

Pediatric Facial Plastic and Reconstructive Surgery

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Chapter 16: Secondary Management of Hard Tissue Cleft Deformities

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Clefts of the palate or alveolus are associated with deformities in many hard tissue structures besides the local cleft area. Primary surgery usually concerns soft tissue repairs only, without addressing the underlying bony cleft defect. Furthermore, many hard tissue deformities appear or become more pronounced with growth. Maxillary transverse or sagittal hypoplasia is generally not seen in infancy and may be manifested to varying degrees any time between early childhood and the end of skeletal growth. Likewise, although dental anomalies may appear in both the primary and permanent dentitions, dental defects are generally not of concern until eruption of the first permanent anterior teeth. Thus, hard tissue cleft deformities are almost always addressed secondarily.

The timing of these secondary procedures is important and is influenced by several factors. Surgical scars have been shown to restrict growth in a direction perpendicular to the scar. Consequently, the risk of growth restriction must be weighed against the benefits of surgical intervention during growth. Transverse growth of the face continues until approximately age 8, whereas vertical and sagittal growth proceeds through the pubertal growth spurt. Orthognathic surgery is usually not undertaken before cessation of skeletal growth, to prevent return of maxillomandibular discrepancy due to disparity in growth. Psychosocial factors, however, must sometimes prevail where early surgery would aid a child with seriously low self-esteem.

Dental development and eruption are important factors in determining the best time for alveolar bone grafting. A tooth that erupts into a cleft will be lacking in periodontal support. Grafting therefore must be done before involved teeth begin to erupt. Overall dental development may also be an important factor when planning coordinated surgical-orthodontic treatment. Usually, however, skeletal maturity occurs after completion of the permanent dentition (excepting third molars) and is thus the overriding factor.

Alveolar/Palatal Cleft

The first step in planning treatment is evaluation. The general influence of the alveolar cleft on the face should be noted. There is often a deficiency of alar base support on the cleft side, and an alveolar bone graft can be used to add bulk to this area. Soft tissue characteristics surrounding the alveolar/palatal cleft should then be examined. The presence, size, and location of fistulae should be determined. Often the fistulae are not immediately evident at the alveolar ridge level and are hidden by redundant gingiva. Here, a small, blunt probe may be helpful in the examination.

The amount of scarring should also be noted. Heavy scarring will make the soft tissue less elastic and, along with the size of bone defect, may influence flap design for an alveolar bone graft. Tissue across a scar may have compromised blood supply and may not be relied

upon for flaps.

The location and extent of the bony cleft must be determined using radiographs. The maxillary occlusal film is the most useful, although periapical dental films may also be informative. Along with the general location, the exact extent of the bony defect relative to the piriform aperture and to teeth in the area must be determined. Teeth directly adjacent to the cleft may be lacking in bone on the root surface facing the cleft, and this deficiency could lead to periodontal defects that in turn could threaten the vitality of the tooth and, rarely, that of the graft. Finally, segment mobility, especially in bilateral clefts, should be carefully documented in order to plan the placement of grafts. Stability of the host bed will enhance graft take. Mobil segments, when present, can temporarily be stabilized using a prefabricated custom occlusal or palatal splint. Alternatively, a heavy, orthodontic maxillary arch wire can be ligated to the teeth to lend support and stability at the completion of the grafting procedure.

Treatment goals of an alveolar bone graft may include the following:

1. create a continuous maxillary arch;
2. provide bony support for facial soft tissue;
3. close the fistulae;
4. allow for eruption of teeth through the graft;
5. provide bony support for teeth;
6. facilitate orthodontic movement of teeth.

A continuous arch lends stability to the bony maxilla and reduces mobility of the segments, especially in bilateral clefts where the mobility of the premaxilla is often pronounced. The reconstructed maxilla also prevents collapse of the arch segments. The graft provides bony support for the alar base and the upper lip. Therefore, grafting should extend to the piriform rim and the anterior aspect of the floor of the nose. It is also advisable to overpack the cleft site with bone. A free, onlay bone graft has a tendency to resorb unless it is stress loaded and stimulated, as in the case there a tooth erupts or is moved orthodontically through the graft.

Finally, it has been noted that fistula closure without placement of an interpositional bone graft is more likely to fail. Autogenous bone used for an alveolar graft may come from one of many sites. More important than the exact site, however, is the composition of the graft to include both marrow and cancellous bone. The more common sites where graft bone is harvested from are the cranium and anterior iliac crest. Membranous bone from the cranium reported revascularizes faster and has less of a tendency to resorb. Advocates for the cranium as a donor site also claim reduced morbidity as an advantage. However, harvesting of cranial bone graft must be performed sequentially before or after dissection of the cleft site. Anterior iliac crest dissection, on the other hand, can be performed by a second surgical team at the same time the recipient site is being prepared, which therefore reduces operative time.

Furthermore, the anterior iliac crest provides a generous source of particulate marrow and cancellous bone for cleft grafting. This bone is highly cellular, heals rapidly, and is resistant to infection. Patients when ambulating generally favor the donor site side for a short time postoperatively, but usually are able to resume school work within a week of the operation. Rib graft, another common source of bone, is more commonly used for primary grafting. Orthodontic movement of teeth into the graft site may begin in about 8 weeks after grafting with autogenous bone.

Allogeneic and certain synthetic graft material such as porous hydroxyapatite blocks may also be used, and have been found to take well in smaller clefts with good vascular supply. This obviates the need for a donor site in the cleft patient. However, a synthetic graft will not allow tooth movement through its substance, and thus should not be used in patients in whom teeth need to be moved through the graft. Allogeneic bone does allow movement of teeth into and through the graft, provided the cementum or root surface of the teeth is not exposed. Allogeneic bone is slower to heal and is more susceptible to infection and graft loss. The potential for transmission of disease with allogeneic bone must also be considered.

As mentioned earlier, bone grafts must be placed before teeth in the cleft area begin active eruption, with the typical indicator being one-half to two-thirds of root formation, as evidenced on dental radiographs. The patient's age varies with the tooth involved. Since the permanent canine has most often been involved, the optimal age for grafting has been 8 to 10 years of age. At this age, however, the central and in particular the lateral incisor, if present, have already erupted, occasionally into the cleft. As a result, they may lack bony support and are frequently malposed. Therefore, if the cleft is in the area of the lateral or central incisor, the graft should be placed much earlier. A retained deciduous or erupted supernumerary tooth in the cleft site must also be considered when planning a graft. The tooth should first be removed in order to facilitate development of soft tissue flaps, and adequate time should be allowed for mucogingival healing. Usually, this is accomplished 6 to 8 weeks before the graft procedure. If the extraction is done too early, resorption of bone in the socket area may complicate the grafting. Furthermore, eruption of other teeth into the cleft could be stimulated by the loss of the primary tooth.

More recently, there is evidence that early secondary repair of alveolar cleft at age 5 to 6 may provide improved periodontal support of the incisors. As the teeth erupt into the alveolar graft site, they stimulate the alveolus and graft bone, reduce malposition, and bring about a healthy canine eminence and lip support. Patients who have had early secondary repair of their alveopalatal cleft with bone graft do not exhibit a higher incidence of posterior crossbite. This seems to support the theory that lateral growth in the region of the cleft defect is completed at age 5 or 6. What remains is appositional growth, which does not seem to be affected by the repair.

Another subject of ongoing discussion is whether to expand the cleft maxillary arch pre- or postoperatively. Each protocol has its advantages. Expanding the maxilla preoperatively widens the cleft, usually making the grafting easier. Postoperative expansion, however, is said to stimulate the bone graft, which enhances graft survival.

Success of alveolar cleft repair is based on careful planning and development of labial, nasal, and palatal flaps to provide tight closure without tension after placement of particulate

marrow cancellous bone chips. A local anesthetic with 1:100,000 epinephrine is injected by infiltration to the mucogingival tissue to effect vasoconstriction. Depending on the width of the cleft, the vertical incisions are placed more or less on the labial aspect of the alveolar ridge to allow adequate tissue on the palatal flap for closure. These vertical incisions adjacent to the cleft are made sharply to bone at the alveolar crest level and the two incisions connected superiorly into the labial sulcus by a partial thickness, mucosal incision. Blunt and sharp dissection is then carried out superiorly deep to the orbicularis oris muscle to expose the piriform rim. Next the palatal tissue is reflected subperiosteally extending from the alveolar crest to the depth of the fistula. The nasal mucosa that extends from the fistula is elevated from the bony cleft and separated from the palatal flap at this level. It is first closed by resorbable inverted mattress sutures to form the floor of the nose. The palatal flaps are then approximated and closed with continuous or mattress sutures. Particulate bone graft is then firmly packed in the cleft from the floor of the nose and piriform rim to the crest of the alveolus. Overpacking of the graft as onlay to the labial bone adjacent to the cleft is advisable, as some degree of graft resorption is inevitable. The labial flaps are then advanced and closed over the graft bone. Releasing periosteal incisions at the posterior aspects of these flaps are usually necessary to allow tension-free advancement and closure.

In bilateral clefts, the repair is essentially the same except for the development of flaps on the premaxilla. Consideration must be given to the blood supply of the segment with its attendant scars from previous soft tissue surgical procedures. Judicious reflection of the mucosal flaps off the premaxilla is essential, and a larger portion of flap tissue for closure must come from the posterior segments. Because of increased mobility of the premaxilla, some form of stabilization is usually necessary at the completion of the procedure. This can be achieved with an orthodontic arch wire. Alternatively, a prefabricated occlusal dental splint can be used and ligated to stable, well-anchored teeth. Postoperative arch expansion, when necessary, may begin 6 to 8 weeks after the procedure before the bone is completely healed. As in conventional arch expansion, the expansion device should be maintained for at least 3 months to allow consolidation of host and graft bone.

Complication and graft failure rate is extremely low in children, especially when autogenous bone is used. Occasionally, small areas of the crestal wound may dehisce with minimal graft loss. This invariably granulates over with gentle cleansing and meticulous wound care and does not affect the final result.

Skeletal Maxillary Constriction

Skeletal maxillary constriction is a frequent finding among cleft individuals. Its etiology is not certain, but generally attributed to the scar tissue from palatoplasty. Details of evaluation and treatment of skeletal dysplasia in children are described in Chapter 23 by Albert, Kuo, and Will. Evaluation of children with cleft deformities are similar, with particular attention directed to a few areas as follows:

During the clinical examination the amount of scarring should be carefully examined. This is to anticipate potential difficulties that may arise during expansion as well as with the extent of skeletal relapse. When surgical expansion is necessary, the surgeon must assess the source of blood supply to the maxilla. In the conventional approach to Le Fort I-type maxillary surgery, surgical access is from the buccolabial aspect, leaving the maxilla to

become dependent largely on the blood supply from the soft palate. Should that be compromised because of previous palatal surgery, a different approach to the maxilla must be considered. In this case, vertical mucoperiosteal incisions in the buccolabial sulcus and tunneling approach to the bony maxilla would be an alternative. Similarly, should surgically assisted palatal expansion (via lateral maxillary osteotomies) be contemplated, the surgeon must be cognizant of the potential for total maxillary osteotomy in the future and design soft tissue and bony cuts accordingly.

Another important finding in an examination is the amount of constriction. This can be determined by measurement on dental casts or on a posteroanterior head film. It should be realized, however, that dental measurements can be misleading due to the varying buccopalatal inclination of the posterior teeth. Measurements of basal bone on a head film are more valid and are preferable. The radiographic maxillomandibular width measures the relationship between the basal bones and is more valuable than any absolute dental measurement clinically (see chapter 23 by Albert, Kuo, and Will).

In a cleft child with maxillary constriction, the deformity can be corrected by conventional orthopedic expansion using a jackscrew device. The pros and cons of pre- versus postgraft expansion have been discussed. The authors generally prefer pregraft expansion as it often allows easier access for dissection and closure of deeper structures. However, the full extent of transverse skeletal constriction in a cleft child may not be realized until maxillary growth has completed. In a skeletally mature cleft patient, maxillary constriction can be treated in two ways: by surgically assisted rapid palatal expansion via lateral maxillary osteotomies or by a multiple-piece Le Fort I osteotomy. Surgically assisted rapid palatal expansion is usually done on an outpatient basis under local anesthesia with conscious sedation. Horizontal bony cuts are made in the lateral wall of the maxilla extending from the piriform rim posteriorly under the zygomatic strut. From there, the cuts are tapered inferiorly to end in the posterior tuberosities. Occasionally, a vertical midline osteotomy is made between the two central incisors when the clefts have been grafted. Since expansion is done gradually using a jackscrew appliance, the inelastic palatal mucosa does not limit expansion as it would during a Le Fort I procedure. Accomplishing expansion at the beginning of orthodontic treatment also allows good dental and arch alignment before any subsequent orthognathic surgery. However, some patients are not good candidates for surgically assisted palatal expansion. Patients who lack good bony support in their posterior maxillary teeth should not have orthopedic forces directed laterally on these teeth. In addition, patients with a significantly rotated lesser segment may not be able to achieve correction of such a rotation with traditional palatal expansion, and may benefit more from exact placement of segments during a Le Fort I surgery.

Maxillary Retrusion

Maxillary retrusion is a common but variable feature among cleft patients. The patient with cleft deformities is subject to other concomitant maxillomandibular skeletal dysplasia such as nasomaxillary hypoplasia, mandibular retrognathia or prognathia, macrogenia, or microgenia. These may either mask or accentuate maxillary deficiency associated with the cleft. Careful evaluation is needed using several methods in order to arrive at the best plan of treatment.

The importance of soft tissue scars has been emphasized. In addition, the presence and functional status of any posterior pharyngeal flap must be ascertained. This is important both from the point of view of perioperative management of velopharyngeal competence as well as adequate mobilization of the maxilla in any reconstructive surgery.

Cephalometrics is obviously a useful method of evaluation. Steiner's Sella-Nasion A point (SNA) angle and Rickett's maxillary depth angle (FH-NA), for instance, are commonly used measurements (see chapter 23 by Albert, Kuo, and Will). These figures should be used cautiously, however, and only in the context of a complete clinical examination. Cephalometric measurements describe only the sagittal prominence of the maxilla, and three-dimensional, clinical examination including the soft tissue is critical. This examination should be both static and dynamic and should include zygomatic support, paranasal fullness, nasolabial angle, upper lip support, and incisor display. Any of these may show evidence of underlying retrusion.

The dental occlusion may also show evidence of maxillary retrusion. With a normal mandible, maxillary retrusion will usually be accompanied by an anterior crossbite and an angle class III malocclusion, in which the maxillary teeth are retruded relative to the mandibular arch. Some degree of dental compensation may occur that may partially mask the severity of the skeletal discrepancy.

Surgical maxillary advancement with the Le Fort I osteotomy is usually indicated for significant maxillary retrusion. Although the same basic technique is used for cleft and noncleft patients, there are some special considerations for cleft patients. A previously placed pharyngeal flap may need to be lengthened or temporarily taken down at the time of maxillary advancement, since its preoperative length may no longer be adequate once the maxilla is advanced. It may also limit adequate mobilization of the maxilla necessary to ensure tension-free advancement and minimize skeletal relapse. Patients without flaps may need them postoperatively, if advancement of the maxilla leads to velopharyngeal incompetence. If indicated, this should be performed 1 year after the maxillary surgery to allow healing and consolidation of bone for maximum stability. Palatal scarring also leads to concerns about blood supply. The typical Le Fort I incision is in the depth of the buccal vestibule and runs from mmmolar to molar, leaving the maxilla to receive its blood supply from collateral circulation in the palate. Alternatives to the conventional approach were described in the previous section. In cases where the anteroposterior discrepancy between the maxilla and the mandible is extensive, a combination of maxillary advancement and mandibular setback should be considered. This may facilitate adequate mobilization of maxillary segment(s) without undue risk of avascular necrosis.

Bone grafting is generally indicated where the amount of surgical advancement exceeds 4 or 5 mm. This is to counteract the relapse tendency that increases with larger advancements, presumably due to increased soft tissue stretch, and, in the case of the cleft patient, from the palatal scar and pharyngeal flap. Corticocancellous bone blocks are placed posterior to the maxilla at the lateral aspects. Porous, synthetic block grafts have also been used with success.

Whether or not a graft is placed, proper intraosseous fixation is vital to maximize stability of the advanced maxilla. Rigid internal fixation using miniplates and screws is now

commonly used and provides excellent stability especially in combination with some degree of interdental fixation.

Dental Anomalies

Dental anomalies are a common finding in cleft patients, due to disruption of the dental lamina in which the teeth form. Teeth in or adjacent to the cleft, usually lateral incisors or canines, are frequently missing or malformed. In addition, they may be impacted or displaced.

Congenitally absent teeth may either be prosthetically replaced or the space they would normally occupy may be closed orthodontically. The decision of which plan to follow depends upon the existing posterior occlusion and the amount of crowding. If the molar relationship is class I and if there is little or no crowding, advancing all the posterior teeth to close the space is usually not feasible, and prosthetic replacement will be necessary. If, however, the molar relationship is angle class II or significant dental crowding exists, the space can be closed orthodontically without prosthetic replacement. No matter how feasible occlusally this plan may be, it must be done with a careful eye to aesthetic and function. In the case of a missing lateral incisor, the canine may substitute for the lateral incisor and the first bicuspid for the canine. The canine crown must be altered to look as much as possible like the lateral incisor on the opposite side. In extreme cases both the lateral incisor on the opposite side. In extreme cases both the lateral incisor and the substituting canine need to be crowned dentally in order to achieve satisfactory aesthetics. Likewise, a first premolar has to be altered somewhat in order to substitute for a canine.

When considering prosthetic replacement, several options are available. In the younger patient, either a removable prosthetic appliance or a bonded Maryland bridge would be the treatment of choice. The large pulp chamber of the younger patient's teeth mandate against fixed bridgework in which teeth must be prepared. It is also not generally accepted treatment to use osseointegrated dental implants in an adolescent, due to the lack of knowledge of their behavior with bone growth. One simple but temporary measure is to incorporate an artificial tooth onto the retainer at the end of prosthodontic treatment. This is probably preferable for the first year after debanding, while the occlusion is settling and stabilizing. A bonded Maryland bridge can be placed subsequently. In skeletally mature individuals, there is no contraindication to fixed bridgework or dental implants. Dental implants come closest to a biologic tooth but require adequate thickness and depth of alveolar ridge. For that reason, many cleft patients with a grafted alveolar cleft would not be suitable candidates for implants, unless the implant is placed within a few months of grafting. Fixed bridgework can be aesthetically very pleasing, especially if the contralateral teeth are included.

In contrast to missing teeth, supernumerary teeth are sometimes found in the area of the cleft. Supernumerary teeth can impede the eruption of other permanent teeth and thus should be extracted.

Teeth adjacent to the cleft, notably canines, sometimes become impacted and will not erupt on their own. When this occurs, the tooth must be orthodontically brought into the arch, taking care to always keep bone around the root. Root surface that has lost its covering of bone will no longer adhere to bone, potentially leading to periodontal problems and eventual

tooth loss.

Lateral incisors and other teeth adjacent to a cleft are often malformed. Defects and generalized hypoplasia of the dental enamel are seen, as well as defects in shape and size of the crown. Enamel defects should be carefully monitored, and should be restored if necessary. Deformed laterals can be built up with composite dental resin to their normal size, but this should be delayed until the end of active orthodontic treatment so that the exact size for the crown can be determined after optimal occlusion and alignment have been established.

Treatment Sequencing

It is well recognized that optimal cleft care can be provided by a multispecialty cleft team. An equally important factor is proper timing and sequencing of surgical repair, dental rehabilitation, speech therapy, and hearing evaluation as well as nutritional and psychosocial counseling during growth and development.

Infancy and Early Childhood (Birth to 2 Years of Age)

General goals in the treatment of infants with clefts include facilitating feeding, closure of clefts, and fostering optimal emotional, speech, and language development. Many considerations enter into the timing decision: nutrition and feeding, speech development, and facial growth. The timing of lip and palate closure varies somewhat, but lip closure is generally performed between 6 weeks and 6 months, and palate closure between 8 and 20 months. One adjunctive procedure used in some centers is the placement of a palatal plate in the newborn period. This plate, fabricated from resilient and hard acrylic, is made from an impression that can be taken on the awake neonate. The plate's resilient flanges are trimmed to provide retention under the palatal shelves, and the hard acrylic palate extends to the height of the alveolar ridges. The plate performs three functions: First, it allows easier feeding by temporarily separating the communication between the oral and nasal cavities; it also forms a shelf against which the tongue can push during feeding. Second, it maintains the width of the posterior segments and prevents the collapse that often occurs. Third, after primary lip repair, the lip can mold the anterior alveolus while the posterior segments are stabilized. The plate is worn full time until the time of palatal repair or, in some instances, until primary alveolar bone grafting.

Childhood (Age 2 to Age 10)

The importance of speech development is addressed in Chapter 13 by D'Antonio and Crockett. During this period, as permanent teeth begin to erupt, much of the treatment attention turns to dental concerns. Treatment goals during childhood center on optimizing dental health as well as alignment, shape, position, and integrity of the maxillary arch. During this time, growth discrepancies between the maxilla and mandible may become apparent, and treatment may be undertaken to correct them. Palatal expansion using teeth as anchors may be done in the primary dentition, in the early mixed dentition before resorption of primary molar roots, or after eruption of the permanent dentition. Maxillary protraction may also be used to orthopedically advance the maxilla if necessary, but alveolar bone grafting is also done at this time, before two-thirds of the root development of involved teeth and even earlier in some cases, as previously described.

Minor tooth alignment may be carried out during later childhood, both for the purpose of aesthetics and for the purpose of allowing optimal flap development during alveolar grafting. If possible, this should be carried out as a distinct first phase of orthodontic treatment and completed at a predetermined end point. When minor orthodontic tooth movement is allowed to creep into full treatment, which usually continues until the cessation of growth, patients often become "burned out" and develop negative attitudes toward the deformities as well as toward treatment.

Adolescence (Age 11 to Cessation of Growth)

During adolescence, rapid pubertal growth gives way to the stability of skeletal maturity. Treatment goals at this stage focus on achieving final, stable maxillary position and dental occlusion. Definitive orthodontic treatment should be done at this stage, accompanied by any necessary secondary grafting and palatal expansion not already accomplished. Palatal expansion should be done as early as feasible, since fusion of circummaxillary sutures after puberty makes orthopedic expansion difficult or impossible, and surgical assistance must be obtained to reduce lateral resistance to expansion. Orthognathic surgery, when indicated, is usually delayed until the end of skeletal growth in order to maximize stability. Soft tissue revisions on the lip and nose can then be performed on a stable skeletal base.

Adulthood

Although this phase of treatment is out of the scope of this text, it should be mentioned in passing for completeness. In the context of a lifelong sequence of treatment, the goals of treatment in adulthood are to achieve the final, proper skeletal and occlusal relationships. Orthognathic surgery is done after skeletal maturity is attained and orthodontic treatment is completed; then, definitive prosthetics can be done, along with further soft tissue surgery as needed.

For the patient who begins treatment as an adult, alveolar bone grafting and palatal expansion can also be done at this stage. Surgical assistance will be required to accomplish palatal expansion, however, and alveolar grafting should only be done if benefits can be realized for the particular patient. If the maxillary segments are stabilized, the teeth have good periodontal health, and no tooth movement in the cleft area is anticipated, then alveolar bone grafting may not be indicated except to aid closure of any residual oronasal fistulae. If, however, teeth have to be moved in the cleft area or if dental implants are contemplated, alveolar bone grafting will be an important factor in achieving the desired treatment outcome.