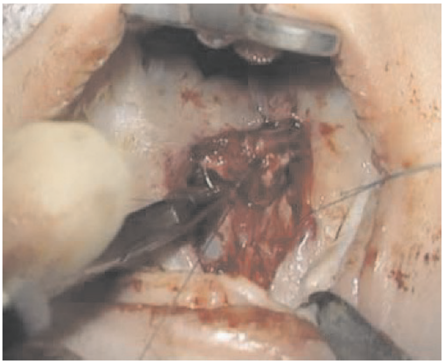

Fig. 14.24 Last suture of muscle

14.5 Closure of Oral Mucosa

Closure of the oral mucosa requires simple mattress suturing. Note that nasal and oral mucosa should be sutured together to stabilize the muscle position and, at the same time, close the dead space. This kind of suture should be used two or three times (Fig. 14.25).

The subsequent sutures are placed in the same way and a part of the muscle tissue should be closed together with mucosa (Fig. 14.26).

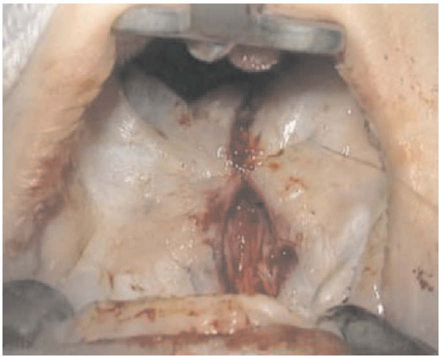

Fig. 14.25 Closure of oral mucosa

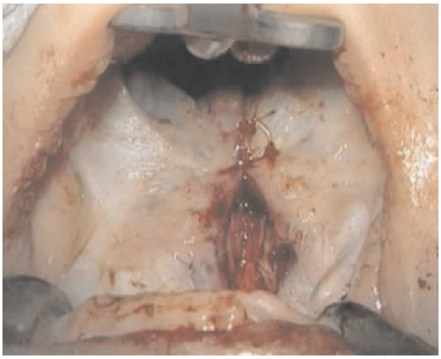

Fig. 14.26 Following suturesof oral mucosa

Suture of uvula: the uvula will turn upwards to the nasal side and facilitate phonation (Fig. 14.27).

Gradual closure of the cleft from back to front (Fig. 14.28).

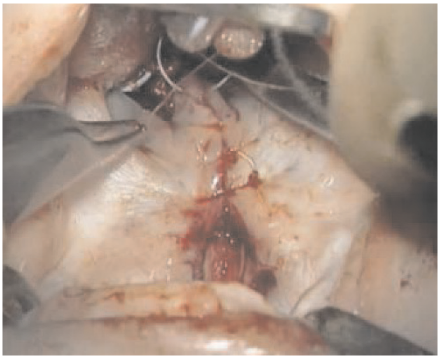

Fig. 14.27 Suture of uvula

Fig. 14.28 Posterior part of cleft closed

Closure of the cleft without releasing incisions: closing the hard palate cleft by a vomer flap during primary cheiloplasty makes the operation more complicated but makes palatoplasty easier [17]. Our research has shown that of all 36 cases, only 3 needed releasing incisions. Furthermore, there is no evidence that the vomer flap technique has any negative influence on maxillary development (Fig. 14.29).

Fig. 14.29 The cleft closed without releasing incision

14.6 Conclusion

Cleft palate repair is essential as it is fundamental not only for vocal communication but also for maxillary growth and appearance. Further exploration of palate repair techniques is required to ensure minimal maxillary growth hindrance and optimal speech outcome.

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15

West China Technique of Cleft Palate Repair

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Cleft palate repair has a profound effect on oral and craniofacial morphology and function, although not all patients are aware of this and neither are some of the clinicians. They do not pay close enough attention to it, or their main concerns have deviated from the goals of palatoplasty. The outcome of palatoplasty cannot be evaluated immediately after surgery, and this allows some surgeons to think of it as less urgent than cheiloplasty for improving the surgical result. How to release the tension and close the palatal cleft seemed to be the major objective of palatoplasty before the advent of speech pathology. Palatoplasty has no less influence on morphology and function than cheiloplasty, sometimes the consequences of inadequate palatoplasty are longer-lasting or even more difficult to remedy [1-3].

15.1 The Correlation between the Objectives of Palatoplasty and Surgical Technique

The aim of palatoplasty is to achieve velopharyngeal closure for speech recovery. The basic techniques include closing the cleft, lengthening the soft palate and narrowing the pharyngeal cavity. Researchers originally took it for granted that speech could not be improved before the cleft was closed. Therefore, attention was always focused on how to close the cleft. Previous palatoplasty, such as Von Langenbeck's flap, Wardill-Kilner's two flaps, Oxford's three flaps and four flaps, were all designed based on the principle of "robbing Peter to pay Paul". Another technique, of "wall-style" suturing, which sacrifices more tissue along the cleft edges, was developed with the promise of more reliable healing at the cleft edges [1]. The soft palate was lengthened, and pushed backwards as far as possible. It was commonly misunderstood that the soft palate should be lengthened as much as possible, while not considering whether there was a maximum effective length of soft palate. Other techniques, such as breaking the pterygoid hamulus and cutting the palatine aponeurosis or nasal mucosa (at the cost of destroying normal structures), were also used to minimize the tension before suture. In a word, the surgical principle was to close the cleft first and then to re-establish the function of soft palate. The real result has been that the first purpose has always been over-emphasized and the latter overlooked.

Much clinical research had indicated that simply closing the cleft was not the only contributor of velopharyngeal function and speech recovery. The speech outcomes are correlated with the anatomy and physiology of velopharyngeal closure. The most essential condition for complete velopharyngeal closure is the adequate upwards and backwards raising of the soft palate and afferent movement of the pharyngeal walls. Most of the procedures in our routine daily palatoplasties had nothing to do with raising the soft palate. It meant that these procedures would not directly help in velopharyngeal closure. On the contrary, these inappropriate methods and techniques caused greater denuding of bone surface, which was shown in clinical and animal studies to be the cause of scar tissue leading to malocclusion and aberrant of maxillary growth. This is the unsatisfactory inheritance of the early palatoplasty procedures. Therefore, the simple resolution should be to start from the aim, i.e. the mechanism of soft palate elevation and putting the functional reconstruction of the soft palate as the priority, then to close the cleft. The trend of modern palatoplasty emphasizes reconstructing the position and continuity of the palate levator muscles.

15.2 The Need to Change the Concept of Palatoplasty

The shift in emphasis in palatoplasty mentioned above is more of a theoretical revolution than a change in technique. Otherwise, the incidence of post-operative fistula would be the most important index for evaluating the success of palatoplasty if both surgeons and patients focused on closing the cleft itself. However, this might in some way misdirect the development of cleft palate treatment and is difficult for most international figures to accept. We found that the palate cleft would be easy to close if the levator muscle was dissected and repositioned [4-6]. The releasing incisions can be ‘cut as you go’ when it is difficult to suture. It has been proven that this technique would not increase the incidence of “real” post-operative fistula which needs secondary surgical repair, though there might be a more delayed healing of the wound, especially in the area of the soft-hard palate boundary. In addition, the hazard of palatal fistula and the difficulty in repairing it are much greater than that of velopharyngeal inadequacy and secondary maxillary deformity. China being a country with the largest population of cleft patients but relatively poorly developed medical conditions and poor medicare, our clinicians must make progress in increasing the velopharyngeal closure rate after surgery and to reduce the incidence of secondary deformity. It is extremely important to change our thinking models in cleft palate repair. Surgeons should choose the most effective method that helps the soft palate extension and elevation after surgery while avoiding denuding the palatal bone [7-9].

15.3 Geometric Basis of Modified Palatoplasty

In the traditional concept, the palatal cleft could not be closed without the medial movement of bilateral palatal flaps. Hence, bilateral releasing incisions were thought necessary in palatoplasty such as in Von Langenbeck's method or the two-flaps procedure. However, Bardach thought that the available width of the palatal flap was actually wider than might have seemed on the basis of plane geometry [10] (see Chapter 13). Therefore, it is possible to avoid releasing incisions if this geometric principle is effectively utilized in palatoplasty: the mucoperiosteal flap can be adequately released and extended and more tissue is available at the cleft edges to close the cleft. The dead space between the palatal flap and the nasal mucosa will eventually disappear in a short period of time after controlling hemorrhage and tight suturing of the nasal layer. Secondary infection has rarely occurred in our practice.

15.4 Reconstruction of the Levator Veli Palatine Muscle is Central to Modern Palatoplasty

Kriens presented the intravelar palatoplasty with thorough dissection and suturing of the levator veli palatini and the tensor veli palatini muscle as early as the beginning of the 1970s [11]. The idea, breaking the abnormal attachment of the levator, transversely suturing bilateral muscles in the velar and reconstructing the muscular sling, had a profound influence on the later theories of other researchers, though his original technique has not become popular. Furlow's opposite double Z palatoplasty in 1986 had several advantages, such as preventing the aberrant maxillary development brought on by denuded palatal bone, correcting the mal-aligned muscles to the normal position and prolonging the length of the soft palate [12]. But the levator muscle and the palatopharyngeus muscle are excessively overlapped and sutured in the midline. The uvularis muscle is crossed over and pushed backwards. Consequently, the normal anatomy of the muscle group in the soft palate is lost and an asymmetric velopharyngeal closure results. Later, Cutting used a different technique to thoroughly dissect and reconstruct the palatal muscles [13]: however, this still raises the mucoperiosteal flaps first and afterwards rebuilds the levator muscle sling.

The palatoplasty reported by Sommerlad in 2003 has two features: 1) it recommended where possible the avoidance of releasing incisions and also avoided denuding the bone surface on the hard palate as much as possible. 2) thorough dissection and reconstruction of the levator. This kind of surgical procedure embraces recovering normal velopharyngeal function for speech as well as minimizing maxillary growth disturbance [14]. However, Sommerlad emphasized that surgery was performed under the microscope. To a large extent, this hindered the promotion of the procedure. In our center, we started to use Sommerlad's palatoplasty in 2004, and found that ideal dissection and rebuilding of the levator muscle could be obtained even with the unaided eye. We developed a series of short-cut procedures to do the dissection in practice, as follows. 1) Cutting along the cleft edges through the mucoperiosteal layer, raising the mucoperiosteal flap with a periosteum detacher from the palatal bone surface. Then placing the tissue scissors behind the greater palatine neurovascular bundle, pushing laterally and backwards, releasing the complex layer of oral mucosa and glands extending anteriorly to the posterior border of the hard palate, posteriorly to the attachment line of the soft palatal muscles on the palatine aponeurosis, and laterally to the attachment line of the levator tendon on the medial pterygoid plate of sphenoid. The white tendon of the tensor veli palatini can be seen attached laterally to the posterior border of the hard palate (Figs. 15.1 – 15.2). 2) Cutting off the attachment of the palatine aponeurosis at the posterior border of the hard palate, laterally to the base of the pterygoid hamulus, making the nasal mucosa and the muscles attached to it approaching to the midline (Fig. 15.3). 3) Sharply dissociating the greater palatine neurovascular bundle, increasing the mobility of the palatal mucoperiosteal flaps and suturing the nasal layer. 4) Dissecting the levator from the nasal layer along its abnormal alignment, from medially to laterally, not from anteriorly to posteriorly. The nasal layer will appear blue after dissection of the muscles. The anterior extent of muscle dissection is to the posterior border of the hard palate, the medial is 5 mm laterally to the midline, the lateral is to the interior of the pterygoid hamulus and the posterior is to the posterior border of the soft palate. The levator muscle bundle is oblate, coming through the lateral pharyngeal wall and can be freely pulled. We do not like to expose the muscle tissue of the levator itself: the dissection should be made to the deep fascia. It is not desirable to separate the muscle so completely as to damage the muscle. The best situation is that the muscle can just be easily turned medially backwards and horizontally sutured with its opposite half. 5) Rotating the dissected muscle backwards to the posterior 1/3 of the soft palate and suturing the bilateral bundles with 4-0 nylon wires (Fig. 15.4). The tendon of the tensor veli palatini in the frontal part of the muscle bundle reinforces the suture. 6) Suturing: perfoliately suture the oral and nasal layers in front of the sutured muscle bundle. Then tightly suture the other part of oral layer (Fig. 15.5). 7) Sometimes, in complete cleft cases, the oral layer might not be able to be drawn together if the cleft is too wide to suture. Cut the mucosa layer along the gum border on one side, horizontally delaminate the mucoperiosteal flap, separate the mucosa layer medially from the periosteal layer to a width of 10 – 15 mm, and vertically cut the periosteal layer. This increases the distance that the flap moves medially, helps the periosteal layer to cover the bone surface near the gum edge, avoids scar formation and aberrant maxillary growth. 8) The Hynes pharyngoplasty or sphincter pharyngoplasty and releasing incisions would be applied with the levator reconstruction palatoplasty for patients more than 5 years old. The aim is to increase the velopharyngeal closure rate after primary palate repair in older patients.

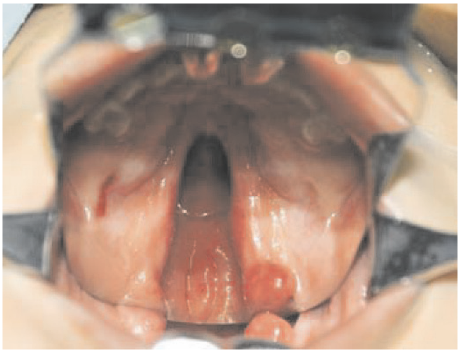

Fig. 15.1 Incomplete cleft palate before surgery

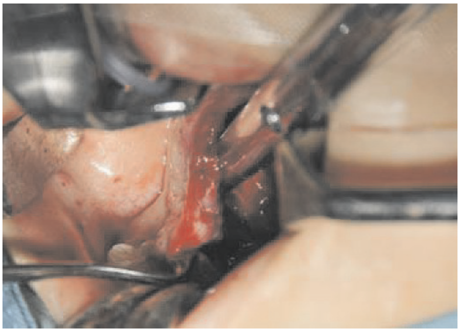

Fig. 15.2 Cut the mucosa along the cleft edge, creep along the posterior margin of hard palate and separate to the attachment of tensor muscles on the pterygoid hamulus

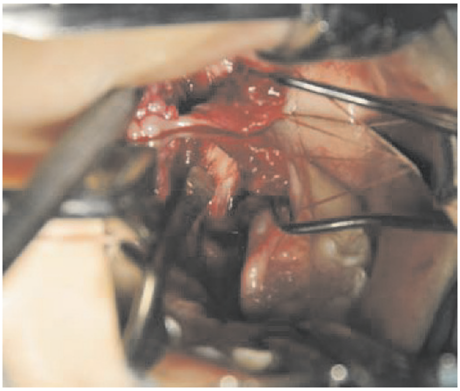

Fig. 15.3 Expose and cut the tendons of bilateral tensor muscles on the pterygoid hamulus. This is one of the most important steps to make bilateral nasal layer be sutured in the midline

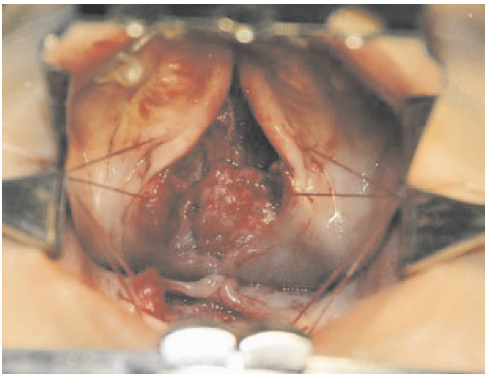

Fig. 15.4 Tightly suture the nasal layer and dissect the whole muscle bundle surrounding the levator laterally and backwardly. Rotate the muscle bundle backward

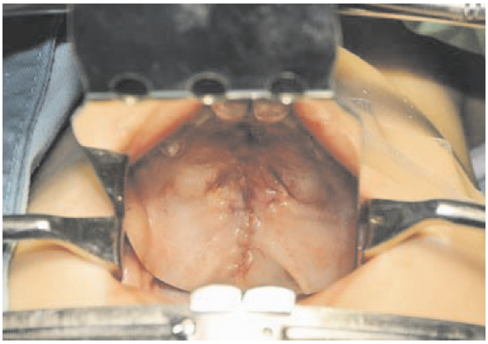

Fig. 15.5 Suture the oral layer, no release incision was made

In our preliminary clinical research, 27.8% of patients were repaired without bilateral releasing incisions. Among these paitients, 55.6% were patients with cleft palate. Among the patients with complete cleft palate, 4.4% had no releasing incisions, 35.2% had unilateral releasing incisions, 60.4% had bilateral releasing incisions ($p<0.01$). The cleft index and cleft width correlated with the length of the releasing incision only in patients with cleft palate ($p<0.01$). The releasing incision length is predicted to be zero if the cleft index is <0.31 or the cleft width is <12.7 mm. The cleft index was not correlated with the necessity of releasing incisions in patients with complete cleft palate ($p>0.05$). Palatal scars are significantly less conspicuous than after the modified Von Langenbeck palatoplasty ($p<0.01$). On follow-up, 64.8% (35 in 54 cases) of the patients achieved complete velopharyngeal closure. All the indices – including post-operative length of soft palate, functional length of soft palate, extension of soft palate functional length, increased angle of soft palate, velopharyngeal gap, rate of successful velopharyngeal closure and adequacy – increased after surgery ($p<0.01$). The position of the levator attachment point moved significantly backwards ($p<0.01$). The statistical analysis suggested that complete velopharyngeal closure could be achieved if the average velopharyngeal gap was within 4.5 mm pre-operatively.

The speech evaluation results proved that the intelligibility, hypernasality and nasal emission were significantly improved after surgery ($p<0.01$). The total incidence of post-operative fistula was 6.8% (12/176). The fistula mostly occurred at the border of soft and hard palate (66.7%), less at the frontal part of the hard palate (25%), and least in the soft palate area (8.3%). The incidence of fistula had no correlation with age or gender ($p>0.05$) but had some correlation with the surgeon's technique and type of palate ($p>0.05$). It can be seen from this that Sommerlad's levator reconstruction palatoplasty can effectively rebuild the structure and position of the levator, reconstruct the levator sling and establish the foundation of normal velopharyngeal function; it reduces the need for releasing incisions, avoids scar formation on the denuded bone surface and the inhibition of maxillary growth. We think it is the most valuable palatoplasty at present because it gives consideration to both speech function and maxillary growth while not increasing the incidence of palatal fistula [15].

15.5 Complementary Approaches to Improve Palatoplasty Outcomes

Presurgical orthodontics can help narrow the palatal cleft and decrease the movement of bilateral flaps to repair the cleft. But presurgical orthodontics is time-consuming and is difficult to establish in developing countries. In cases with complete cleft lip and palate, we recommend the application of simultaneously repairing hard palate clefts with a vomer flap during primary lip repair, in order to perform levator reconstruction with less or without making releasing incisions. This can prevent further widening of the cleft palate, maintain bilateral bone segments in a relatively close position and help to smoothly close the narrowed cleft with less or without releasing incisions. Some researchers were worried about the negative effect of the vomer flap on maxillary growth at an early stage of intervention. However, comparison among multiple cleft surgery centers in Europe found that the facial development of patients treated with vomer flaps was not significantly different from those not so treated [16]. We noted that repairing the hard palate cleft with a vomer flap could turn a compete cleft palate into an incomplete cleft palate. This post-operative incomplete cleft palate had a V shape, which was quite different from the common incomplete cleft palate and easier to repair. In our center, only five cases from seventy nine patients who accepted simultaneous hard palate repair with vomer flap during primary cleft lip repair needed releasing incisions during palatoplasty. Four of them were unilateral cleft and one bilateral. The maximum length of the releasing incisions is 15 mm and the minimum is 5 mm. If it is imperative to make releasing incisions, the periosteum near the gingival margin is preserved. Only the mucosa layer is moved to the midline. Animal experiments have shown that this could prevent the formation and attachment of Sharpey's fibers, avoid or diminish interference with maxillary growth, and guarantee the normal development of the maxilla and dental arch when the palate cleft is effectively closed.

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Part V

Bone Grafting of Cleft Palate

16

Cutting's Technique of Cleft Palate Repair

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16.1 Introduction

The Cutting cleft palate repair has evolved from a one-stage repair performed around one year of age, in which the hard palate is closed in two layers utilizing widely undermined mucoperiosteal flaps, to a two-stage repair in which a vomer flap is raised at the time of cleft lip repair to close the hard palate, followed by a soft palate repair around one year of age. By limiting subperiosteal dissection in the area of the hard palate, iatrogenic injury to midface growth is theoretically minimized.

Although the vomer flap is used to close the hard palate, partial mucoperiosteal undermining through a modified Langenbeck dissection is sometimes needed in the wider clefts to achieve adequate closure of the junction between the hard and soft palate. Therefore, the principles used in traditional two-flap closure of the hard palate [1] must be understood and utilized in a controlled and directed manner to ensure a stable closure of the palate while limiting the subperiosteal dissection of the hard palate. The surgeon's judgment in these cases balances the need to avoid fistula formation with limiting iatrogenic impediment to midface growth.

The key principle involved in maximum mobilization of the oral mucoperiosteal flaps for stable hard palate repair is directed subperiosteal dissection medial and posterior to the greater palatine vessel, the blood supply to the oral mucosa of the hard palate. In addition to this subperiosteal dissection, a supraperiosteal dissection is performed lateral to the vessel, releasing the remaining fibrous attachments of the oral mucosa flap to the bone. This dissection is followed by a careful incision of the periosteal cone medial and posterior to the greater palatine vessel and into the supraperiosteal pocket lateral to the vessel, freeing the periosteal attachments of the mucoperiosteal flap from the bony hard palate. This later procedure can be the most challenging aspect of cleft palate repair for the novice surgeon to execute. However, this procedure is critical for tension-free closure at the junction of the hard and soft palate, particularly in wide clefts.

The Cutting soft palate repair incorporates three key principles, two of which are shared by the independently created Sommerlad soft palate repair [2, 3]:

1) Complete separation of the aberrant attachments of the soft palate musculature from the posterior aspect of the hard palate.

2) Transection of the tensor veli palatini tendon. These two principles are critical to anatomic reconstruction of the levator sling and, when properly executed, are associated with a low rate of velopharyngeal incompetence [2, 3]. In addition, a third principle, which will be described below, has been added to preserve Eustachian tube function after tensor veli palatini tendon transaction.

3) Tensor Tenopexy. The pathologic anatomy of the cleft palate velum as originally described by Victor Veau [4] and later by Kriens [5] and Fara [6] revealed a fusion of the levator veli palatini and palatopharyngeus muscle of the soft palate into a "cleft muscle" that abnormally inserts into the posterior edge of the hard palate rather than spanning the posterior pharynx to create a muscular sling. The levator veli palatini functions as the prime elevator and retractor of the soft palate [7] and in unaffected patients originates from the petrous portion of the temporal bone and passes anteriorly and inferiorly, under the cartilaginous lip of the Eustachian tube before normally entering the soft palate to meet the same muscle on the opposite side. Braithwaite originally described the correction of the abnormally positioned cleft musculature during cleft palate repair [8]. This anatomic reconstruction of the levator sling was later named intravelar veloplasty [5].

The first principle of the Cutting intravelar veloplasty technique is dissection of the abnormal muscle attachments from the posterior edge of the hard palate in order to anatomically transpose the cleft muscle posteriorly and medially to recreate the muscular sling of the soft palate. If these abnormal muscle attachments are not released prior to transposition, only isometric contraction of the levator veli palatini will occur between its bony points of origin and insertion, compromising future velopharyngeal function.

Another anatomic finding of the classic dissections of the clefted soft palate musculature is the abnormal relationship between the aponeurosis of the tensor veli palatini and the cleft muscle. Normally, the tensor veli palatini takes its origin from the scaphoid fossa, greater wing of the sphenoid and the lateral membranous portion of the Eustachian tube [6] and travels posteriorly and inferiorly towards the hamulus. Once the tensor rounds the hook of the hamulus, it turns medially and forms an aponeurotic sheet which joins the contralateral tensor aponeurosis at the midline. In the cleft patient, the aponeurotic sheet turns anteriorly after rounding the hamulus to insert into the posterior edge of the hard palate, blending with the abnormal insertion of the cleft muscle [4-6]. The fibrous attachment of the tensor tendon to the levator veli palatini within the cleft muscle will tether the levator to the area of the hamulus even after freeing the abnormal muscular attachments from the posterior edge of the hard palate. This is best illustrated by a 3-dimesional digital simulation created by Court Cutting [9]. These findings have led to the recommendation of cutting the tensor tendon medial to the hamulus [3, 5, 6, 10, 11], or fracturing the hamulus [12, 13] in order to completely free the levator veli palatini for levator sling reconstruction. The second principle of our cleft palate repair is, therefore, transection of the tensor veli palatini tendon. This procedure, however, is not without functional consequence.

There is a general consensus that the tensor veli palatini is a prime opener of the Eustachian tube [5, 7, 14]. Therefore, transection of the tensor tendon or fracturing of the hamulus may have a detrimental effect on middle ear ventilation. Previous limited follow-up studies have shown that hamular fracture does not have a detrimental effect on Eustachian tube function [13]. However, a more recent long-term multi-institution study has shown there is a statistically significant increase in the need for myringotomy tubes in patients who undergo transection of the tensor veli palatini during cleft palate repair compared with those who do not [15], suggesting that tensor tendon transection and likely hamular fracture is damaging to Eustachian tube function.

Tensor veli palatini transection, however, is a critical step to anatomically reconstruct the muscular sling of the levator veli palatini during cleft palate repair. Indeed, some of the lowest pharyngeal flap rates in the literature (4% – 6%) are by levator sling palatoplasty with division of the tensor veli palatini [2, 3, 11]. Therefore, the benefit to speech brought by tensor tendon transection must be balanced by its detrimental effect on Eustachian tube function.

In appreciation of the ill effects to middle ear ventilation caused by transection of the tensor tendon, the tensor tenopexy has been developed to preserve the function of the Eustachian tube after transection of the tensor tendon. The tensor tendon is identified inserting into the cleft muscle of the soft palate. The tendon is displaced medially, a movement which places traction on the tensor veli palatini muscle, pulling the Eustachian tube open, and while maintaining medially directed tension, the tensor tendon is sutured to the hamulus. The tensor veli palatini can then be transected, medial to the hamulus and pexy suture. Patients who undergo levator sling palatoplasty with tensor tenopexy have a statistically significant decrease in the need for myringotomy tubes compared with patients who undergo "traditional" levator sling palatoplasty in which the tensor tendon is transected [15]. As anatomic reconstruction of the levator sling can be performed while still providing benefit to Eustachian tube function, the tensor tenopexy has become the third principle to our soft palate repair.

16.2 Technique

16.2.1 Stage 1—Anterior Palate Repair

The first stage of the Cutting cleft palate repair is performed at the time of cleft lip repair. In patients with a unilateral cleft lip deformity, this is approximately 3 months of age. In patients with a bilateral cleft lip deformity, this is approximately 5 months of age. The palate repair precedes the lip repair in all cases. After proper patient positioning and infusion of local anesthesia in the area of the vomer and lateral palatal shelf, a needle cautery is used to incise the posterior end of the vomer from the skull base. The use of cautery in this area will help prevent post-operative bleeding from the posterior septal branch of the sphenopalatine artery. After the posterior aspect of the vomer flap is incised with cautery, the remainder of the incision may be continued anteriorly with a 67 Beaver blade. Care is taken to incise the vomer flap approaching the edge of the hard palate to ensure a tension-free transposition of the vomer flap under the oral mucosa of the lateral palatal shelf. The vomer flap is then dissected in a subperiosteal plane from the skull base and inferior aspect of the cartilaginous septum.

The lateral palatal shelf is then incised with a 69 Beaver blade along the nasal edge of the hard palate. A subperiosteal dissection is then performed on the oral side of the lateral palatal shelf approximately 2 – 3 mm laterally. Several fine absorbable sutures are placed posterior to anterior through the oral mucosa on the lateral palatal shelf and into the small subperiosteal dissection pocket, then through the periosteal face of the vomer flap and out through the mucosa of the vomer flap. The pass is then returned approximately 2 mm anteriorly along the vomer flap. The return suture is placed through the mucosal surface of the vomer flap, to the subperiosteal face, then through the small subperiosteal pocket of the lateral palatal shelf and through the oral mucosa of the hard palate. Several such horizontal mattress sutures are placed posterior to anterior and left untied as an arcade. Once all sutures are in place, the sutures are tied anterior to posterior. After completion of the vomer flap reconstruction, the cleft lip repair is performed, if indicated. In patients with a bilateral cleft lip deformity, a unilateral vomer flap is performed prior to a bilateral cleft lip repair and a unilateral gingivoperiosteoplasty is performed, if indicated. Three months later, a contralateral vomer flap and contralateral gingivoperiosteoplasty is performed. Finally, at one year of age, the soft palate is reconstructed.

16.2.2 Stage 2—Soft Palate Repair

After proper patient positioning and infusion of local anesthesia into the soft palate and posterior aspect of the hard palate and vomer, an incision is made along the medial border of the clefted soft palate starting from the vomer closure and continuing posteriorly, bivalving the uvula. On the cleft side, the incision is extended approximately 10 mm anteriorly on to the hard palate. A limited amount of subperiosteal dissection is then performed on the non-cleft side, exposing the posterior edge of the hard palate and the periosteal cone around the neurovascular bundle. Once the posterior edge of the hard palate is exposed, the aberrantly oriented cleft muscles are bluntly released from their attachments to the posterior edge of the hard palate. The dissection is extended laterally towards the hamulus and superiorly towards the skull base. A periosteal elevator is then used to bluntly dissect the mucoperiosteum from the nasal side of the hard palate up to the junction with the vomer.

On the cleft side, nasal mucoperiosteal flaps are mobilized by first making a small incision approximately 5 mm anterior to the cleft edge, on to the bone of the hard palate. By pushing a small elevator through this incision, a subperiosteal tunnel is then created towards the posterior nasal spine. A 69 Beaver blade is then used to connect this dissection pocket with the incision at the edge of the soft palate, surgically connecting the previously created vomer flap and the nasal mucoperiosteal flap on the cleft side as a continuous flap. This dissection will allow for a tension-free closure of the nasal side mucoperiosteal flaps. Blunt dissection is similarly performed on the posterior edge of the hard palate to free the aberrant bony attachments of the soft palate musculature.

The soft palate nasal mucosa is then sharply dissected from the soft palate musculature. The dissection starts through the soft palate musculature in the middle of its thickest point. Once an edge has been established, the dissection proceeds superiorly to establish a plane between the nasal mucosa and the soft palate musculature. The nasal mucosa will appear blue. The blue dissection plane is followed down to the skull base. Care is taken not to damage the delicate levator veli palatini muscle during this dissection. It is far better to create holes within the nasal mucosa than to cut into the levator muscle, as this will compromise the functional result of the soft palate repair.

Once the nasal mucosa has been dissected free from the underlying soft palate musculature, the periosteal cone around the greater palatine vessel is scored. This step is critical to the tension-free closure of the oral mucoperiosteal flaps, particularly over the area of the hard and soft palate junction. A tension-free closure of the posterior aspect of the hard palate cleft commonly requires medial advancement of the oral mucoperiosteal flaps to the midline. If the tough periosteal cone around the greater palatine vessel is not released, then these flaps will be tethered to the greater palatine foramen, resulting in a rotation of the mucoperiosteal flap with an axis based at the posterior-lateral aspect of the hard palate. This will result in the least amount of tissue and the greatest degree of tension at the closure over the hard and soft palate junction, predisposing to fistula formation.

A relaxing incision is first made starting lateral to the hamulus and curving anteriorly around the medial aspect of the maxillary tuberosity, approximately 10 mm on to the lateral aspect of the hard palate. A supraperiosteal dissection is performed with care to break all fibrous connections from the oral mucoperiosteal flap to the bone. Approaching the neurovascular bundle from the medial side, a subperiosteal dissection is then performed medial and posterior to the periosteal cone surrounding the greater palatine artery. Using a fresh knife, the periosteal cone is scored on the medial and posterior surface. A small amount of fat should become visible through the incised periosteum. Approaching the periosteal cone laterally, a knife is inserted over the area of the hamulus and advanced medially, behind the greater palatine vessel, incising through the periosteum and into the subperiosteal pocket created on the medial side. Dissection scissors are inserted posterior to the periosteal cone and the scissors are carefully opened. The force created by spreading the scissor blades will release the remainder of the periosteal attachments around the periosteal cone and allow for tension-free mobilization of the mucoperiosteal flap medially.

Once the periosteal cone around the greater palatine artery is released and preservation of the artery is confirmed, the oral mucosa of the soft palate is sharply dissected from the overlying soft palate musculature. If the greater palatine vessel is damaged at the time of dissection around the periosteal cone, the blood supply to the mucoperiosteal flaps will be dependent on a random pattern blood flow emanating through the soft palate via the ascending palatine artery branch of the facial artery [16]. Therefore, it is important to separate the oral mucosa from the soft palate musculature after the periosteal cone has been dissected and preservation of the greater palatine artery confirmed. If the greater palatine artery is damaged, then separation of the soft palate musculature from the oral mucosa is abandoned.

The oral mucosa flap is dissected thicker than the nasal flap, about 4 mm, in order to preserve blood supply to the flap. Note the palatoglossus, the most superficial muscle in the soft palate, is an antagonist to the levator veli palatini [6] and dissection through this cleft muscle may potentially enhance levator function [3]. As the dissection proceeds laterally, the dissection plane becomes more superficial to come over the hamulus. Once the hamulus is reached, use a peanut dissector to gently dissect over the area of the hamulus. At this point, a fibrous white band should be visualized emanating from around the hamulus, directed toward the midline. This is the tensor veli palatini tendon. Note that despite release of the cleft muscle from the posterior edge of the hard palate, radical mobilization of the levator veli palatini towards the midline is not possible owing to the fibrous attachments of the tensor veli palatini tendon to the levator. Full mobilization of the levator veli palatini is only possible through transection of the tensor tendon.

Prior to transection of the tensor tendon, the tensor veli palatini tendon is grasped with forceps and pulled in the medial direction, theoretically opening the Eustachian tube. With medial traction maintained, a long-lasting absorbable suture is placed around the hamulus and tensor tendon affixing the tendon to the hamulus. The suture is passed anterior to posterior, around the hamulus in order to avoid puncturing the greater palatine vessel. Once the tensor tenopexy is performed, the tensor veli palatini is cut just medial to the hamulus and blunt dissection is performed in the loose areolar plane lateral to the cleft muscle with a peanut dissector in order to preserve the arterial supply to the muscle. The levator veli palatini should be visualized emanating from the skull-base. After this procedure, a radical mobilization of the levator veli palatini to the midline is possible. The tensor tenopexy procedure is best illustrated by the 3-dimensional animation created by Court Cutting [9] (Figs. 16.1 – 16.4).

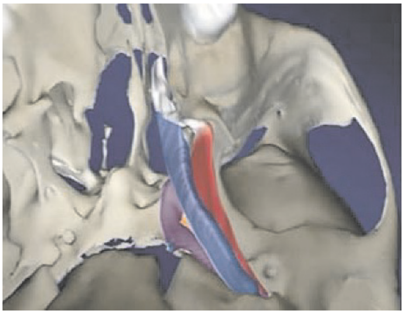

Fig. 16.1 Digital reproduction of the aberrant cleft palate musculature on one side. The skull and skullbase is seen from the underside in grey. The zygomaticarch is seen on the right, the maxillary tuberosity and a molar tooth can be seen superiorly. The patient's anterior is superior and lateral is to the right. The levator veli palatini is demonstrated in blue. Note the aberrant orientation of the levator toward the posterior edge of the hard palate instead of toward the midline (left). The tensor veli palatini is demonstrated in red. This muscle can be seen passing around the hamulus (center). At this point, the tensor veli palatini muscle becomes a tendon (white) and coalesces with the muscle fibers of the levator veli palatini

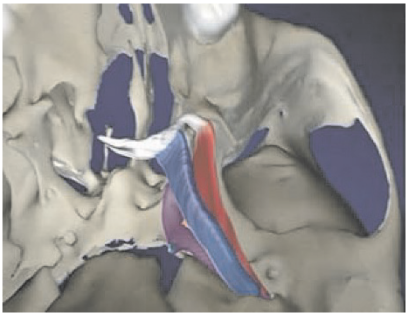

Fig. 16.2 Although freeing the abnormal muscular attachments of the levator veli palatini from the posterior edge of the hard palate will partially mobilize this muscle, as demonstrated, the tough tendinous attachments to the tensor veli palatini will prevent full mobilization of the levator veli palatini to the midline

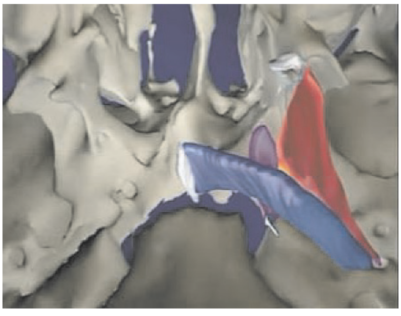

Fig. 16.3 Radical mobilization of the levator veli palatini toward the midline can occurs after transection of tensor veli palatini tendon medial to the hamulus. As the tensor veli palatini is the prime opener of the Eustachian tube, a suture is placed around the tensor tendon and the hamulus (tensor tenopexy) to prevent retraction of the tensor veli palatini after transection

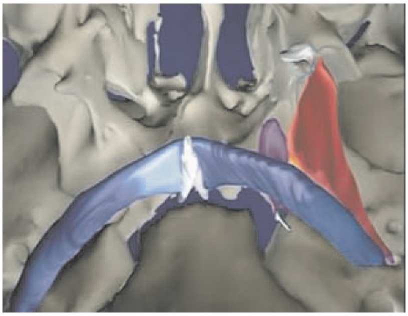

Fig. 16.4 A completed levator sling palatoplasty is demonstrated

The nasal mucosa is closed anterior to posterior with care taken to tie the knots on the nasal side. The uvula is reconstructed in horizontal mattress fashion. The levator sling is also reconstructed in horizontal mattress fashion. Care is taken to ensure a snug fit to the levator sling. However, the surgeon should be cautioned against "over-tightening" the levator sling, as this can lead to the development of sleep apnea, the need for a nasal airway in the immediate post-operative phase or re-intubation [3]. Over-tightening of the levator sling may be particularly treacherous in the Pierre Robin patient. The remainder of the oral mucosa is closed in vertical mattress fashion. Anterior to the levator sling reconstruction, nasal mucosa is incorporated in the "deep" vertical mattress suture. These key sutures, which are tied after the rest of the oral mucosa has been closed, obliterate the space between the oral mucosa flaps and the nasal flaps, preventing fistula formation. The lateral relaxing incisions are loosely affixed to the surrounding gingiva with absorbable sutures.

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17

The Foundation of a Finite Element Model for Cleft Palate and Analysis of Biomechanical Properties

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17.1 Introduction to the Biomechanics of the Cleft Maxilla

Bony restoration of the alveolus cleft with grafting material for a cleft 1：p and plate child has become an essential part of the contemporary surgical management of many orofacial cleft deformities. While the concept of grafting of the cleft maxilla was introduced in the early 1900s, it was not widely recognized until a half century later [1]. Beginning in 1955, clinical reports from several European centers approved the successful cortical grafting of maxillary clefts in both infancy and later childhood[2]. Since that time, alveolar cleft grafting has continued to grow in both popularity and success and is now generally acknowledged to be a necessary management for cleft 1ip and plate patients as that of the primary lip or palate repair.

Any patient born with a complete cleft should be considered for alveolar grafting [3]. This benefits the patient and the goals of the operation are well recognized, including the stabilization of the maxillary arch, elimination of palatal fistula, enrichment of bony support for the subsequent teeth eruption, as well as the reconstruction of the aplasia margin of the pyriform aperture and henceforth an increase in soft tissue nasal base support.

Based on the structure of the alveolar cleft, research has given us different ideas. Some researchers have thought the alveolar cleft causes the collapse of the dental arch and discrimination of maxilla and mandible [4, 5]. The bony restoration of the alveolar cleft would provide physical support which will resist both alveolar and maxillary arch displacement and collapse.

On the midface, the maxillary complex is composed of malar, nasal and lacrimal bone, and the maxillary dentition. With a cleft palate, the maxillary segments of the cleft palate will collapse under the postoperative lip pressure [6, 7, 8]. The maxillary arch will become narrowed and the dentition disarranged. When the maxillary arch and dentition change their shape, the process could be confirmed by animal experiment. However, the result could not be observed directly by researchers [9, 10].

Although alveolar bone grafting has been widely applied in the world with accepted timing and bone donors, there remains unsettled an obvious problem. It seemed that the most ideal method promising normal maxillary growth and function was to repair the whole maxillary bone defect based on the biomechanical theories. Feasibility and practicability forced the clinicians to adopt alveolar bone grafting. There is still basic research in progress concerning bone grafting the cleft maxilla, and the results cannot be applied directly in the clinic. Most clinicians do not recognize whether there are any differences between alveolar bone grafting and palate bone grafting and how apparent the differences are, considering the resistance to the bioforce of the surrounding tissues. Furthermore, rare research centered on the changeable patterns pre- and post-grafting under the bioforce of the surrounding tissues.

These ambiguities may somehow weaken confidence in alveolar bone grafting. Recently we used the three-dimensional finite element method to provide further biomechanical evidence for alveolar bone grafting.

The three-dimensional finite element method (FEM), with which we have been concerned [11], could be another way to represent this process by numerical methods with engineering and mathematical physics. Most interesting areas could be reconstructed and for further analysis. With FEM we could separate the objects of studying into different elements. The intrinsic action of the model could thus be judged through computer operation, and the result of the interactive force would be directly conducted to the model. This kind of property could prompt some experiments that are impossible in animals, especially for the studies of a growth vector potential in an animal experiment.

Currently, there are disputes on the status of bone grafts for the cleft maxilla in terms of mechanism and the type of bone graft used [12, 13]. We will generate a FEM cleft maxilla model from a cleft palate patient. Applying an imitated lip pressure on the front side of the model with a certain strength, we will observe the pressure distribution and potential changes in different dimensions of the cleft maxillary FEM model with and without bone grafts. The results are as follows.

17.1.1 Methods for Studying the Mechanical Properties of Cleft Maxilla

A 15-year-old male patient with a right unilateral complete cleft palate was taken as the subject. The patient was placed on the table for scanning with multi-slice spiral CT (Philips MX8000 (formerly Marconi MX8000), Philips Inc, Netherlands). The patient's head was kept in a fixed position with a foam pad to avoid movement artifacts. The scanning was performed at 120 kV and slice increments of 1 mm. CT data were recorded in high-resolution mode with a reconstruction matrix of 512×512 pixels. The scanning range was started from the anterior nasal spine to tubercular sellae posteriorly, which includes all the bony structures of the midface. The geometry of the maxilla slice was performed by image-editing program (Adobe Photoshop 7.0, Adobe Systems Inc, California). The bone outlines (inner and outer compact surfaces) were plotted into digitalized contours on continuous CT images.

A cleft maxilla finite element (FE) model was generated with ANSYS commercial software (version 6.1, ANSYS, Inc, Canonsburg, PA) for each sectional slice, based on the digitized XYZ voxel resolution of the image. The mechanical properties of cancellous bone were taken from previous studies [14]. Depending on the different analytical requirements, different dimensions of models were generated according to anatomical configurations. The maxillary sinus, palatal shelves, alveolar crest and pterygoid process were established separately. They were added to a whole FE model of the cleft maxilla. Then, an alveolar bone graft model and a complete palate bone graft model were established and added to a different cleft FE model for the studies.

Force was loaded onto the anteriolateral buccal aspects of the alveolar arch vertically at a strength of 7.16 N, which is equivalent to average normal lip closing force [15]. The posterior surface of the pterygoid process was taken as immovable area of cleft maxilla FE models. The bony structure of the model was set isotropically, uniform with Young's modulus of 8.0×10^3 MPa. The Poisson's ratio is 0.3 [14]. Three types of model were composed with 110,000, 120,000 and 190,000 elements for cleft palate, cleft palate with alveolar bone graft, and cleft palate with whole cleft bone graft respectively, as shown in Fig. 17.1 and Table 17.1. The criteria and distribution of the forces and the displacement of the model were taken as indicators of the changes of cleft models before and after bone graft. All these calculations and data acquisition were completed with an HP nw8000 computer mobile workstation.

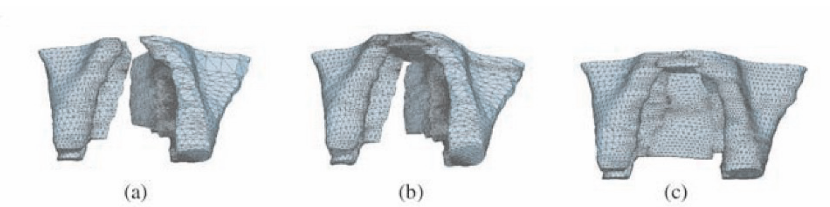

Fig. 17.1 Three types of models for cleft palate with or without bone graft; (a) Cleft palate without bone graft; (b) Cleft palate with alveolus bone graft; (c) Cleft palate with whole cleft bone graft

In addition, based on the small-sized model, we tried to build up a cleft maxillary complex (CMC) model. By enlarging the dimensions of the model to include malar bone, malar arch, nasal bone and root of the malar arch, we generated a CMC model which was composed of 67,201 nodes and 304,884 elements. This CMC model was more approximate to the midface skeleton (Fig. 17.2a). We intended to explore the different changes from a small-sized model to a relatively larger model, by which we hoped to better understand the biomechanics of these models.

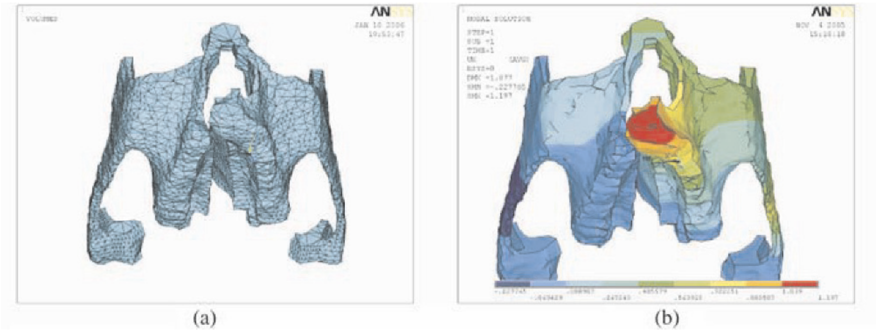

Fig. 17.2 Cleft maxillary complexes. (a) Model; (b) Displacement of freedom (DOF) of the model under loading condition. The red color area presents to be where the maximum DOF will be. The blue presents to be the minimum DOF area

17.1.2 Post-loading Results of Analysis with FEM

The dimension of the generated model was judged by the number of nodes and elements. According to FE theory, the number of nodes and elements are related to the veracity of the study. In this study, the numbers of nodes and elements are shown in Table 17.1. The vector of the axis is shown in Fig. 17.3.

Table 17.1 Numbers for the constitution of different models

	CP	CP+ AL	CP+ Whole	CMC
Nodes	24898	26859	45018	67201
Elements	111746	122321	192508	304884

CP: Cleft palate only; CP+AL: Cleft palate with alveolar bone graft; CP+ Whole: Cleft palate with; whole cleft bone graft; CPC: Cleft maxillary complex

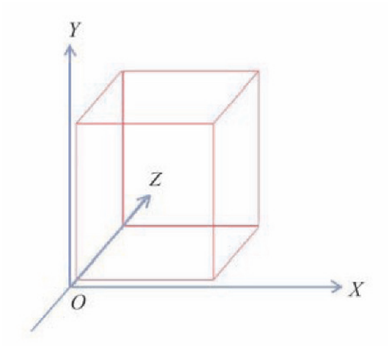

Fig. 17.3 Shown of three dimensional axes for the model as we learned in solid geometry. In these three directional explains, the *X* axis means the model displacement occurs on the horizontal plane; the *Y* axis means that the model displacement present on the vertical plane and the *Z* axis means the displacement of the model on the posteroanterior plane. Because the following 3-D models has their vectors same with this legend, so the following values have negative mark which means opposite displacement to the arrow direction. It is important to remember this before analyzing following data in the table

Displacement and deformation of cleft FE models.

Table 17.2 shows the maximum displacement along the *X*, *Y*, *Z* axes of the model.

Table 17.2 The maximum displacement along axis of different models (mm)

axis	CP	CP+AL	CP+Whole	CMC
X plane	–13.13	1.07 (–92%)	0.91 (–15%)	1.20
Y plane	–7.46	–2.63 (–65%)	–2.64 (+0.4%)	–1.28
Z plane	–8.68	–3.52 (–59%)	–3.29 (–7%)	1.01

The data in the brackets shows the displacement decreased greatly compared to that of the previous data along the same axis. The results show that for the model without bone restoration, the greatest displacement occurred along the *X*-axis, which represents the horizontal plane. However, after alveolar bone restoration, the *X*-axis displacement of the model is decreased 92% compared with the model without the bone graft. But for the model with the whole cleft bone restoration, it is only decreased by 15% compared to the model with alveolar bone restoration. Thus, we could infer that the hard palate bone restoration may have minor superiority.

Stresses and their distribution. The stresses for the models produced by anterior physical strength are specific parameters for calculating and demonstrating the results of the model after force-loading. The stresses mean a potential crack or destruction of the models. The greater the stress, the more likely the model will be wrecked.

Table 17.3 presents the maximum stresses for the different models.

Table 17.3 The maximum stress in the interior of the different models

Types	CP	CP+AL	CP+Whole	CMC
S1	24842	10883 (–57%)	4278.10 (–61%)	125.30
S3	1204.90	623.74 (–48%)	269.28 (–57%)	34.44
Shear	18351	9595 (–47.7%)	973 (–89.9%)	22.35
VM	29375	14276 (–51%)	6185.8 (–57%)	188.76

Note: S1: S1 force; S3: S3 force; Shear: Shear force; VM: von Mise force

The results show that under a constant force-loading, the maximum interior stress of the cleft palate model is reduced by 50% – 60% with alveolar bone restoration. However, for the CMC model, maximum stress is greatly different from that of the small-sized model, probably because of the greater dimension.

The first principal stress (S1) distribution on the surface of the models is presented for the small-sized and CMC model respectively (Figs. 17.4 – 17.5). S1 stress is presented to be a kind of stretching force loaded on the model which would reflect the material property of the structure. The model would crack if the stretching force exceeded a certain range.

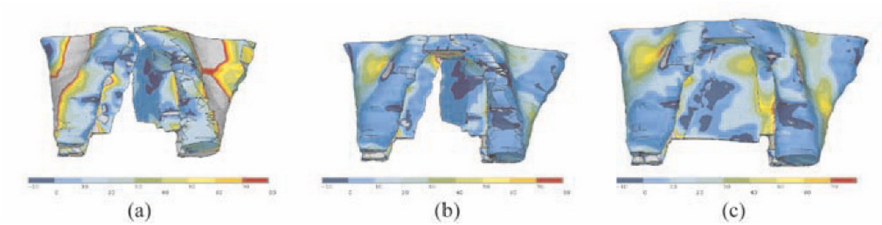

Fig. 17.4 The S1 stress distribution properties were over different small-sized model; (a) Cleft palate without bone graft; (b) Cleft palate with alveolus bone graft; (c) Cleft palate with whole cleft bone graft

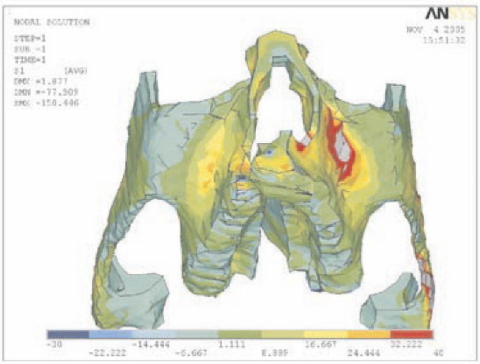

Fig. 17.5 S1 stress distributed on the CMC model, which was mainly focused on the non-cleft side of infraorbital area (the grey-red-yellow area) and the ridge of piriform aperture of cleft side. We could observe influence of loading force over the CMC model. The non-cleft side bears more stress because of the long fragment of the alveolar carries more loading force

The third principal stress (S3) distribution on the surface of the small-sized model and CMC model respectively, under same loading condition (Figs. 17.6 – 17.7). S3 stress presents a kind of compressive force for the interior structure of the model. If the model is compressed to a certain range, the model will become cracked under the loading force.

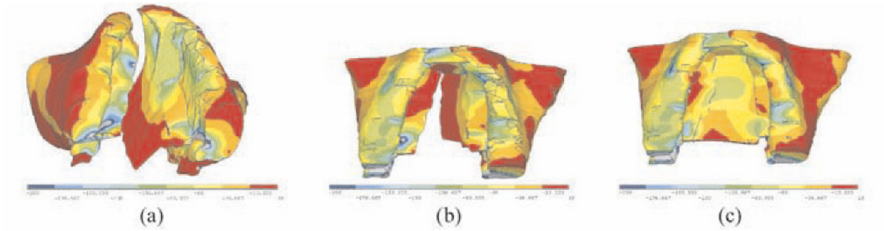

Fig. 17.6 The S3 force distribution was on the surface distribution of different models; (a) Cleft palate without bone graft; (b) Cleft palate with alveolus bone graft; (c) Cleft palate with whole cleft bone graft

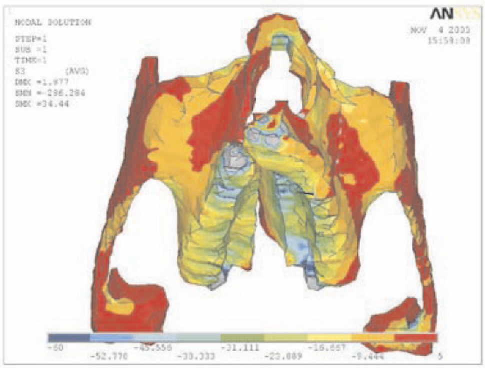

Fig. 17.7 The S3 stress distribution was mapped over the CMC model. It was noted that S3 stress (red area) mainly concentrated along the piriform ridge of cleft side and infraorbital area of the non-cleft side as well as the outer surface of the malar and zygomatic arch

The shearing stress distribution along the *X*-axis of the model was demonstrated on a small-sized (Fig. 17.8) and CMC model (Fig. 17.9). However, the shearing stress presents the deforming action of the model along the opposite direction of the same *X*-axis of the model. It is more than a transformation tendency under the loading force condition of the model but rather a kind of resistance.

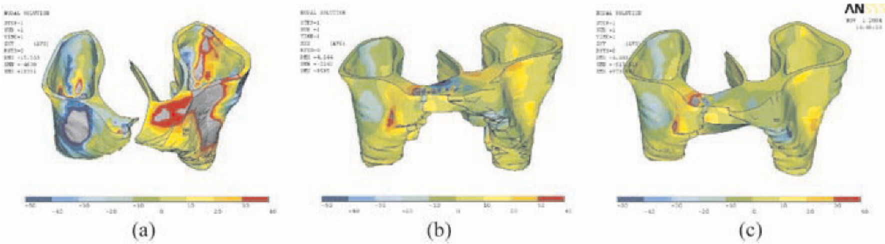

Fig. 17.8 It was the demonstrated distribution of the shear force on the anterior surface of different models; (a) Cleft palate without bone graft; (b) Cleft palate with alveolus bone graft; (c) Cleft palate with whole cleft bone graft

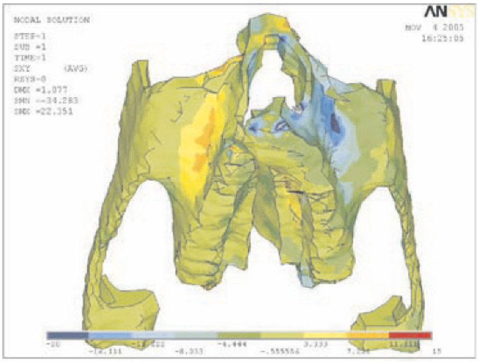

Fig. 17.9 Shear force distributed over the CMC model and its properties colored by blue and yellow which are means the maximum stress areas but have right about *X*-axis direction. It was clearly to be noted that when two maxillary fragments (long and short) comes together after loading force pressed, bilateral infraorbital and piriform ridge areas bear the maximum shear force

The von Mises stress distribution is shown in Fig. 17.10 for the small-sized model and in Fig. 17.11 for the CMC model respectively. In materials science and engineering, the von Mises distribution acting as a yield criterion can be also formulated in terms of the von Mises stress or equivalent tensile stress, a scalar stress value that can be gained from the stress tensor. The von Mises stress is used to predict the extent to which materials yield under loading conditions from the results of simple uniaxial tensile tests. On an accessible basis, the von Mises force presents an average force pressed on the model. The colors reflect the minimum (the blue area in the picture) to maximum (the gray area in the picture) average interior force of the model (Figs. 17.10 – 17.11). It is understood more directly from color changes than from the data. However, the demonstration is based on explaining the distribution of the loading force of the model.

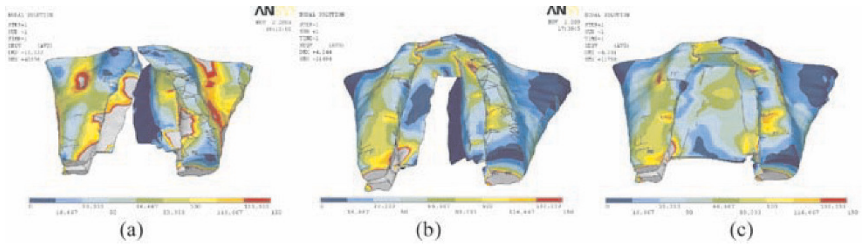

Fig. 17.10 The picture presented von Mise force distribution on the surface of three models; (a) Cleft palate without bone graft; (b) Cleft palate with alveolus bone graft; (c) Cleft palate with whole cleft bone graft

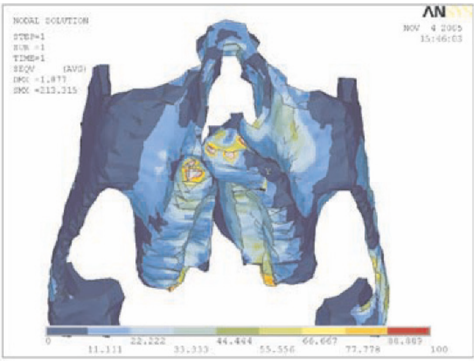

Fig. 17.11 The picture was shown the property of distribution for von Mises stress. Most area of the model (deep blue color) except anterior wall of the maxilla and the inner aspect of the alveolus ridge are equivalent to zero. But the anterior ends of the alveolus ridge presents to be the most yielding area (red-yellow-grey color)

Deformation and displacement of the models and their interpretations. As is generally known from materials physics, an object will change its form under external force no matter what the material properties are. However, the process design parameters and production environments inevitably have variation and noisy factors, which will possibly affect the model formability and the deformation of the model structure. In this study, we assume that the model is made of an isotropic elastic material, and that the model is fixed by the posterior surface that is assumed to be immovable, no matter what kind force is pressed against it from the anterior aspect of the model. Thus, with the lip closing force documented in the literature [15] acting on the anterior tips of the alveolus arch, the deformation and movement will be observed.

As we can see from the movement of the model shown in Fig. 17.12, the anterior ends of alveolus arch without bone graft will approach each other. The same phenomenon can be generally observed in clinics after cleft lip surgery. However, for the model with bone graft, only deformation of the model was observed. That is because we pre-assumed that the model is immovable. The fragments of the model cannot move along the *Y*-axis and *Z*-axis, but can move along the *X*-axis. The enlarged picture (Fig. 17.13) shows the anterior ends of the alveolus arch without bone graft coming together. We can see this more clearly, so as to help understand the displacement of the model.

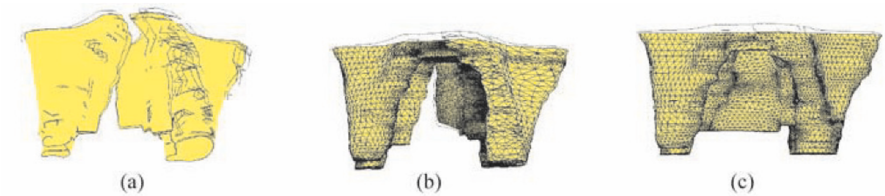

Fig. 17.12 The picture presented the deformation of the models under loading force condition. The outlines are the original models before loading force. It can be obviously concluded from the shifting extent that graft block be effectively stop the horizontal displacement of the models which are observed as dental arch narrowed clinically, but still with deformation; (a) Cleft palate without bone graft; (b) Cleft palate with alveolus bone graft; (c) Cleft palate with whole cleft bone graft. For CMC model displacement, please refer to Fig. 17.2b

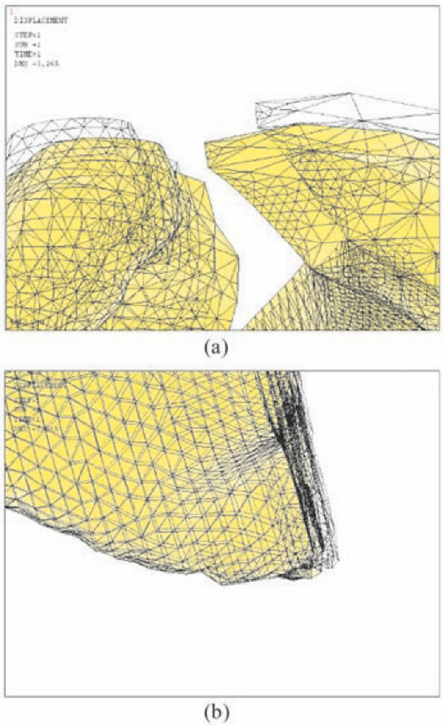

Fig. 17.13 The enlarged observation of the anterior ends of the model without bone graft presented obvious displacement under loading condition from bottom view (a) and lateral view (b) They have two prominent directional displacement along *X*-axis (towards midline) and *Z*-axis (backwards) but with less downwards (negative *Y*-axis) displacement for no-bone graft model. For better understanding, please refer to Table 17.2

Because of its complexity, the CMC model changed the properties of its presentation in comparison to small-sized models. Considering the dimension of the CMC model, which makes it harder to examine in detail, we apply a color scale for the presentation of the changes in the CMC model. From the color scale of the CMC model, we can observe the maximum area of movement around the tip of the alveolus arch and this especially happens at a long segment. From presentation of both the local and CMC model, we infer that long segment of the alveolus arch is moving prominently among segments, especially at their tips. We observed the same phenomenon both from research results and from clinical manifestations.

17.1.3 Discussions for the Significance of Criteria

17.1.3.1 Models and Forces

It is generally known that two bone segments of the complete cleft palate would come together when their anterior ends were pressed after lip restoration [6, 16]. However, for a cleft palate model, the anterior segments of the maxilla will also come to the midline and will deform after being loaded on the anterior aspects of the segments. In clinical observation, a doctor would hardly have the chance to observe the dynamic change of cleft maxilla during the postoperative stage. The results of the maxillary changes will show up as the patient grows to a certain age. But in this research, we apply animate force on a finite element model from cleft palate maxilla, the model will change as the force is applied and the process only depends on the calculation of the program within a matter of hours. For research results, a patient would spend years waiting for the results from the clinic.

The experimental results show that the model will become deformed and dislocated along the direction of the force. As to the longer segment of the cleft maxilla, it has more obvious displacement and deformation than that in the shorter segment. The same signs were observed by other authors [6, 11, 17]. At the same time, the shear stress, produced by the deformed segments, is highly concentrated over the infraorbital regions and along the piriform rims. These focused intrinsic stresses would change the structure of regions.

For the model with intimated bone graft, they would mainly deform and compress along the *Y*-axis and *Z*-axis, which means downwards (*Y*-axis) and backwards (*Z*-axis) movement of the model. The grafted bone will resist the compression of the segments of both the longer and short ones along the *X*-axis. This would avoid the narrowing and deforming of the cleft gaps between the alveolar long and short segments. From graphical representation, we observed the force conducting along the outer surface of the alveolus and focused on the bicuspid area of the alveolar ridge inner surface. What we obtained from the model may have some relationship with the clinical manifestation of the crowded dentition in the same region. As we focus on the intimated bone graft, the complete cleft bone graft model demonstrated only slight superiority over the alveolar bone graft regarding aspects of deformation and dislocation of the model, as well as on the distribution of the force over the model. The distribution of the loading force over the model tends to be more uniform as the dimension of the model increases.

17.1.3.2 Biological Force Presentations of the Different Models

Under loading force action, models expressed different dominant changes which are as follows:

For the cleft maxilla model without bone graft, the deformation of the model occurs mainly over the anterior part of the segments. The frontal ends of the segments will rotate to the gap of the cleft, and will be narrowed and deformed as an inverted V, but for the hard palate they were hardly changed. The shear force arising from the deformation will predominantly show up on the anterior wall and piriform rim. The bicuspid area acts as a rotation axis, thus the loading force can cause deformation of the anterior alveolus segment. As to the von Mises distribution, it was mainly concentrated on the palatal plate and anterior wall of the maxilla. The range of the force for the model without bone grafting is from 0 to 29,375 kPa and the range will be from 0 to 14,276 kPa for a model with alveolar bone graft. But for the model with whole cleft bone graft, the force range was greatly diminished to a range from 0 to 6,185.8 kPa. This force range change suggests to us that the strength of the force will be greatly diminished as the bone graft range increases (Table 17.3).

The movement and deformation behaves differently between a model with or without bone graft. The displacement of the anterior alveolar segment in a model with bone graft will show a rotation downwards rather than a coming together in the model without bone graft. But the results suggested that the graft bone block bears the most compression force and resisted the deformation of the anterior parts of the segments. This experiment also told us that it is necessary to do bone grafting on the cleft palate. For the other aspect, subjoining a hard palate bone graft, the results of the experiment tend to be slightly superior to those of the alveolar bone graft. Theoretically, the whole cleft bone graft would have a more realistic and satisfactory outcome under loading force circumstances. There are authors who have stated the necessity of the whole cleft bone graft to gain a normal palatal form [13].

However, for the CMC model, despite its dimensions which are much greater than that of the small-sized local models without the bone graft applied, it still presented the same appearance of distribution and mode of displacement with that of a small-sized local model. According to Table 17.2 and Fig. 17.2a, we explicitly distinguish between CMC and a small-sized model without bone graft. They behaved with the same motion except for the extent of the displacement.

17.1.3.3 Biological Effects of Bone Graft

The result of the experiment in Fig. 17.5 demonstrates that the von Mises stress is still conducted along the alveolus ridge to the pterygomaxillary pillar, despite the bone graft being applied. As soon as the posterior aspect of the pillar was defined as immovable in advance, maximum compressive force was focused on the lower end of the pterygomaxillary fissure. This force would compress the alveolar ridge and would probably result later in the eruption of crowded teeth. Both this study and clinical dentition showed the result which has been stated before [16].

With support of the bone graft, the segments of the maxilla will move backwards and downwards instead of coming together. And the value of shear stress and the mode of S1 stress distribution on the model changed greatly after the bone was grafted (Table 17.3). This is mainly because the graft block prevented the segments of the model from collapsing and deforming. However, for the graft block itself, both aspects of the contacted segment bear the greatest force. This probably suggested that bone absorption in a clinic may have a theoretical relationship with various types of stress changes. And the shear force on the model could be highly minimized by the graft resistance, especially after the whole cleft bone graft has been applied (Table 17.3).

17.2 Conclusions and Controversies

In this investigation, a non-repaired alveolus arch of a cleft palate will be displaced and deformed by focused force produced by lip restoration. Alveolus and whole cleft bone restoration will greatly reduce the effect of various forces and reduce their strength over the model. Bony restoration of the cleft will help resist displacement of the alveolar segments and minimize the distortion forces which will probably affect alveolar growth type [8, 11, 16].

For the purpose of bony restoration of the secondary hard palate, the experimental data suggest that it could enhance maxillary rigidity, which would help reduce the risk of graft bone absorption. This is a more optimistic type of restoration of the hard palate. From the viewpoint of the biological study of this experiment, we gain a minute difference between alveolus arch and hard palate bony restoration of the cleft palate with the same compressive force conditions applied to anterior ends of the alveolus. Moreover, the stress and strain can be calculated. The advantages may lead to more extended analysis in the near future. We should concentrate on questions of time and money as well as initiating the probe.

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West China Technique of Alveolar Bone Grafting

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According to the biomechanical analysis of the effects of bone grafting in the repair of cleft palate described in the last chapter, we found that repairing cleft palate with bone grafts can stabilize and support the maxillary dental arch, protect the arch against the pressure of the lip, cheek and tongue, and effectively prevent tissue collapse. It is interesting that, when we further compared the effect of bone grafting in cleft alveolus with cleft palate and alveolus, we found that there was no significant difference between the two grafting modes with respect to their support to the maxillary dental arch. It implied that in practice bone grafting in cleft palate repair can be completely replaced by bone grafting in cleft alveolus with little loss of efficacy [1, 2]. The first attempt at bone grafting in cleft alveolus can be traced back to the beginning of the 20th century, whereas the real application of modern bone grafting in cleft alveolus repair started from the mid-twentieth century. At the beginning, bone grafting was applied to cleft infants in order to prevent their dental arches from collapse. In the early 1970s, Boyne presented the concept of secondary bone grafting in cleft alveolus repair and suggested that the optimal time for secondary bone grafting was at the age of nine to eleven years, before the eruption of the cleft side permanent canine [3, 4].

With the rapid development of surgical technique and a more comprehensive understanding of morphological and functional reconstruction, bone grafting in alveolar cleft has become a systemic treatment combining plastic surgery with orthodontics, prosthodontics and implantodontics. Optimal reconstructive results will be achieved if the systemic treatment is suitably performed.

18.1 The Clinical Manifestations of Alveolar Cleft

The tooth buds near the region of the alveolar cleft will be affected and abnormalities may occur in the number, morphology and location of adjacent teeth. More secondary deformities and symptoms will arise as the patients grow. If the cleft extends to the nasal floor, there can be several consequences: the nasal ala on the cleft side collapses, the columella deviates to the non-cleft side because of a lack of skeletal support, and the facial contour looks asymmetric; the alveolar segment on the cleft side often rotates to the palatal side; the teeth beside the alveolar cleft erupt abnormally; microdontia, crown deformity, tooth mal-positioning, enamel hypoplasia, missing lateral incisors, and supernumerary teeth can occasionally be present. The lack of sufficient bone support near the cleft and an unhealthy periodontium always loosen the permanent teeth around the cleft so they are easily lost, while the crowding and malaligned dentition causes poor oral hygiene and invariably severe caries; the premaxilla always protrudes anteriorly and dislocates inferiorly in many bilateral alveolar cleft cases, but in some other cases the premaxilla can dislocate posteriorly.

No matter how the premaxilla locates, the lateral maxillae segments collapse medially and anterior and/or posterior crossbites occur. Both in patients with unilateral and in patients with bilateral alveolar cleft, instability of the maxillary alveolar process often makes it difficult to achieve sufficient retention for fixed or removable dentures. The deformed dental arch caused by the alveolar cleft usually limits the normal movement of the tongue and leads to misarticulation, especially of the fricatives and affricatives such as /s/, /z/, /sh/, /ch/, /j/. The normal oronasal cavity is separated by the hard palate and the soft palate. Though the oral cavity and nasal cavity both take part in breathing and pronunciation, they have totally different physiological functions. The main function of the oral cavity is mastication and swallowing, while the nasal cavity deals with olfactory sensation and air flow conditioning. When patients with alveolar cleft have an oronasal fistula, the different functions will interfere with each other, and abnormal speech, such as hypernasality, will occur [5].

18.2 The Goals of Bone Grafting in Cleft Alveolar Repair

The goals are to eliminate the alveolar bone deficit, to promote normal eruption of the permanent canine and to provide the foundation for later orthodontic treatment, to restore the continuity and stability of the alveolar processes, to rebuild the normal dental arch and periodontal support surrounding the cleft, to close the oronasal fistula, to avoid or simplify the prosthetic restoration of the missing teeth in the cleft area and to support the alar base on the cleft side [6] (Fig. 18.1).

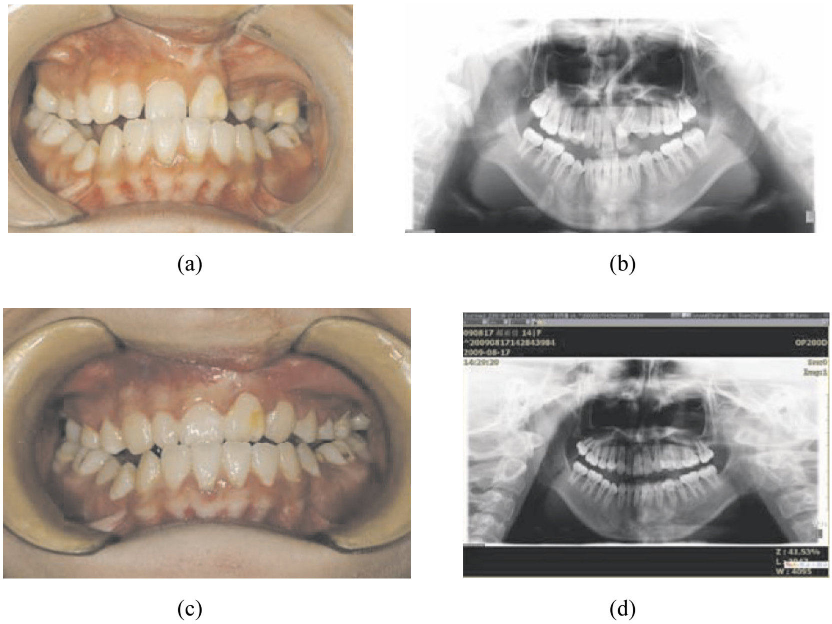


Fig. 18.1 (a) Left complete cleft alveolar (intraoral view); (b) Left complete cleft alveolar (panoramic photograph); (c) Left complete cleft alveolar after autogenous iliac cancellous bone graft (intraoral view); (d) Left complete cleft alveolar after autogenous iliac cancellous bone graft (panoramic photograph)

18.3 Timing

The optimal timing of cleft alveolar repair is still controversial. Formerly, primary repair of the alveolar cleft was performed at the same time as primary lip repair or palate repair. Long-term clinical observation indicates that the results of this synchronous primary repair are inconsistent. Moreover, choosing an autologous rib as the implant always inhibits maxillary growth in its sagittal and vertical directions. Therefore, the synchronous mode of alveolar repair fell out of favor. Other options have included early secondary alveolar repair before the eruption of the cleft side permanent incisor, conventional secondary repair during the mixed-dentition stage, between the age of 8 and 11 years before the eruption of the permanent canine, or late secondary repair after the eruption of the permanent canine [7, 8].

The most widely accepted treatment is conventional secondary repair during the mixed-dentition stage before the eruption of the permanent canine on the cleft side. Relatively satisfying results can be achieved between the ages of 8 and 11 years when the root of the permanent canine has developed half to two-thirds of the whole mature root length. This stage is believed to be appropriate for bone grafting because of the minimal adverse effect on facial development, the benefit to the periodontal health of adjacent teeth and the eruption of the permanent canine.

Studies on early secondary alveolar repair are relatively fewer than conventional alveolar repair. Supporters consider that early secondary alveolar repair should be done as early as 4 years of age when the central incisor and the lateral incisor tend to erupt malpositionally from the alveolar cleft area because the dental arch lacks sufficient bone support.

Years of clinical observations have shown that synchronized repair of the hard palate cleft and alveolar cleft with a vomer flap during primary cleft lip repair, as carried out by Carstens, could effectively improve the outcomes of cheiloplasty and successfully close the alveolar cleft. Our experience also proved that this kind of surgical approach could provide a significant advantage for later palate and alveolar repair, greatly reduce the difficulty of the operation and even avoid the necessity to perform alveolar surgery in adolescence. This synchronized surgery was found not to have much of a negative influence on maxillary growth, at least not worse than lip repair only, according to the long-term investigation in our center. Of course, this alveolar cleft closure is rather a kind of boneless bone grafting with periosteum-induced ossification than real bone grafting [9].

Late secondary alveolar bone grafting has been shown to have a lower success rate because of the poor blood supply, alteration of flora in the oral cavity and poor oral hygiene, especially in cases with bilateral cleft lip and palate. Most of the cases treated at this stage are those where repair has failed before the eruption of the permanent canine. The late bone grafting can be postponed to the stage when the orthognathic surgery is performed [10].

18.4 Presurgical Orthodontic Management of Alveolar Cleft

Short-term orthodontic treatment lasting approximately 6 months is usually required before bone grafting. The objectives of this treatment include alignment or de-rotation of the mal-positioned incisors, correcting the crossbite of the anterior teeth and expanding the posterior and anterior maxillary arch to build a convenient path to the palatal fistula. In some cases, bone grafting should be performed before the orthodontic expansion. The important point for these cases is that the orthodontic treatment should not be postponed to more than 3 months after the surgery.

In some patients with bilateral cleft lip and palate, the upper incisors incline to an extreme degree posteriorly. We should raise these incisors to their normal positions and eliminate the crossbite through orthodontic treatment. In some other patients with bilateral cleft lip and palate, the premaxilla protrudes prominently forwards, the lateral dental arches collapse and the lateral maxillae nearly connect with each other. Expansion of the lateral maxillae should be performed before bone grafting in these patients to provide sufficient space for the posterior movement of the premaxilla. On the other hand, labial orthodontic wires connecting the premaxilla with the lateral maxillae are also needed to maintain the stability of the premaxilla. The labial orthodontic wires are temporarily removed just before surgery and relocated immediately after. These wires should be retained for about 3 – 4 months after surgery.

For patients whose lateral incisors adjacent to the cleft are covered by thin boney lamella on the distal surfaces, the orthodontic treatment should be delayed till after the bone grafting to prevent the bone lamella from perforation or complete absorption. However, orthodontic treatment should be done within 3 months of bone grafting.

Any redundant tooth or deciduous canine near the cleft site should be extracted 3 – 4 weeks before surgery. The superficial mucosa of the wound has enough time to heal during this time. This promises the intactness of the mucoperiosteal flap, so that the attached gum can be completely freed and migrate to cover the operative region.

It is important to highlight good oral hygiene: this greatly influences successful bone grafting. Brushing and curettage should be adopted to improve oral hygiene before surgery, and other measures should be taken to maintain good oral hygiene before the wound heals.

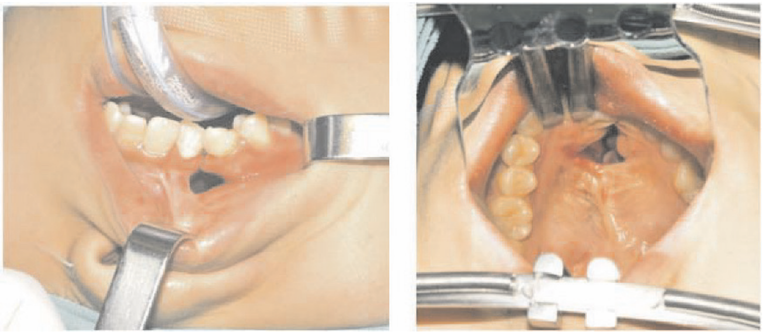
18.5 The Choice of Graft Source

Although several different sources of bone for alveolar grafting have been reported, such as autologous external lamella of mandibular symphysis, rib, maxillary tuberosity, cortical plate of cranium, tibia, allogeneic bone and artificial bone [11-15], we still insist on using autologous iliac cancellous bone. This is because it survives easily in the recipient site, is abundant and obtaining it is operationally simple. The rate of post-operative complications is extremely low in our center and the patients never suffered those severe pains or malaise as reported in the earlier literature.

18.6 Bone Grafting in Unilateral Alveolar Cleft

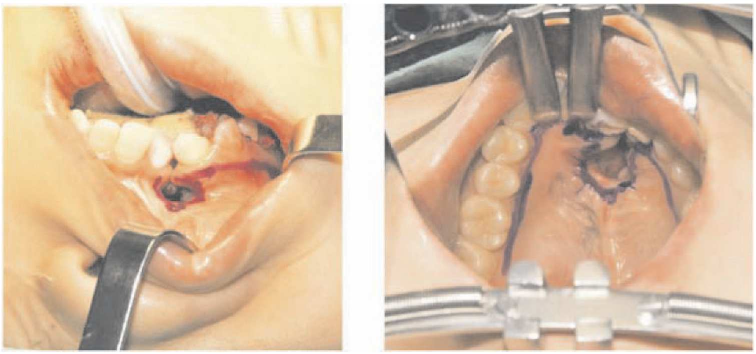
18.6.1 Design of the Incisions

The vestibular incision is made along the margin of the alveolar cleft, keeping the scalpel vertically towards the alveolar crest and avoiding slicing the tissue. The incisions are carried along the marginal gum and gingival papilla. On the cleft side, the incision extends to the first molar. At this end, an oblique and superiorly directed back-cut is made towards the vestibular groove. On the non-cleft side, the incision extends to the incisors and is then turned upwards. The extension of the incisions, i.e. the size of the labial mucoperiosteal flap, is determined by the size of the oral-vestibular fistula (Figs.18.2 – 18.3).



(a) (b)

Fig. 18.2 Right complete cleft alveolar: (a) Labial view; (b) Palatal view



(a) (b)

Fig. 18.3 (a) The labial incision in right complete cleft alveolar repair; (b) The palatal incision in right complete cleft alveolar repair

If there is a fistula on the palatal aspect, incisions are made along the fistula and the palatal marginal gum (Fig. 18.4). If there is only a narrow space on the palatal aspect, incisions are not necessary.

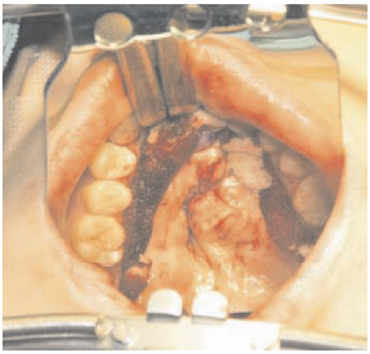


Fig. 18.4 Raise bilateral palate mucoperiosteal flaps, advance them medially and repair the palatal fistula

18.6.2 Formation of the Recipient Site

A small periosteal elevator or the rostrum of ophthalmic scissors is used to dissect the mucoperiosteal flap along the buccal incision. Mucosa is dissected around the fistula in the nasal vestibule extending to the septum and the lateral wall. Special attention should be paid to the length-width ratio of the flap and ensure sufficient blood supply (Fig. 18.5). The scars and the connective tissue on the surface of the alveolar process, especially those on the top of the alveolar crest, should be completely removed (Fig. 18.6). Sufficiently exposing the osseous ends of the bilateral alveolar processes can guarantee the widest contact of the bone graft to the recipient area and enhance the success rate of the operation. At the same time, by removing the scar and connective tissue, adequate space is also made available for further upward and backward movement of the mucosal flaps along the cleft sides: no more transecting incisions need to be made to prevent the leakage of the grafts.

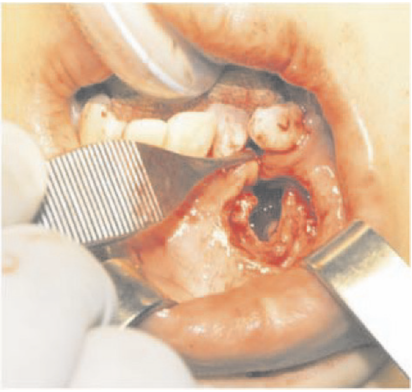


Fig. 18.5 Make semi-annual incision along the cleft edges on the bone surface, sharply separate the mucosa flap

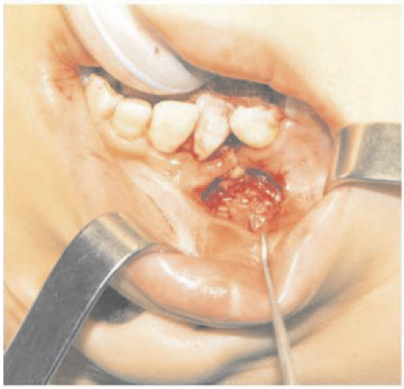
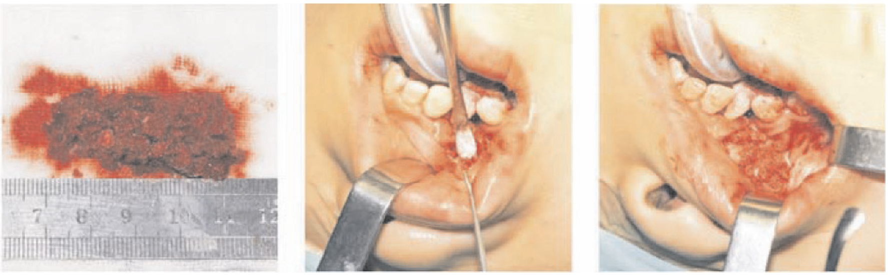


Fig. 18.6 Expose bilateral alveolar bone, excise the scar tissues in the cleft and not be bone as much as possible, prepare the implanting site

Bilateral nasal mucosa flaps are raised upwards and appositely sutured. Thus, the nasal floor is closed, ie, the roof of the recipient site is formed. In patients with palatal fistula, the incisions are carried along the palatal marginal gum, and the palatal mucoperiosteal flaps are raised and appositely sutured (Fig. 18.4). If there is no palatal fistula, the palatal mucosa and the inferior nasal mucosa beside the cleft are raised, turned down and appositely sutured. In this way, the floor of the recipient site is formed. The palatal mucoperiosteal flaps should be tailored and redundant scar tissue cut off before suturing. The lateral walls of the recipient site should be bared bone and the roof and the floor of recipient site should be rigorously sutured. If the recipient site is not large enough to accommodate sufficient grafts, the scar tissue and connective tissue beneath the nasal floor can be excised as much as possible, as well as part of the orbicularis oris muscle if necessary, to obtain adequate space and consequently to enhance favorable healing of the bilateral bony segments.

18.6.3 Bone Grafting

The autologous cancellous bone is first shattered into small pieces. When the bone grafts are implanted, the cancellous bone should be moderately compressed to increase the density and reduce the absorption (Fig. 18.7). If the cleft extends to the nasal floor, a quantity of cortical bone can be implanted on the roof of the alveolar cleft. Cancellous bone should also be implanted along the margin of the maxilla and piriform aperture near the alveolar cleft to support the collapsed ala on the cleft side. In this procedure, suction should be avoided in order to protect the palatal mucosa.



(a) (b) (c)

Fig. 18.7 (a) Get sufficient iliac cancellous bone; (b) Fill the implanting site with iliac cancellous bone layer by layer, try to ensure that the graft bone fully contact with the cleft bone surface; (c) Implant the iliac cancellous bone into the implanting site

18.6.4 Closure of the Incisions

Incisions are made with small rotary or sharp blades on the base of the buccal mucoperiosteum to release the tension. Cutting through the periosteum and partial submucosal tissue would thoroughly release the flaps to cover the implant areas under zero tension. This is helpful for better healing because of the tension-free suture (Fig. 18.8). The bilateral mucoperiosteum flaps near the cleft and the palatal mucoperiosteal flap are pulled together with interrupted mattress sutures. Finally, the distal buccal mucoperiosteal flap and the corresponding palatal mucosa are sutured through the interdental papillae (Fig. 18.9). Complete hemostasis of the releasing incisions is necessary before the suture. The bared bone surface of the maxilla may be left distal to the buccal flap after the sutures, which do not need further special treatment.

Fig. 18.8 Raise the buccal mucoperiosteal flap under the dental papilla along the gingival margin, release the periosteum and slip the mucosal flap to the cleft region, cover the bone grafts and close the buccal wall of the implant bed

Fig. 18.9 Tightly suture the wounds

18.7 Bone Grafting in Bilateral Alveolar Cleft

The technique of closing the cleft on each side of the bilateral alveolar cleft is the same as that for unilateral alveolar cleft closure when the cleft is narrow. The most important point in bilateral alveolar cleft repair is that the incisions should be designed for the survival of the premaxillary mucosa.

However, it often happens that the alveolar clefts are too wide and/or there is palatal fistula, so that the bilateral alveolar cleft is extremely difficult to close. Sometimes, a two-stage technique is used in bilateral alveolar cleft repair to gain good soft tissue closure and sufficient bone graft repair. First, bilateral clefts and the fistula are closed with mucoperiosteal flaps. Then, 6 – 8 months later, bone grafting in the alveolar cleft is performed.

In patients with a too wide alveolar cleft, the cleft is difficult to close merely with advancing the adjacent buccal mucoperisteal flaps. The tunnel flap, nasolabial flap, forearm flap, temporal musculofascial flap and tongue flap are sequentially developed to overcome this problem.

Of these flaps, the tongue flap is generally accepted as the most suitable and is widely used because of its availability, similar texture to the recipient site, and convenient transfer: also, it seldom leaves any tongue dysfunction after surgery.

For patients with bilateral alveolar cleft, bone grafting in the cleft on each side is similar to that in unilateral alveolar cleft repair. The minor differences are:

(1) The premaxillary mucoperiosteal flaps should not be dissected too widely to affect the blood supply of the premaxilla. Sometimes, when the cleft is too wide, the bone grafting can be divided into two steps. The side with the wider cleft is repaired first, and the other minor cleft is repaired 6 months later.

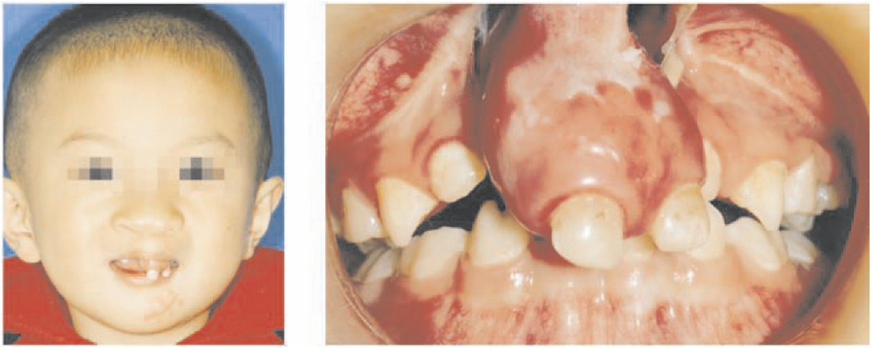
(2) A specific occlusal pad should be made before the operation. After preparation of the recipient site, the occlusal pad is fixed on the dental arch before bone grafting and is maintained on the dental arch for 4 weeks. The aim is to restrict the movement of the premaxilla and to ensure healing of the recipient site.

(3) Secondary correction of residual nasolabial deformity is better not performed at the same time as bone grafting. The secondary correction should not be performed until 6 months after bone grafting.

(4) If the premaxilla protrudes forwards or conspicuously extends inferiorly, surgical retraction of the premaxilla should be performed before bone grafting.

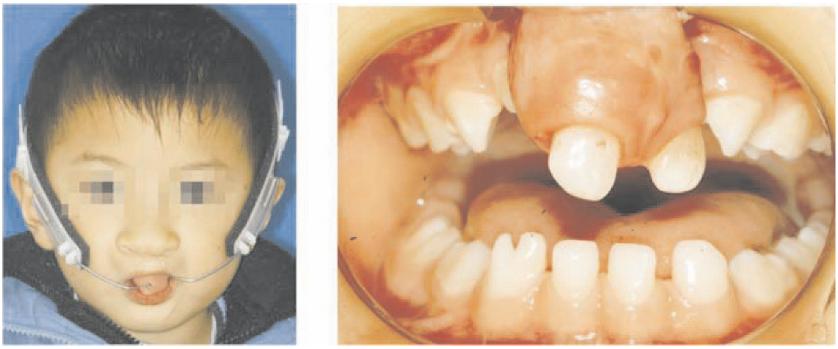
18.8 Simultaneous Surgical Retraction of Premaxilla and Bone Grafting in Bilateral Alveolar Cleft Repair

The incision design is the same as for bone grafting in bilateral alveolar cleft repair. The vomer locates behind the protruded premaxilla. The incision is along the midline of the inferior edge of the vomer. Then, the bilateral mucoperiosteal flaps are raised to the opposite side, extending to the inferior margin of the mid-septum cartilage. Vertically cut off 2 – 3 mm of the vomer beside the fissure between the premaxilla and the vomer (Fig. 18.10). If necessary, the septum cartilage located above the vomer can also be removed a little at the same time for repositioning of the protruding premaxilla. The occlusal pads made before the operation are fixed on the molars of each side to keep the premaxilla in its normal position and prevent its rotation. Then, the recipient site is prepared and the iliac cancellous bone implanted in the alveolar cleft (Figs. 18.11 – 18.12). The occlusal pads are removed 4 weeks later and a retaining appliance is maintained for a further 6 – 8 months.



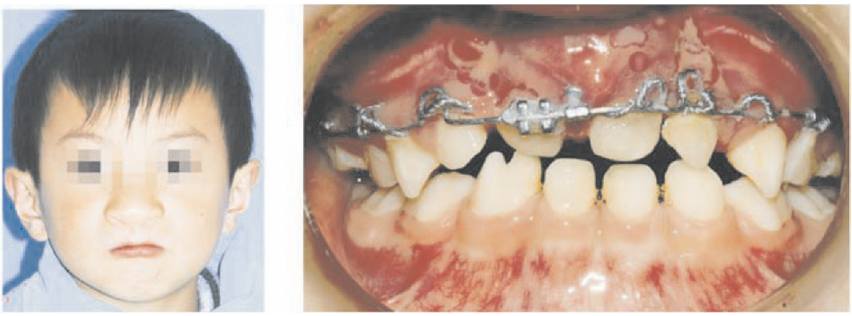
(a) (b)

Fig. 18.10 Bilateral cleft alveolar: (a) Frontal view; (b) Intraoral view



(a) (b)

Fig. 18.11 (a) Extra-oral maxillary traction before bone graft; (b) The premaxilla still excessively protruded after orthopedic traction



(a) (b)

Fig. 18.12 (a) The facial appearance changed a lot after premaxillary osteotomy and bilateral alveolar iliac cancellous bone graft; (b) Occlusion after bone graft

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19

Chang Gung Technique of Alveolar Bone Grafting

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19.1 Introduction

A patient with cleft lip and palate usually has a residual alveolar cleft after primary lip and palate repair. The alveolar cleft, together with the adjacent buccal and palatal oronasal fistulae, will cause food particle retention or fluid regurgitation into the nasal cavity during eating. The inferior turbinate on the cleft side will become hypertrophic, resulting in nasal obstruction or sometimes allergic rhinitis [1] (Fig. 19.1). It is easy to develop dental caries as it is difficult to maintain good oral hygiene in the presence of these fistulae. The life span of the teeth next to the cleft is decreased, mainly because of lack of bony support. The malocclusion and dental gap are usually difficult to correct orthodontically as there is no bone across the cleft [2]. There is downward tilting of the nasal pyramid and a vertical discrepancy of the nostrils, caused by bony deficiency under the alar base and nostril floor on the cleft side [3] (Figs. 19.2 – 19.3). It is difficult to correct this kind of nasal deformity by performing soft tissue revision. For bilateral clefts, the patients will usually have some difficulty in biting hard food, as the premaxilla is separated from the lateral maxillary segments and is mobile (Fig. 19.4). All of these problems related to the alveolar cleft can be corrected by a well-performed alveolar bone grafting procedure [2]. Alveolar bone grafting for cleft patients was first reported in 1901 by von Eiselsberg [4] and subsequently by Lexer [5] and Drachter [6]. The technique, however, was not popular until several surgeons reported their approaches and experience for primary and secondary bone grafting in cleft patients in the mid-1950s [7, 8]. The procedure is now accepted in most craniofacial centers as a routine procedure in cleft lip and palate rehabilitation.

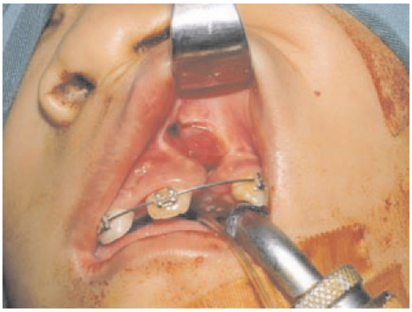

Fig. 19.1 A patient with left alveolar cleft shows the hypertrophic inferior turbinate seen through the buccoalveolar fistula the cleft side

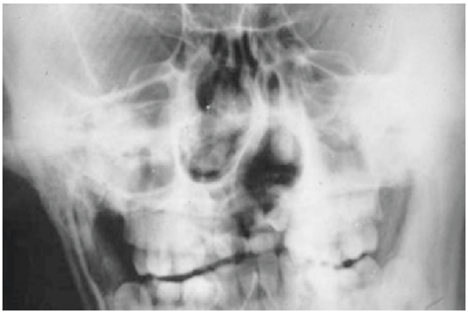

Fig. 19.2 A patient with unrepaired alveolar cleft. Cephalometric X-ray shows the bony deficiency on the nasal floor of

Fig. 19.3 Photo of the same patient shows the deficiency on nasal floor and alar base

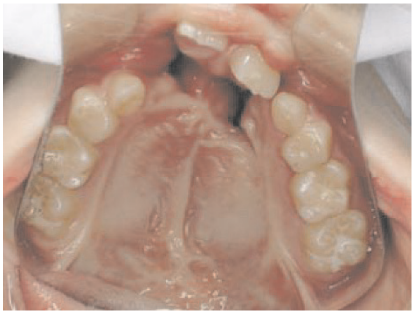

Fig. 19.4 The mobile premaxilla in bilateral clefts. This patient also has huge post-alveolar fistulae, sagittal discrepancy between the premaxilla and right maxillary segment and deviation of the premaxilla with wider cleft on the right side

19.2 Timing of Alveolar Bone Grafting

The timing of alveolar bone grafting is generally classified into four groups [2]: primary bone grafting performed in patients younger than 2 years of age, early secondary bone grafting between 2 and 5 years, secondary bone grafting between 6 and 15 years and late secondary bone grafting in physically mature patients. Although Rosenstein [9] and Nordin [10] claimed consistently good results following early primary repair of the bony cleft, most centers have abandoned the technique and reached a general agreement that facial growth was worse after the primary bone grafting procedure [11, 12]. It is now generally accepted that the best times for alveolar bone grafting are at 5 to 7 years of age, before the eruption of the cleft side central incisor, and at 9 to 11 years of age, when the cleft side canine root is

1/2 to 2/3 formed [13] (Fig. 19.5). In considering facial development, maxillary alveolar growth is mostly complete at 8 to 9 years, and a procedure performed after this age will have minimal adverse effects on facial growth. If successful, the central incisor or canine will erupt through the bone graft after surgery. This will stabilize the bone graft and increase the alveolar process, as an erupting tooth is known to have the potential to induce alveolar bone generation [14, 15].

Fig. 19.5 The general consensus for the timing of alveolar bone grafting is when the cleft side canine root (the left side in this patient) is 1/2 to 2/3 formed

19.3 Presurgical Preparation

All cleft patients are regularly followed in the author's Center with a 6-month interval since 7 years old. Serial cephalometric, panoramic and occlusal X-rays are first taken at the age of 5 years and then every two years. The timing of alveolar bone grafting is decided by the orthodontist according to the extent of root formation of the teeth adjacent to the cleft. Patient and parents have to arrange the surgical date 6 to 12 months in advance to allow enough time to optimize dental care and oral hygiene. Panoramic and occlusal X-rays are taken one week before surgery as the baseline to evaluate the surgical result. For patients who have already fully erupted permanent dentition and a residual alveolar cleft, a bone grafting procedure is still indicated in order to improve orofacial esthetics and function [16].

19.4 Indications for Presurgical Orthodontic Treatment

Although it is difficult to correct the malocclusion and close the dental gap with orthodontic treatment before an alveolar bone grafting procedure, it is the consensus in author's center that the following situations should be the indications for presurgical orthodontic treatment:

(1) Tilting or rotation of the central incisor adjacent to the cleft (Figs. 19.6 – 19.7).

(2) Sagittal discrepancy between the greater and lesser segment in unilateral clefts and the premaxilla and lateral segments in bilateral clefts (Fig. 19.4).

(3) Vertical discrepancy between the greater and lesser segment in unilateral clefts and the premaxilla and lateral segments in bilateral clefts (Fig. 19.8).

(4) Laterally displaced premaxilla with asymmetric dental gaps in bilateral clefts (Fig. 19.4).

Fig. 19.6 A patient with tilting of the cleft side central incisor in front of the cleft

Fig. 19.7 A patient with tilting of the cleft side central incisor in front of the cleft

Fig. 19.8 A patient of bilateral clefts with downward displacement of the premaxilla and vertical discrepancy between the premaxilla and both lateral maxillary segments

It usually takes 6 months of treatment to correct these conditions. Another benefit of the presurgical orthodontic treatment is the better oral hygiene and dental care before the operation as the patients are seen by the orthodontists every month [17].

19.5 Surgical Technique

The technique of alveolar bone grafting in the Chang Gung Craniofacial Center is adopted and modified from the technique used by Dr JC Posnick, when the author did his fellowship in the Hospital for Sick Children in Toronto [18].

19.6 Flap Design

In earlier reports, little attention was given to flap design for soft tissue coverage of the bone graft, and a variety of local mucosal flaps have been advocated [19]. Abyholm [20] was the first to emphasize the importance of flap design in secondary bone grafting in cleft patients and to stress its importance for the outcome of surgery. Histologically, the gingiva consists of a layer of keratinized stratified squamous epithelium and dense lamina propria with immovable attachments to the underlying alveolar bone. It can tolerate the masticatory load and provide protection against chemical and bacterial damage. The labial or buccal mucosa, on the other hand, is covered by non-keratinized epithelium with a thin lamina propria which contains more elastic fibers. It is fixed to the underlying muscles and is highly movable [21], and has less tolerance to masticatory load. If a mucobuccal or mucolabial flap is used to cover the graft, it will increase the chance of further surgical exposure of teeth as it will impede tooth eruption [14]. These mucosal flaps might also cause more bone graft resorption [22].

19.7 Source of Bone Graft

Although controversies still exist with respect to the best donor site for alveolar bone grafting, it is generally agreed that cancellous bone particles give the best result [2]. Evidence increasingly shows that iliac bone is better than calvarium or rib as a donor site owing to its abundance of cancellous bone [2, 11, 20, 23, 24]. A report by Steckeler showed that 3 to 7 ml of cancellous bone could be harvested from iliac crest compared with only 1.5 to 2.5 ml from parietal bone [25]. As the volume of the bone graft needed in unilateral clefts usually exceeds 5 ml, iliac bone is clearly the better donor site than the skull. Post-operative pain is the major disadvantage in using the iliac crest as a donor site. The discomfort can be effectively reduced by routine post-operative analgesics such as oral Codeine phosphate (Figs. 19.9 – 19.10).

Fig. 19.9 Incision line on iliac crest

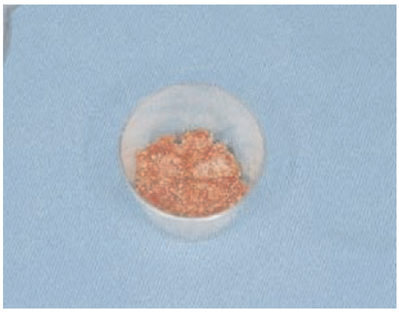

Fig. 19.10 Cancellous bone particles harvested from iliac crest

19.8 Operative Techniques for Unilateral Clefts

Operative techniques for unilateral clefts [16] start with general anesthesia, in which the gingiva and upper buccal sulcus are infiltrated with 1% xylocaine with 1 : 200,000 epinephrine solution for hemostasis and easier dissection. Incisions are made along each side of the alveolar cleft. A superiorly based gingival mucoperiosteal flap is designed and raised sharply from the gingival margin on the lesser segment (Fig. 19.11). The flap is extended posteriorly to the first molar then curved up to the lateral buttress of the maxilla. This curved incision splits the gingiva in an oblique fashion that not only facilitates medial advancement of the flap but also maintains some attached gingiva on the alveolar bone after advancing the gingival flap. The flap on the medial segment is elevated in a similar fashion towards the midline (Fig. 19.12). The palatal mucoperiosteal flaps are raised to a level beyond the deepest margin of the buccoalveolar fistula (Fig. 19.13). The fistula margins at the palatal side are freshened to facilitate wound closure. The nasal floor tissue is completely separated from the palatal mucoperiosteum after raising the palatal flaps and could then be stripped off the bony cleft. The nasal floor tissue is dissected upwards reaching the piriform aperture on the lateral segment and the cartilaginous septum on the medial segment. This allows a tension-free closure of nasal floor tissue and adequate correction of the vertical discrepancy of the nostril sill (Fig. 19.14). The nasal floor fistula is securely repaired. The medial margins of the palatal flaps are freshened and approximated with mattress sutures (Fig. 19.15). Cancellous bone chips, which have already been harvested from iliac bone by a separate team, are packed firmly into the bony defect to the level of the alveolar process (Fig. 19.16). If there is any bony deficiency under the alar base on the cleft side, this is also corrected with an onlay bone graft on the piriform aperture. The periosteum of the lateral gingival flap is scored to reduce the tension, especially at the lateral end of the incision (Fig. 19.24). The lateral gingival flap is then advanced and sutured to the medial flap and palatal flap to provide a watertight and tension-free closure (Fig. 19.17).

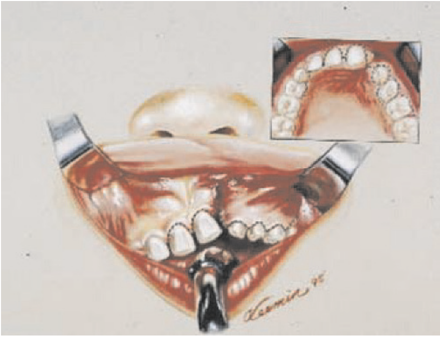

Fig. 19.11 Incisions for the superiorly based gingival flaps are shown by dotted lines. Note the oblique incision line curved upward on the molar region for splitting the attached gingiva. *Inset*: the incision lines on the palatal side (With permission from Noordhoff Craniofacial Foundation)

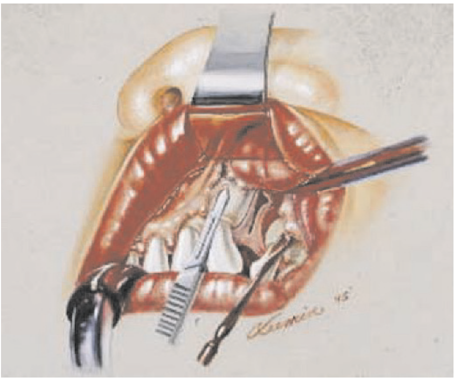

Fig. 19.12 Superiorly based gingival flaps are raised on the labial side with exposure of the cleft margin (With permission from Noordhoff Craniofacial Foundation)

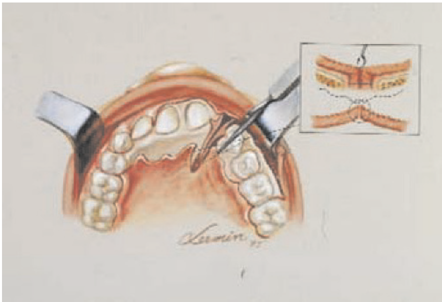

Fig. 19.13 Palatal flaps are raised to a level beyond the deepest margin of the buccoalveolar fistula. This procedure can separate the nasal floor tissue from the palatal mucoperiosteum thus completely expose the bony cleft. *Inset*: The incision lines in the cleft margin is deep toward the nasal side to leave more tissue attached to the palatal flap to facilitate wound closure on the palatal side (With permission from Noordhoff Craniofacial Foundation)

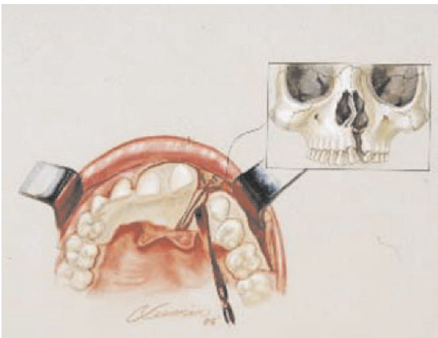

Fig. 19.14 Nasal mucosal flaps are sutured for nasal floor reconstruction up to the level matched to the non-cleft side. *Inset*: Dissection of the nasal floor upward to facilitate wound closure without excessive tension (With permission from Noordhoff Craniofacial Foundation)

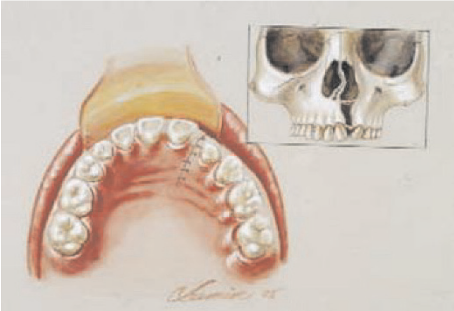

Fig. 19.15 The margins of the palatal flaps are freshened and sutured. *Inset*: Complete closure of the nasal floor and palatal tissue leaving a pocket in the cleft region (With permission from Noordhoff Craniofacial Foundation)

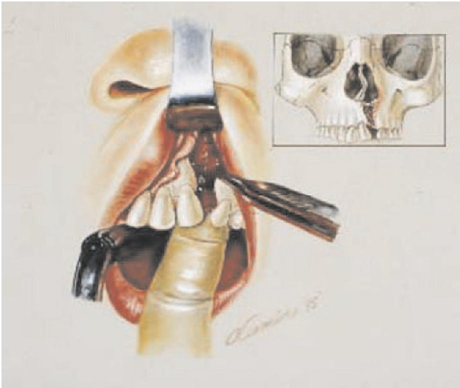

Fig. 19.16 Cancellous bone chips from iliac crest are packed into the bony defect and the cleft side pyriform aperture. *Inset*: Bone chips are packed into the pocket to an adequate level (With permission from Noordhoff Craniofacial Foundation)

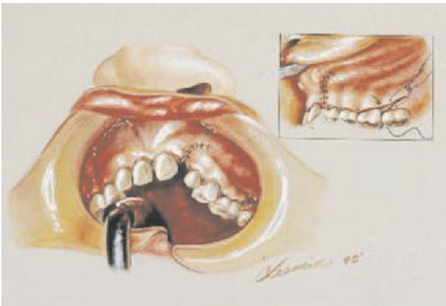

Fig. 19.17 Closure of labial incisions after advancement of lateral gingival flap (with scoring of the periosteum). The gingival flap is sliding along the oblique incision above the molar thus the alveolar margin is covered by gingival tissue instead of buccal mucosa. *Inset*: There is no raw surface in lateral part of the maxilla (With permission from Noordhoff Craniofacial Foundation)

19.9 Operative Techniques for Bilateral Clefts

The technical difference between the unilateral clefts and bilateral clefts is the dissection on the premaxilla. The mucoperiosteum on the premaxilla is dissected for only 2 mm inside the cleft margin and leaves most of the tissue attached to the bone. The palatal mucoperiosteum on the premaxilla is also left intact except for a small portion along the cleft margin. The attached mucoperiosteum on the labial side of the premaxilla can maintain a better blood supply to the premaxilla and the palatal mucoperiosteum on the premaxilla. The author's preference is to do a one-stage bone grafting procedure on both sides unless the size of the premaxilla is too small, e.g. in the presence of a median facial dysplasia. It is much easier to repair the nasal floor in a one-stage procedure, as the premaxilla is still mobile and the soft tissue re-distribution is much better. The techniques of bone grafting in bilateral clefts are shown in Figs. 19.18 – 19.25.

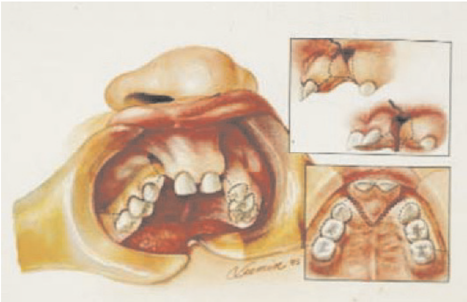

Fig. 19.18 The buccal incision lines in bilateral clefts. *Upper inset*: The trident incision lines on the cleft margins in both the premaxilla and lateral maxillary segments. *Lower inset*: Incision lines on the palatal side (With permission from Noordhoff Craniofacial Foundation)

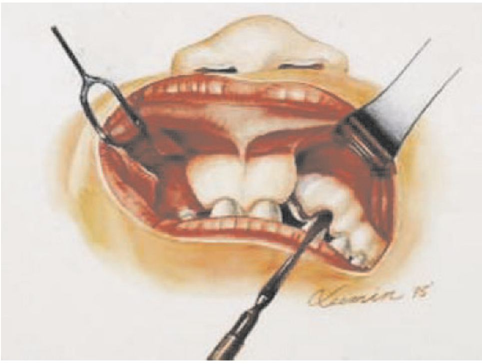

Fig. 19.19 Elevation of the superiorly based gingival flaps on the lateral maxillary segments (With permission from Noordhoff Craniofacial Foundation)

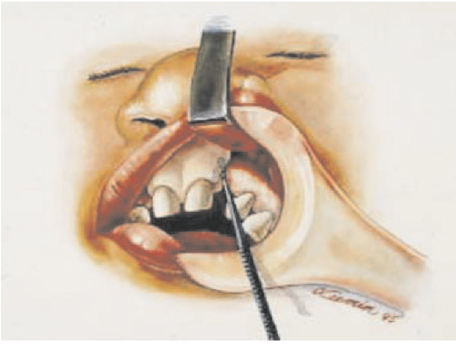

Fig. 19.20 Limited dissection of the gingiva (less than 2 mm) along the wound margins on premaxilla to ensure the blood supply to the soft tissue on the palatal side (With permission from Noordhoff Craniofacial Foundation)

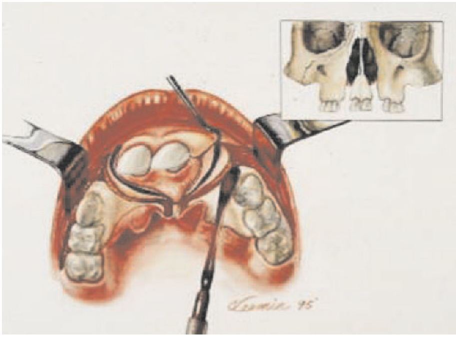

Fig. 19.21 After raising the palatal flaps, the nasal floor mucosa can be completely separated from the palatal tissue. The soft tissue of the premaxilla on the palatal side is also undermined in a limited extent. *Inset*: Dissection of the nasal mucosa to an adequate level can facilitate wound closure without tension (With permission from Noordhoff Craniofacial Foundation)

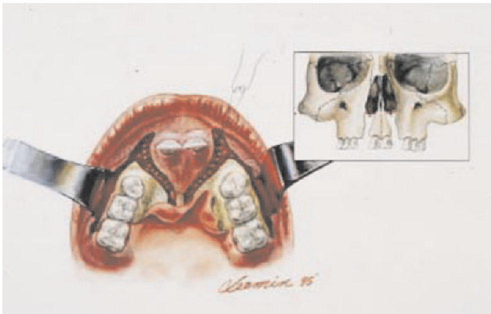

Fig. 19.22 Closure of the nasal floor tissue to an adequate level. *Inset*: Complete wound closure in nasal floor (With permission from Noordhoff Craniofacial Foundation)

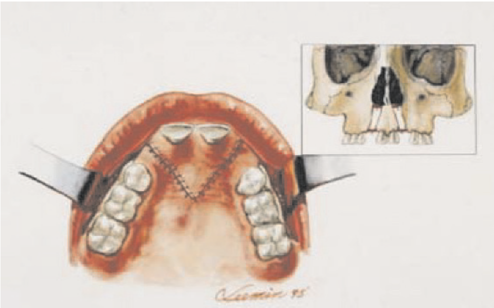

Fig. 19.23 Suturing of the palatal flaps to the premaxilla. *Inset*: Complete closure of the nasal floor and palatal tissue leaving a pocket in the cleft region (With permission from Noordhoff Craniofacial Foundation)

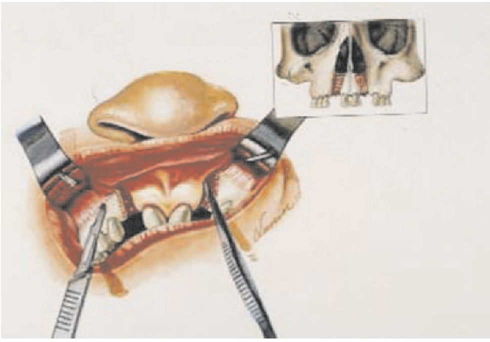

Fig. 19.24 Scoring of the periosteum of the superiorly based gingival flap (shown on the left side of the figure with a blade) and packing of the bone chips into the cleft (shown on the right side of the figure). *Inset*: Packing the bone chips to an adequate height (With permission from Noordhoff Craniofacial Foundation)

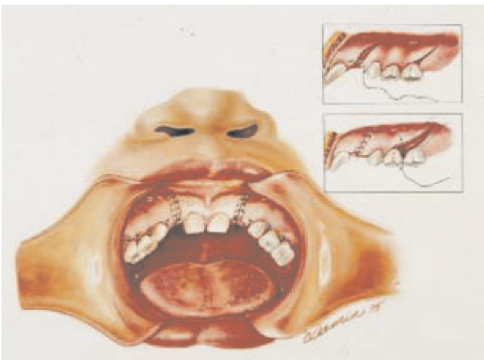

Fig. 19.25 Complete closure of the wounds. *Upper inset*: Water tight closure at the cleft site with sutures passing through the gingival flap, the premaxilla and the palatal flaps. *Lower inset*: Advancing the gingival flap along the oblique incision line on the molar region to maintain the attached gingiva in this region (With permission from Noordhoff Craniofacial Foundation)

19.10 Post-operative Care

Peri-operative antibiotic coverage is given with broad-spectrum parenteral antibiotics. The patient is instructed to start oral hygiene care using a waterpik or toothbrush soon after they return to the ward. Analgesics (codeine phosphate 0.5 mg/kg/dose, QID for two days) are routinely prescribed to reduce discomfort at the donor site. Most patients are discharged on the second post-operative day and kept on oral antibiotics for a further five days.

19.11 Evaluation of Results

All patients were seen by both surgeon and orthodontist during the post-operative follow-up. Panoramic and occlusal X-rays were taken at one week, 6 months and one year after surgery. The results of bone grafting were evaluated on the basis of:

(1) The marginal bone levels and morphology of bone in the grafted area. The height of the inter-dental septum was related to the length of adjacent tooth roots and divided into three types according to Abyholm et al. [20] (Table 19.1). Although dental computed tomography is more popular in modern practice, the traditional occlusal and panoramic X-rays remain the best tool for evaluation of the results.

(2) Eruption and migration of teeth into the grafted area.

(3) Closure of the alveolar oronasal fistula.

(4) The gingival height and nostril floor fullness.

Table 19.1 Classification of bone graft results according to dental X-ray measurements (the interdental septum height or marginal bone level)

Type I	Approximately normal
Type II	At least 3/4 of normal
Type III	Bony bridge less than 3/4 of normal
Failure	No bony bridge across the cleft

* According to (Abyholm et al., 1981) [20]

19.12 Results

Among the 97 patients receiving an alveolar bone grafting procedure from 1991 to 1999 by the author, 71 were unilateral clefts, and 26 bilateral. Their age varied from 8 to 28 years. Their follow-up varied from 13 months to 8 years.

19.12.1 Dental X-ray Measurements

Among the 71 unilateral cleft lip and palate patients receiving alveolar bone grafting, 68 (95.8%) had a result rated as type I. Two patients (2.8%) were rated as type II and one patient as type III (1.4%). The success rate in terms of dental X-ray evaluation was 98.6% in this study as both types I and II were evaluated as a success according to Abyholm's classification. Among the 26 bilateral clefts (52 sites), 4 were rated as type I (7.1%), 42 as type II (82.2%), 5 as type III (8.9%) and 1 as failure (1.8%).

19.12.2 Canine Eruption

Among the 123 sites of alveolar bone grafting, 84 sites (67.9%) already had erupted canines on the cleft side before the bone grafting procedure. In these patients, the purpose of the bone graft was to close the oronasal fistula, increase support to the teeth adjacent to the cleft, help orthodontic movement of the teeth into the grafted area, and improve nasal esthetics. The high eruption rate in this series is due to the late timing of alveolar bone grafting in the author's center in the early 1990s. The canine had not erupted in 39 sites (32%) by the time of the alveolar bone graft. Thirty of them (25%) had canine eruption through the grafted area several months after surgery. In 9 sites (7%), the canine teeth had not erupted one year after the procedure.

19.12.3 Fistulae Closure

Sixty nine patients with unilateral clefts (97.2%) and 45 sites in bilateral clefts (86.7%) had their buccoalveolar oronasal fistulae successfully closed. No fluid leakage to the nasal cavity was reported following the operation.

19.12.4 Nasal Esthetics

Among the 71 unilateral clefts, three patients (2.8%) had a persistent discrepancy in the nostril sill after surgery. All other patients had a balanced nostril sill after bone grafting. The alar base or alar-facial groove on the cleft side frequently bulged excessively in the immediate post-operative period, but this bulging gradually resolved within 6 months in most patients. Three patients with bilateral clefts (11.5%) had persistent asymmetry in their nasal floor after bone grafting.

19.12.5 Gingival Height

The height of the attached gingiva on the grafted area was evaluated by the orthodontist. Six patients among the 71 unilateral clefts (8.4%) and 2 sites in bilateral clefts (3.6%) lost their attached gingival height on the grafted area. The vestibule became shallow and part of the alveolar process was covered by buccal mucosa instead of attached gingival tissue in these two patients.

19.13 Complications

Some minor complications were encountered, especially in older patients. Minor bone graft exposure was noted in 6 cases with unilateral clefts (8.4%) and 11 sites in bilateral clefts (21.4%), all of which healed with conservative treatment. One unilateral cleft (1.4%) and 6 sites in bilateral clefts (11.5%) had wound infection with major dehiscence and bone graft exposure. They were treated in a conservative way and healed eventually but with some unsatisfactory results.

Examples of the results of bone grafting are shown in Figs. 19.26 – 19.37.

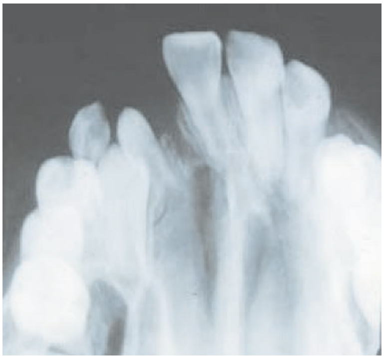

Fig. 19.26 A 10 years old boy with right side cleft lip and palate. The occlusal X-ray before the bone grafting procedure shows the bony cleft

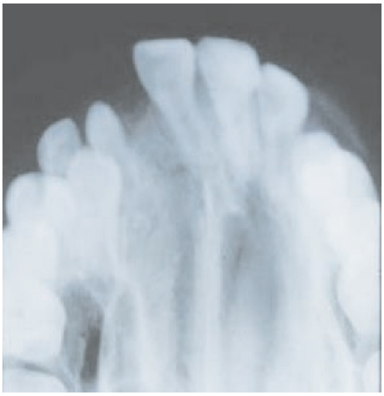

Fig. 19.27 Immediate after the alveolar bone grafting. X-rays shows well packed bone graft

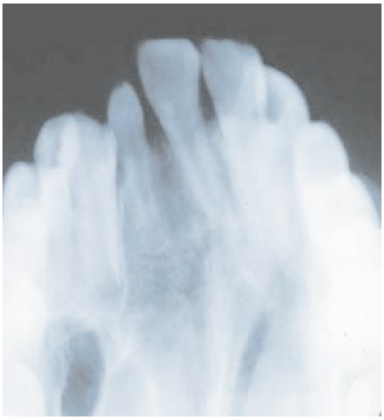

Fig. 19.28 One year after the alveolar bone grafting. X-rays shows good maintenance of the bone graft

Fig. 19.29 A very wide alveolar cleft in an adult. The cleft side central incisor is already lost

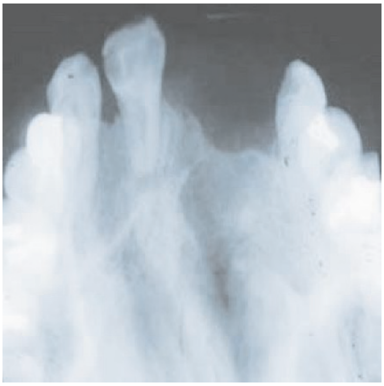

Fig. 19.30 Occlusal X-ray one year after the bone grafting. The bone graft is well maintained

Fig. 19.31 A 9 years old girl with bilateral alveolar clefts

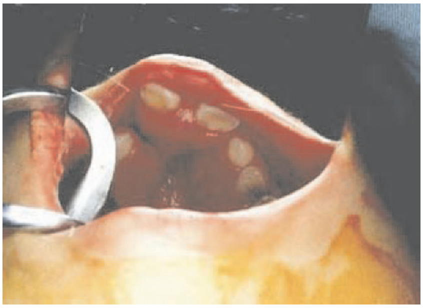

Fig. 19.32 Palatal side of the same patient showing the mobile premaxilla with wide alveolar clefts on both sides

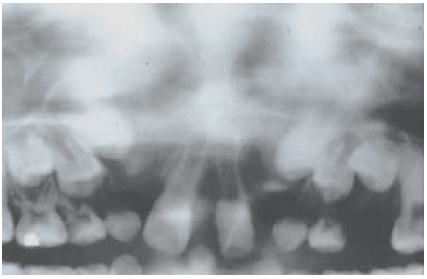

Fig. 19.33 Panoramic X-ray shows the bony defects on both sides

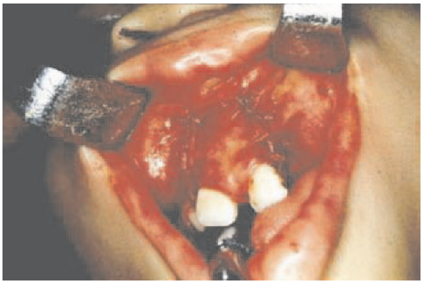

Fig. 19.34 Immediately after the bone grafting. The soft tissue is completely closed

Fig. 19.35 Complete soft tissue closure on the palatal side

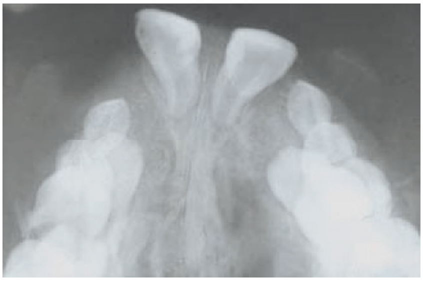

Fig. 19.36 Occlusal X-ray immediately after the bone grafting showing well-packed bone graft

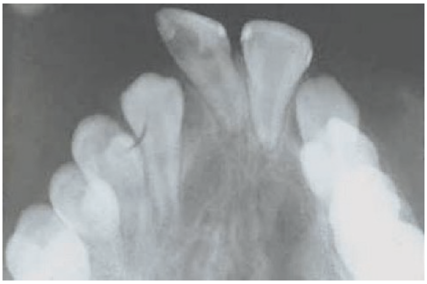

Fig. 19.37 Occlusal X-ray one year after the bone grafting procedure shows the bone graft is well maintained

19.14 Discussion

Autologous bone graft of an alveolar cleft area has following advantages: 1) assistance in the closure of buccoalveolar oronasal fistula, 2) provision of bony support for unerupted teeth and teeth adjacent to the cleft, 3) formation of a continuous alveolar ridge to facilitate orthodontic correction of malocclusion, 4) supporting the nostril floor and alar base to improve nasal esthetics. Autologous bone grafting has been accepted in most craniofacial centers as a routine procedure in cleft lip and palate rehabilitation

Timing is an important factor to achieve a good result. While there is a general consensus that early bone grafting may result in severe facial growth disturbance, other reports have shown that the success rate decreases in older patients. The best timing for alveolar bone grafting is dependent on the timing of tooth eruption in the cleft area, i.e. the central incisor or the canine. Alveolar bone grafting performed in patients older than 16 years gives less optimal results. This is probably because the general health of the oral tissue deteriorates with age. Older patients had a higher risk of wound infection and dehiscence which probably represented a less satisfactory healing process and lesser tolerance to infection. On the other hand, minor dehiscence or gingivitis was sometimes encountered in younger patients, but all healed successfully after conservative treatment. Optimizing oral hygiene before bone grafting, especially in the older patient, is extremely important in contributing to the success of the procedure: post-operative oral hygiene is also important. Gingivitis was frequently observed in patients who did not brush their operative wound during the first week following surgery.

Flap design is another important issue. Although raising a superiorly based gingival flap on the lesser segment is more extensive compared with a local rotational mucosal flap, it is very important to use a gingival flap and palatal flaps to cover the bone graft [20, 22, 23, 26]. The gingival tissue is histologically different from the buccal mucosa (detailed above). The gingival tissue can better tolerate masticatory force and has less bone graft resorption after operation. By splitting the gingiva in a curvilinear fashion in the molar region, one can advance the gingival flap into the cleft for easy cleft closure and still maintain some attached gingiva on the posterior part of the segment. Other methods usually make a vertical back-cut in the posterior part of the flap. This will often leave a raw surface on the alveolus of the molar teeth which will heal under less optimal conditions.

Another important step for obtaining a good result is the extent of the palatal flaps. Abyholm and Bergland suggested raising the palatal flap along the cleft margin and around the gingival margins for just one tooth on each side of the cleft to ensure blood supply to the graft. Lilja preferred a wide exposure of the cleft on the palatal side. The author's preference is to raise the palatal flap in a wide fashion. Raising the palatal flap can help to separate the nasal floor tissue from the palatal tissue to which it is tethered in the cleft. The nasal floor tissue can be stripped away from the cleft area after complete separation from the palate and can then be pushed upwards to a normal level as in the non-cleft side. The bony cleft can be well exposed in this technique and the bone graft volume needed to fill the gap is markedly increased. This might be an important factor in contributing to a good result as the depth of the bone graft is markedly increased. Another important point of the procedure is the extensive dissection of the nasal floor tissue, which allows an adequate correction of the vertical discrepancy of the nostril floor, thus giving significant improvement in nasal esthetics.

19.15 Summary

In summary, alveolar bone grafting is a routine procedure in cleft lip and palate rehabilitation. A satisfactory result can be achieved by optimizing pre-operative preparation, patient selection, surgical technique and post-operative care.

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