Palatoplasty: Evolution and Controversies

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Treatment of cleft palate has evolved over a long period of time. Various techniques of cleft palate repair that are practiced today are the results of principles learned through many years of modifications. The challenge in the art of modern palatoplasty is no longer successful closure of the cleft palate but an optimal speech outcome without compromising maxillofacial growth. Throughout these periods of evolution in the treatment of cleft palate, the effectiveness of various treatment protocols has been challenged by controversies concerning speech and maxillofacial growth. This article reviews the history of cleft palate surgery from its humble beginnings to modern-day palatoplasty, and describes various palatoplasty techniques and commonly used modifications. Current controversial issues on the timing of cleft palate repair, and the effects on speech and maxillofacial growth are also discussed. *(Chang Gung Med J 2008;31:335-45)*

Key words: history, palatoplasty, techniques, controversies

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The history of treatment of cleft palate deformities can be traced back many centuries. The variety of techniques used in palatoplasty has grown considerably from ancient times to the new millennium. Since the beginning of the 20th century, the treatment objective in palatoplasty has not only been simple closure of the soft and hard palate but also improvement in speech and avoidance of abnormal maxillofacial growth after repair. Today, the surgical management and outcome evaluation of cleft palate deformities have become a complex and intricate art. This article reviews the history of palatoplasty, principles learned through many years of modifications in surgical technique, and present day controversies.

HISTORICAL PERSPECTIVE

From ancient times to the renaissance period

The condition called cleft lip and palate has been known for a long time but without any indispensable therapeutic solution. Isolated archaeological evidence from the ancient Schönwerda and Peruvian civilizations have described persons with untreated cleft deformities who lived until they were adults.[1] Although the early Egyptians, Mesopotamians, Indians, Greeks and Romans were pioneers in their respective medical and surgical fields. No descriptions of cleft operations were recorded.[2] For many centuries, cleft palates were

often confused with a more common condition caused by tertiary syphilis and this deformity was not addressed surgically because of this association.

The earliest recorded operative treatment in a cleft patient appeared in ancient China during the Chin dynasty, in the 4th century AD. At that time, only repair of a cleft lip was described with no mention of cleft palate repair.[3] In the 13th century, a Flemish surgeon named Jehan Yupperman was the first to describe in detail the repair of a cleft lip, but made no mention of cleft palate. He noticed that the hypernasal speech of untreated cleft patients could be corrected by plugging the palatal defects with cotton, or plates of silver or lead.[4]

For many centuries, the only method used to close palatal fistulae was the application of an obturator. It was Ambroise Paré in 1564 who first used the term 'obturateur' to describe the plates of gold and silver used to occlude palatal clefts. In ancient times, the operative treatment for cleft palate was not only technically demanding but also painful due to the absence of anesthesia. The advent of chloroform anesthesia permitted a quantum leap in cleft surgery and thus allowed the first known cleft palate surgery to be performed in the early 19th century.[4,5]

The period of growth
A French dentist, Le Monnier, performed the first surgical repair of a cleft velum in 1764.[6] He described a three-stage operation in which he approximated the cleft edges with sutures, cauterized the cleft edges and realigned the fresh edges. Carl Ferdinand von Graefe in 1816 and Philibert Roux in 1819 reported the first successful repairs of the soft palate.[7,8] The first successful closure of the soft palate in America was performed by John Collins Warren in 1820.[4] The progress of palatal surgery has evolved from repair of the velum or uvula (staphylorrhaphy) to morphological closure of the soft and hard palate (palatoplasty). In 1828, Johann Friedrich Dieffenbach improved the surgical treatment of cleft palate by elevating the mucosa on the hard palatal to close the palatal cleft. He even employed lateral osteotomies to aid closure of the cleft palate.[9] Further developments in technique by Bernhard von Langenbeck in 1859,[10] Victor Veau in 1931,[11] Thomas Kilner in 1937 and William EM Wardill in 1937[12] led to palatal closure by advancement of bipedicled mucoperiosteal flaps medially, which has

been considered the surgical standard up to the present time. The improved vascular supply of the mucoperiosteal flaps significantly reduced the incidence of dehiscence following palatoplasty.

The eve of the 19th century witnessed great evolution in the technique of palatoplasty, allowing successful closure of a cleft palate and optimal outcomes. Refinements in the basic principles of repair and greater attention to the details of anatomy and function marked the beginning of modern cleft palate treatment. The surgical techniques of modern palatoplasty address the concerns of speech development and midfacial skeletal growth. Although developments in cleft palate surgery are centuries old, some are still in use today.

TECHNIQUES OF PALATOPLASTY AND THEIR MODIFICATIONS

Von Langenbeck palatoplasty
A simple palatal closure introduced by von Langenbeck in 1859 is possibly the oldest palatoplasty still widely used today.[10] The von Langenbeck palatoplasty is commonly used for an incomplete cleft of the secondary palate without the presence of a cleft lip and alveolus.[13] This technique closes the incomplete cleft of the hard and soft palates without lengthening the palate by mobilizing bipedicled mucoperiosteal flaps medially. The cleft margins can be approximated with a lateral relaxing incision that begins posterior to the maxillary tuberosity and follows the posterior portion of the alveolar ridge (Fig. 1). Modifications of the von Langenbeck technique include repair of the levator palatini muscle and intravelar veloplasty to reproduce the normal muscle sling. Von Langenbeck repair can also be used in combination with a Furlow double opposing Z-palatoplasty to increase palatal length with minimal mucoperiosteal undermining.[14]

Veau-Wardill-Kilner or VY pushback palatoplasty
Velopharyngeal incompetence is relatively common following palatoplasty either because there is insufficient mobility of the soft palate or because the length of the repaired palate is inadequate to reach the posterior pharyngeal wall. To increase the anteroposterior length of the palate at the time of primary palatoplasty, various mucoperiosteal flap maneuvers
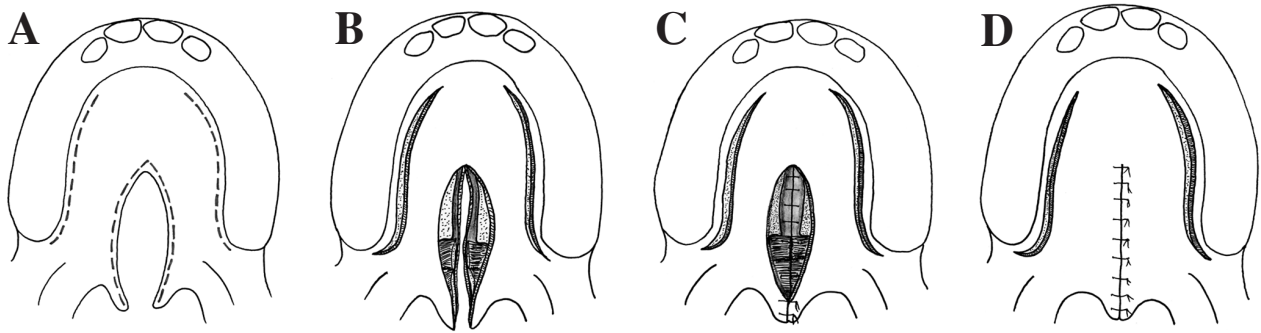
Fig. 1 The von Langenbeck palatoplasty. (A) Markings for the flap design. (B) Bipedicled mucoperiosteal flaps elevated from lateral relaxing incisions to the cleft margins. (C) Closure of the nasal mucoperiosteal layer. (D) Completion of oral mucoperiosteal flap closure.

in the hard palate have been described in the literature.[15,16]

Veau-Wardill-Kilner or V-Y pushback palatoplasty is derived from a modification of the von Langenbeck technique. It can be used to increase the palatal length. The Veau-Wardill-Kilner pushback palatoplasty can be suitably used for incomplete clefts of the hard palate. The flap design is similar to the von Langenbeck palatoplasty. The essence of this technique is the V to Y incision and closure on the hard palate (Fig. 2). The pushback technique has the advantage of lengthening the palate and repositioning the levator muscle in a more favorable position. However, this modification involves extensive dissection. The superior pedicle is divided leaving the mucoperiosteal flap on either side of the cleft based on the greater palatine pedicle posteriorly. At the free anterior end, the mucoperiosteal flaps can then be approximated directly or in a V-Y closure to lengthen

the soft palate. This modification allows more flap advancement than the von Langenbeck technique and enables posterior lengthening of the palate, thus improving velopharyngeal competence. The Wardill-Kilner pushback palatoplasty offers significant long-term improvement in speech in terms of nasality and nasalance score.[17]

The pushback palatoplasty has several disadvantages. The denuded palatal bone from which the mucoperiosteal flaps are raised adversely affects midfacial growth in cleft palate patients.[14,18,19] This technique also has a higher rate of fistula in complete cleft palate than other techniques because it provides only a single nasal mucosa layer anteriorly.[20]

Two-flap palatoplasty

Janusz Bardach in Poland first described the two-flap palatoplasty in 1967. The original Bardach two-flap palatoplasty can only be used to close rela-
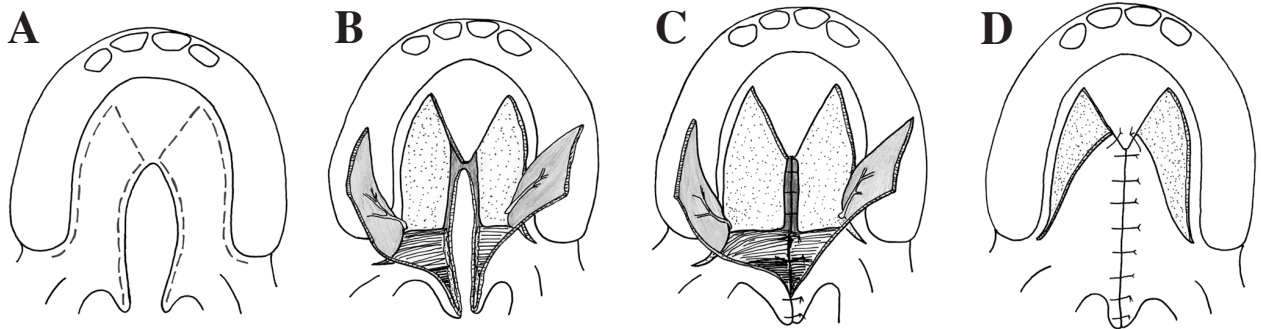
Fig. 2 Veau-Wardill-Kilner or VY pushback palatoplasty. (A) Markings for the incisions. (B) Oral mucoperiosteal flaps raised with preservation of the greater palatine vessels on both sides. (C) Retroposition and repair of the levator veli palatini muscles (intravelar veloplasty) after completion of nasal mucoperiosteal repair. (D) Final appearance after closure of the oral mucoperiosteal flaps.

tively narrow clefts by releasing mucoperiosteal flaps from the cleft margins. Later some modifications of this technique involved more extensive dissection and extension of the relaxing incisions along the alveolar margins to the cleft edge to provide tension free closure (Fig. 3). The design of this flap is entirely dependent on the greater palatine neurovascular pedicle and it provides greater versatility to cover the cleft.[21]

In a complete unilateral cleft, the mucoperiosteal flap from the medial segment can be shifted across the cleft and closed directly behind the alveolar margin. The fistula in the anterior hard palate can be virtually eliminated by this technique.[22] Two-flap palatoplasty also has a minimal effect on subsequent maxillofacial growth due to the limited area of bone denudation on the hard palate when the mucoperiosteal flaps are elevated.[23,24] The limitation of this technique is that it does not provide additional length to the repaired palate to allow normal speech production. A variation from the standard technique of two-flap palatoplasty has been reported using supraperiosteal flaps instead of the mucoperiosteal technique for palatal closure.[25] Although this new approach improves speech outcome, it still requires further evaluation in a larger series to ascertain its applications. Nevertheless, the goal of palatal lengthening in palatoplasty is still considered essential to reduce the space in the posterior pharyngeal wall. Presently, widely accepted methods to reduce velopharyngeal insufficiency include retropositioning and reorientation of the velar muscles by performing either an intravelar velopasty or Furlow double opposing Z-palatoplasty.[14,26,27]

The challenges in the repair of a bilateral wide cleft palate are to reduce the incidence of wound dehiscence and minimize the amount of denuded palate after palatal repair. Further innovation using a combination of bilateral buccal flaps in conjunction with a modified Furlow double opposing Z-palatoplasty to cover the denuded areas on the posterior hard palate has been reported.[28] This technique has proven useful in gaining palatal length in wide cleft palates and it provides better tissue coverage for the denuded palate than previous methods, such as palatal island flap.[29]
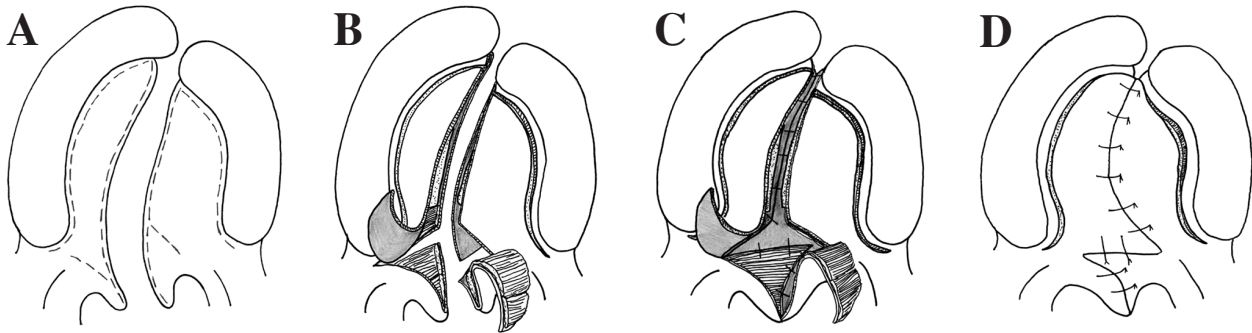
Furlow double opposing Z-palatoplasty

In 1978, Leonard T. Furlow Jr. unofficially introduced the double opposing Z-palatoplasty and much of his work was later published in 1986.[30] This technique involves alternating the reversing Z-plasties of the nasal and oral flaps and repositioning the levator veli palatini muscle within the posteriorly mobilized flaps (Fig. 4). With this technique, there is no need to raise large mucoperiosteal flaps from the hard palate. At the same time, the soft palate can be lengthened within the substance of the soft palate together with palatal muscle reorientation. This technique has shown early success in both speech outcomes and midfacial skeletal growth.[30-34] Furlow Z-palatoplasty is effective for primary closure of a submucous cleft palate and secondary correction of marginal velopharyngeal insufficiency.[35,36]

Palatal closure in Furlow Z-palatoplasty is not anatomic and completely ignores the small longitudinal uvula muscle, but overall speech results are comparable to or better than those with other tech-
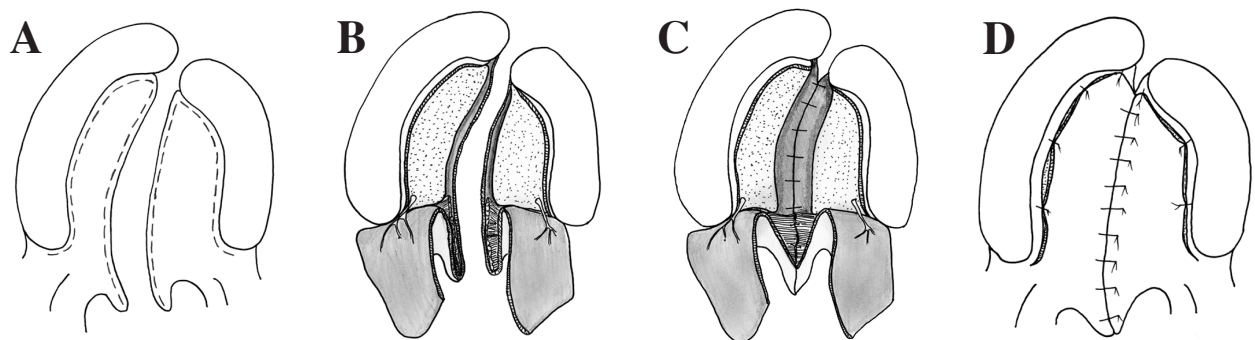
Fig. 3 Two-flap palatoplasty. (A) Markings for the flap design. (B) Elevation of two mucoperiosteal flaps from the oral surface. The greater palatine vessels on both sides are preserved. (C) Retroposition and repair of the levator veli palatini muscles (intravelar veloplasty) after completion of the nasal mucoperiosteal repair. (D) Final closure of the oral mucoperiosteal flap.

Fig. 4 Furlow double opposing Z-palatoplasty. (A) Markings for the Z-plasty and relaxing incisions. In a wide cleft palate, the relaxing incisions are made anteriorly to the cleft margin as a two-flap palatopalasty. (B) Elevation of the oral flaps. The oral layer consists of a musculomucosal flap on the left side and only a mucosal flap on the right side. The muscle is raised as a posteriorly based flap. Similarly, the incisions are marked in a reverse fashion for the nasal layer. (C) The nasal musculomucosal flap on the right side is transposed across the cleft. (D) Final appearance of the oral layer closed by Z-plasty.

niques.[31,37] Problems may be encountered when this technique is used to close a very wide cleft palate, in which the distance traversed by the Z-plasty may be excessive. Modification of this technique to overcome excessive tension during closure involves extension of the relaxing incisions anteriorly to the cleft margin to create an island flap based on the palatine vessels. This maneuver provides greater mobility and shifts the closure to the side of the posteriorly based flap.[31,38] Other ancillary procedures for tension free closure in a wide cleft palate include a combination of Furlow Z-palatoplasty with any of the following maneuvers: hard palate mucoperiosteal undermining, careful dissection into the space of Ernst, infracture of the hamulus or stretching of the greater palatine neurovascular bundles.[32] One unanswered question is whether the procedure of hamulus fracture that was once popularized by Billroth has a theoretical advantage in displacing the attachment of the tensor veli palatini from the hamulus process and facilitating tension free closure during palatoplasty.[39] Tension reduction seems advantageous in terms of outcome. However, studies have confirmed that this additional maneuver is unnecessary and does not confer any benefits to speech, hearing or maxillofacial growth outcomes.[40-42]

Intravelar veloplasty

The levator muscle repositioning procedure or intravelar veloplasty during palatoplasty is the most widely practiced method to achieve velopharyngeal competence. In the early 20th century, Victor Veau first described the 'cleft muscles' and advocated the concept of midline levator palatini muscle re-approximation.[11] He emphasized the importance of an encircling suture to pull the levator muscle bundles together, side to side.[14] A new generation of cleft surgeons focused on the anatomy and physiology of the velopharyngeal sphincter.

Braithwaite and Kriens further improved this technique.[43,44] They emphasized careful dissection of abnormally positioned levator muscles and the need to free the levator palatini from the posterior edge of the hard palate to restore the levator sling and allow tension free closure in the midline. The operation is technically challenging, and there is great variability in the degree of muscle dissection and overlap across the midline. Hence, results vary among the surgeons.

A controlled, prospective study conducted by Marsh et al found no difference between intravelar veloplasty and the traditional side to side technique on velopharyngeal incompetence, after repeated assessment over several years.[45] Others, however, have found more radical levator muscle dissection and overlapping in cleft palate patients offer better functional results for velopharyngeal competence and otological function. In a prospective cohort study conducted by Hassan et al, a comparison of three-layer palatoplasty (Kriens technique) with intravelar veloplasty versus two-layer palatoplasty (Wardill-Kilner) pushback palatoplasty without intravelar veloplasty has shown that palatal muscle reconstruction in cleft patients offers better velopharyngeal competence and eustachian tube function.[46] Both

Cutting and Sommerlad proposed the technique of radical intravelar veloplasty,[47,48] which involves division of the tensor palatini tendon, and repositioning the muscle at the hamulus with extensive dissection of the levator muscles from both the oral and nasal mucosa. The tensor tendon is released just medial to the hamulus, and the levator muscle may be overlapped to provide appropriate tension for closure. This technique results in an excellent speech outcome. In a different approach to intravelar veloplasty, Sommerlad has adopted a technique for radical retropositioning of the velar musculature and tensor tenotomy using an operating microscope to allow accurate levator muscle reconstruction. His experience with this technique resulted in a significant decrease in secondary velopharyngeal rates for successive 5-year periods from 10.2% to 4.9% to 4.6%.[49]

Vomer flaps

In 1926, Pichler introduced the use of a vomer mucoperiosteal flap for palatal closure.[50] The original vomer flap was inferiorly based. It was raised by an incision made high on the nasal septum and reflected downward to provide a single-layer closure on the oral side. This flap has a high incidence of maxillary retrusion, presumably from injury from vomer-premaxillary sutures, and a high fistula rate.[51-53] However, similar problems have not been commonly found in a superiorly based vomer flap. This technique involves reflecting the mucosa from the septum close to the cleft margin with limited dissection to allow adequate closure of the nasal mucosa on the opposite site.

In a bilateral complete cleft palate, a midline incision along the free margin of vomer is required to create two septal-mucosal flaps in opposite directions. These two flaps are used to bridge the gap between the free edges of the nasal mucosa. The two-flap palatoplasty combined with a vomer flap results in a four-flap palatoplasty that can be applied for simultaneous closure of the nasal and oral defects in the cleft palate. This technique results in a two-layer closure with a low fistula rate and less maxillary growth retardation. The long-term effect of this technique on facial growth is minimal.[20,54,55]

Two-stage palatoplasty

One of the greatest challenges in treated cleft patients is late midface retrusion. Many studies have revealed that patients with unrepaired clefts have normal skeletal cephalometric relationships compared with those with repaired clefts.[56-58] The effect of midface retrusion may be influenced by excessive scar tension in the anterior-posterior vector which retards normal midface growth.[59] On the contrary, there are also reports suggesting that intrinsic tissue deficiency is a factor for maxillary hypoplasia in cleft patients.[60,61] It is probable that a true tissue deficiency exists in some cleft patients. Thus, it seems logical that the timing and technique of palatoplasty should be determined individually, balancing the requirements necessary to achieve the goals of optimizing speech and maxillofacial growth.

The problem with maxillary growth has led some surgeons to advocate a two-stage approach to palatoplasty with different protocols aimed at early repair of the soft palate, followed by delayed repair of the hard palate. Schweckendiek introduced a protocol for two-stage palatoplasty for early closure of the soft palate and delayed closure of the hard palate to allow normal maxillary development.[62] He entailed soft palate repair at the same time as cleft lip repair around the age of 4-6 months. During this period, the hard palate could be occluded with a prosthetic plate followed by delayed hard palate repair at the age of 12-15 years. He postulated that this method would allow normal speech and normal maxilla growth. A similar approach was also practiced by Rohrich et al, advocating an early two-stage repair of the palate that results in complete closure of the cleft by 15-18 months of age.[63] Perko further modified the two-stage palatoplasty protocol to repair the soft palate at the age of 18 months and delayed palatal closure at 5-6 years. It was reported that despite delayed closure of the hard palate, speech development was not affected to a relevant degree.[64]

Primary pharyngeal flap

Surgical repair of a wide cleft palate has proven to be a formidable task for surgeons. Attempts to close wide clefts with these techniques may place the palatal tissue under great tension and result in a high incidence of postoperative oronasal fistula formation. To ensure tension free closure for a wide cleft palate, immediate placement of a posterior pharyngeal flap during primary palatoplasty has been advocated in

the literature for many years.[65-68]

Bengt Johanson[69] first described an elongated pharyngeal flap for extremely wide cleft palate closure, and Bumsted[66] subsequently applied this method in four patients. A 3 cm wide flap from the posterior pharyngeal wall at the level of the cricoid cartilage was raised and extended cranially to cover the palatal defect. Bumsted performed a two-layer closure by turning over the nasal mucoperiosteal flaps on the cleft margin to facilitate closure of the defect in the oral side along with the raised oral mucoperiosteal flaps. He was successful in 75% of his repairs and had one postoperative fistula. Holmstrom et al. performed the procedure on 11 patients with wide clefts who were obturator dependent using a Wardill-Kilner palatoplasty in combination with pharyngeal flap.[67] None of their patients required additional surgery. However, 2 patients developed fistulas postoperatively. A primary pharyngeal flap with a two-flap palatoplasty is often required to close un-repaired cleft palates in adults, as it is frequently associated with palatal tissue hypoplasia and a wide cleft. Nevertheless, the effects of the pharyngeal flap in the treatment of velopharyngeal insufficiency remain uncertain.

CONTROVERSIES

There are still no standard protocols to address the issues of ideal timing for cleft palate repair to attain optimal speech and to avoid abnormal maxillofacial growth after repair.

While there are many controversies on the timing of cleft palate surgery, the current debate concerns how early palatal repair should be performed. The ideal timing of cleft palate closure should depend upon the type of cleft involved, the patient's condition and the capabilities of the cleft team to manage associated morbidities. Because some cleft patients have associated anomalies and syndromes, the timing of palatoplasty should be tailored individually after thorough clinical evaluation.[70] Surgery should be delayed in cleft patients with airway problems or cardiac anomalies because the timing of cleft repair changes with these co-morbidities.[71] In severely disabled children with neuromuscular delay, palatoplasty at an early age may lead to altered airway status and an obstructed upper airway. Infants with profound developmental delay and a projected short life span should have surgical intervention delayed or should undergo palatoplasty only under special circumstances. When a cleft palate is repaired in patients with associated anomalies or syndromes, parents should not be given unreasonable expectations that the surgery will stimulate or allow a severely disabled child to speak. It is critical to explain that palatoplasty may aid speech production but not speech development.

The longstanding controversies on the timing of cleft surgery have led to a variety of timing protocols at different institutions. Proponents of early repair advocate surgery before the age of 12 months to benefit speech development, because the speech process in children begins at 1 year of age.[72-75] Delay in the treatment of palatal closure may cause less maxillofacial growth disturbance but speech development tends to be poor.[76] Most would agree that the best speech outcomes are correlated with closure of the palate near the time of language skill acquisition, which for a normally developing child is before 12 months of age.[77,78] The optimal timing for palatoplasty still remains scientifically unproven. A literature survey showed that surgical techniques and timing of palatal repair have a profound influence on the incidence of velopharyngeal insufficiency following palatoplasty (Table 1).[27,32,49,79] Many confounding variables such as surgical technique, skill of the surgeon, and lack of standardization of speech evaluation, and therapy preclude exact determination of optimal repair.[74]

Conversely, proponents who support the theory that transverse facial growth is not completed until the age of 5 years advocate delayed repair to facilitate proper maxillofacial growth.[6,62-64,80,81] Studies on experimental models have demonstrated that lip repair may restrict sagittal growth of the maxilla, but it seems that the effect from palatoplasty is more significant.[82] Transverse maxillary arch deficiency is a common occurrence in children with repaired cleft palates, and it may require orthodontic treatment. Although some centers prefer to delay palatal repair until a more advanced age to permit maxillofacial growth, it is far more challenging to establish normal speech in older children after palatoplasty than to correct occlusion with a combination of orthodontic treatment and orthognathic surgery.

It has long been recognized that a cleft palate should be repaired before 2 years of age.[83,84] An

Table 1. Influence of Surgical Techniques and Timing for Palatoplasty on Velopharyngeal Insufficiency

Technique	Age at palatoplasty	Incidence of VPI (%) (Secondary Velopharyngeal Surgery)
(Marrinan EM et al)		
von Langenbeck palatoplasty	8 months to > 16 months	14%
VY pushback palatoplasty	8 months to > 16 months	15%
(Salyer KE et al)		
Two flap palatoplasty	before 12 months	8.92%
VY pushback palatoplasty	before 12 months	13%
(D LaRossa et al)		
Furlow Z palatoplasty	10 months	6.5%
(Sommerlad BC)		
Intravelar veloplasty	before 12 months	4.6%

overwhelming number of studies on cleft palate and the timing of palatal closure have concurred with the current trend towards closure before 18 months of age. However, medical centers vary in their approach. A Philadelphia center recommends primary palatoplasty for hard and soft cleft palate by 18 months of age.[14] At the Riley Hospital for Children in Indianapolis, primary palatoplasty in otherwise healthy children is performed in a single stage between 9 and 12 months of age.[74] However, the University of Texas Southwestern Medical Center recommends a two-stage palatoplasty, with soft palate repair at 3 to 6 months of age and hard palate repair at 15 to 18 months of age.[63] Another notable finding in the present literature is the shift to Furlow Z-palatoplasty as the most frequently used procedure for primary palatoplasty as a result of its good outcomes in speech and maxillary growth.[14,30,31,83,84] In the author's craniofacial center, the current treatment protocol is to repair the cleft palate between 6 and 12 months of age. A preferred timing is 6 months of age for patients with isolated cleft palate, and 9 to 10 months for patients with cleft lip and palate. A Bardach-Salyer two-flap palatoplasty and a Furlow Z-palatoplasty are the two favored techniques for primary palate repair in this center.

Conclusion

The art of cleft palate repair has enjoyed considerable development over many years. Although the controversies regarding the timing and closure of a cleft palate seem to have been resolved, with a consensus for surgery being completed at 18 months, there are still many issues which need to be resolved by well-controlled, randomized, prospective clinical trials to ascertain the optimal timing of palatoplasty and its long-term relationships on speech development and maxillofacial growth. Results from these trials will improve the treatment outcomes for patients with cleft palate repair.

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顎裂修補手術：演進及爭論

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　　顎裂的手術治療經過了一段長時間的演進，今日我們所使用的各種手術方法，是經歷很多年不斷地的改變修飾學習得來的。現代的顎裂修補手術，不只是把顎裂成功的縫合而已，並且還要得到良好的語言功能，以及不影響顎顏的成長。在這段顎裂治療的演進過程中，各種不同治療方式的有效性，受到許多有關語言和顎顏發展的爭議嚴苛的挑戰。這篇文章回顧顎裂手術的發展歷史，並且描述幾種常用的顎裂手術方法以及改變，討論目前主要的爭論焦點，也就是顎裂手術的時機、語言結果，和顎顏發展的影響。(長庚醫誌 2008;31:335-45)

關鍵詞：歷史，顎裂手術，技術，爭論