

# Orthodontics in 3 millennia. Chapter 14: Surgical adjuncts to orthodontics

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Around 1970, after overcoming obstacles related to anesthesia, infection, and blood supply, orthognathic surgeons come into their own. The history of cleft lip and palate treatment has a much earlier beginning because a deformed infant evokes a strong desire to intervene. Angle's belief that orthodontists can grow bone finally came to fruition with the advent of distraction osteogenesis, which developed from the limb-lengthening procedures of Ilizaroff in Russia. Now distraction osteogenesis has replaced osteotomies in many applications. (*Am J Orthod Dentofacial Orthop* 2007;131:561-5)

**T**he treatment of patients whose mouths and jaws were deformed from birth or by accident offers an unequaled opportunity for orthodontists to demonstrate that their interests involve much more than aligning teeth. In the previous chapter, we acknowledged our medical and dental colleagues who scrubbed for these surgeries. In this chapter, we continue this time line and add the related fields of cleft lip and palate treatment, and distraction osteogenesis.

## **SURGERY MATURES**

The early 1950s began a period of rapid development in orthognathic surgery. In 1954, Caldwell and Letterman developed a vertical ramus osteotomy technique, which had the advantage of minimizing trauma to the inferior alveolar neurovascular bundle. This method could be used instead of a body ostectomy to correct mandibular excess. Europe then became the center of progress. Pupils of the Vienna School of maxillofacial surgery, Richard Trauner and Hugo Obwegeser (1957), introduced the intraoral bilateral sagittal split ramus osteotomy, allowing corrections in all 3 planes of space without a need for bone grafting.<sup>1</sup> Even so, it was not until the early to middle 1960s that mandibular surgeries became popular in the United States.

Marsh Robinson and S. M. Moos developed a reliable extraoral procedure for prognathism: the vertical sub-sigmoid or vertical ramus osetotomy with a bone cut posterior to the inferior dental nerve. Spectacular changes in the midface resulted from the treatment of craniofacial deformities and the orbital areas by Paul

Tessier in France during the 1960s and 1970s. Derek Henderson also developed appropriate planning techniques using a combination of photocephalometry and accurate model surgery. He emphasized anticipating soft-tissue changes. Alveolar surgeries were the next procedures to gain popularity in the United States after being pioneered in Europe. In 1959, Heinz Köle, a student of Obwegeser, introduced subapical dentoalveolar osteotomies in the anterior mandible.<sup>2</sup>

In 1960, Obwegeser began performing maxillary surgery and, by 1969, had described many LeFort I osteotomies, marking the beginning of a new era in the correction of dentofacial deformities: before the mid-1960s, maxillary deficiency was typically treated by mandibular surgery. Obwegeser also performed the first total 2-jaw surgery (1970), facilitating the correction of extensive aberrations in a single operation.<sup>1</sup> Advances in mandibular surgery included intraoral vertical oblique osteotomy (for advancement or setback), total mandibular subapical osteotomy, and refinement of lower border osteotomy.

Again, Europeans led the way. In 1972, Paul Tessier came to New York to demonstrate the surgeries he had perfected in the 1960s, and it was not until then that American surgeons, concerned as they were about blood supply and total or partial loss of the osteotomized fragment, could be convinced of the possibilities of moving the midface skeleton. In 1974, the European literature featured 104 LeFort I osteotomies that demonstrated remarkable stability and predictability. In the mid-1970s, Bell and Epker started to popularize the procedure, now commonplace in the surgeon's repertoire.<sup>3</sup>

About that time, orthodontists and oral surgeons began to realize that, contrary to current practice, orthodontists, having aligned the separate arches, could better detail the occlusion if the appliances were left in

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place during surgery. Improvements in the stiffness of orthodontic wire helped make this possible, even after the introduction of bonding. At the same time, training of oral surgeons started to include orthognathic procedures.

Until about 1975, the prevailing concept of facial deformities was that they existed only the sagittal plane, but, as diagnosis became more thorough, surgeons acquired a measure of control over the vertical and transverse dimensions.

Plating techniques (1983) and screws for the fixation of jaw fragments reduced the risk of relapse and allowed intermaxillary fixation to be dispensed with in many patients. By the 1990s, the use of rigid fixation had become routine, increasing precision and patient comfort (eliminating 6 to 8 weeks of wired jaws, liquid diets, inability to brush lingually, and "claustrophobia").<sup>2</sup> More recently, the use of resorbable bone plates in Helsinki and Groningen reduced the risk of leaving plates permanently in situ or the necessity of a second operation.<sup>4</sup>

Other technological improvements have included freeze-dried bone, bovine bone, and autogenous bone; biodegradable osteosynthesis material<sup>5</sup>; hypotensive general anesthesia (to reduce blood loss); smaller instruments with better intraoral designs; computer-aided treatment planning; and computerized axial tomography scans (3-dimensional reconstruction).

## CLEFT LIP AND PALATE TREATMENT

Long before dentists held the notion that they could give patients pretty smiles, innovative surgeons were coping with a challenge far more fundamental: how to give certain unfortunate infants new faces. Many children born with cleft palates, unable to nurse, failed to survive because of malnutrition. Others were left to die either because of superstition or because the anomaly was too hideous to contemplate.

The term "harelip," now considered demeaning, is believed to have come from the cleft lip's resemblance to a rabbit's mouth. It was once believed that children with cleft lips were born to women who, when pregnant, were frightened by the devil, who had assumed the shape of a hare.<sup>6</sup> The incidence of cleft lip and palate—the single most common defect affecting orofacial structures<sup>7</sup>—is approximately 1 in 1000 births; for cleft palate only, 1 in 200; isolated cleft lips occur in 20% of all clefts.

Cosmetic surgery began in the ancient world. The Romans performed simple techniques such as repairing damaged ears. Physicians in ancient India used skin grafts for reconstructive work as early as 800 BC.

However, the early history of cleft lip and palate surgery describes only unilateral procedures.

The first report of surgical cleft lip repair appears in *Chin Annals*, involving repair of an apparently congenital cleft in 390 BC. The treatment consisted of cutting and stitching the edges of the cleft together, followed by 100 days of complete bed rest, when the patient could eat only thin gruel and was not allowed to smile or talk.<sup>8</sup> Hippocrates (400 BC) and Galen (AD 150) mentioned cleft lips, but not cleft palates, in their writings.<sup>9</sup>

The first exact description in the western world of cleft lip surgery was given by Johan Yperman, who practiced in the 14th century. He performed a 2-layer operation with waxed, twisted thread. In 1552, Houlier proposed suturing palatal clefts; 12 years later, Ambroise Paré illustrated obturators for palatal perforations.<sup>10</sup>

For centuries, perforations of the palate were considered to be secondary to syphilis, and cleft palate was not recognized as a congenital disorder until 1556, when Pierre Franco, along with Paré, described in detail the principles and techniques of cleft palate surgery. Franco has been called the "father of cleft palate surgery."<sup>9</sup>

Hendrik van Roonhuyze of the Netherlands (1625-1672) advised that a cleft lip should be repaired when the baby was between 3 and 4 months of age, because if done earlier, the results would be unfavorable. James Cook of Warwick (1614-1688) was the first to warn against removal of the premaxilla because of the danger of interfering with subsequent growth. Pierre Fauchard, in his book *Le Chirurgien Dentiste*, described several different obturators to close the cleft palate defect.<sup>11</sup>

The first successful closure of a soft palate defect was reported in 1764 by Le Monnier, a French dentist, using sutures along with cautery of the edges (the first *palatorrhaphy*).<sup>9,10</sup> In the United States, Matthew Wilson, practicing in the 18th century, was the first to publish an account of a cleft lip surgery. Because of the dangers associated with surgery in any form, especially that involving the head or face, it was not until the 19th and 20th centuries that such surgeries became commonplace.

A successful operation on a cleft palate finally occurred in 1816 when C. von Graefe published the first satisfactory results (Philbert J. Roux, called by many the founder of modern cleft lip and palate surgery, did so in 1819). Von Graefe cauterized the margins before suturing them together. When the wound failed to heal, he freshened the wound margins and fastened them to the cheeks, so that they could not rip out.

Roux's operation is well known because the first patient to undergo this procedure, medical student John Stephenson, wrote a thesis about it to complete his degree in medicine. After the introduction of chloroform, cleft surgery made remarkable progress.<sup>11</sup>

In 1820, Jonathan C. Warren was probably the first American surgeon to perform reconstructive rhinoplasty and close a palate successfully.<sup>11</sup> In 1828, he performed a successful closure of a soft palate, noting that, after closure, the width of the hard palate cleft also diminished. Thus, Warren became an early pioneer in preoperative orthopedic repositioning of the premaxilla.

The first plastic surgeon in the United States was John Peter Mettauer. He performed the first cleft palate operation in 1827 with instruments that he designed himself.<sup>12</sup> In 1828, Johann F. Dieffenbach enhanced cleft palate surgery by elevating the hard palatal mucosa to allow closure of the hard palate cleft. He also performed the first closure of both hard and soft palates in 1834.<sup>9</sup>

The introduction of general anesthesia in the late 1840s led to great advances in cleft palate surgery. In the 1840s, Simon P. Hullihen (1810-1857) advocated surgical repair in infancy before eruption of the dentition and used an adhesive strap from 1 cheek to the other before surgery.<sup>13</sup> In 1861, von Langenbeck was the first to use a mucoperiosteal flap, which was separated from the hard palate. This method is still used in many centers. Norman W. Kingsley's *Treatise on Oral Deformities as a Branch of Mechanical Surgery* in 1880 was the first recognized work on orthodontic and prosthetic treatment of cleft palates.

In the field of cleft lip surgery, Hagedorn was a leading pioneer (1884). He used a quadrangular flap to increase the thickness of the medial part of the lip.<sup>11</sup> The first attempts at bone grafting in patients with clefts were performed by von Eiselberg in 1901 and Lexer in 1908. Drachter in 1914 reported closure of a cleft with tibial bone and periosteum.<sup>8</sup>

The 1930s were an important decade for developments in both cleft palate and cleft lip. Blair and Brown (1930) attempted to correct the anterior nares by shifting the tissues toward the midline. Also that year, V. Veau, a leading figure in cleft surgery, advised that bilateral cleft lips could be closed in 2 to 3 stages, depending on the width of the gap.<sup>11</sup> His name was perpetuated when he devised a 4-part classification of clefts. Later in the decade, Kilner and Wardill independently developed the "pushback" procedure (in which tissue from the palate is moved back to lengthen it).<sup>9</sup>

The first cleft palate clinic in the United States was established in 1939 when Herbert Cooper opened the

Lancaster (Pa) Cleft Palate Clinic. Cooper's recognition of the need for multidisciplinary involvement resulted in the formation of a clinic that had all the necessary dental and surgical specialists in 1 location. He was also among the first to use cineradiography to evaluate velopharyngeal function.

In a patient with a bilateral cleft palate, the surgical closure of the lip is different from that of a unilateral condition because of the position of the premaxilla, the short columella, and the absence of the muscles in the prolabium. Surgeons who excised the premaxilla to suture the gap in the lip did not realize the damage being done to maxillary growth with this operation. Elastic traction to reposition the premaxilla in bilateral cleft lip and palate patients is still being practiced.<sup>8</sup>

In 1950, C. Kerr McNeil, often called the founder of modern-day, premaxillary orthopedic treatment, described the use of acrylic appliances to reposition bony cleft segments, in addition to traction. Also in 1950, T. M. Graber,<sup>\*14</sup> in his PhD dissertation, was the first to document a disturbance in facial growth as a result of palatal surgery. His work led to the alteration and staging of surgical procedures.<sup>8</sup> About that time, surgeons in Europe were inserting bone grafts as a primary procedure.

In the 1960s, Sheldon W. Rosenstein, working with surgeons, introduced the technique of placing a plate in the maxilla of a newborn before surgical lip closure to guide the maxillary segments into proper alignment. After lip closure, the aligned segments helped guide the teeth into better positions and reduced the incidence and severity of crossbite and segment malalignment.<sup>15</sup>

The late 1960s and early 1970s was a period when primary bone grafting and maxillary orthopedics were in vogue, but by the 1970s many who had previously advocated the bone-graft procedure had abandoned it because their results had negative effects on the growth of the maxilla and the midface. Others, including Hugo Obwegeser, recommended the LeFort I osteotomy with secondary bone grafting after development of the adult dentition, especially as an aid to orthodontic and prosthetic reconstruction.<sup>16</sup>

Additionally, much discussion has occurred over the role and the timing of presurgical appliances. Both the hard palate and the alveolus can be molded with passive molds and active devices, with the shared ultimate goals of facilitating surgical repair and providing an improved long-term outcome in both facial form and palatal function.<sup>10</sup>

\*As Tom Graber approaches his 90th birthday, he joins a select few (including P. R. Begg, B. F. Dewel, Rolf Fränkel, Paul Lewis, and Fred Schudy), who made substantial contributions to our specialty past their 89th years.

## DISTRACTION OSTEOGENESIS

Distraction osteogenesis (DO) is a surgical technique in which new bone formation is induced by gradual separation of bony segments after an osteotomy. Just as orthognathic surgery has enabled orthodontists to treat the untreatable, DO now allows us to literally “grow bone” in patients hitherto treatable only by surgery. DO is especially useful in the treatment of the severe growth deficiencies of craniofacial syndromes.<sup>17</sup> The use of DO appears to follow the same pattern of bone alteration associated with rapid palatal expansion. Once traction stops, ossification and concomitant remodeling occur.<sup>18</sup>

### Pioneers

Wescott first reported placing mechanical forces on the bones of the maxilla in 1859. He used 2 double clasps separated by a telescopic bar to correct a crossbite in a 15-year-old girl. However, the entire expansion procedure was slow and tedious, lasting several months. A year later, Angell performed a similar procedure with a differentially threaded jackscrew connected to the premolars. Palatal expansion was achieved rapidly in 2 weeks by the separation of the maxillary bones at the midpalatal suture. Goddard, in 1893, further standardized the palatal expansion protocol. He activated the device twice a day for 3 weeks followed by a stabilization period to allow the deposition of “osseous material” in the created gap.<sup>19</sup>

Codivilla, who lengthened a femur to correct limb length deficiencies, first reported bone lengthening by DO in 1905. Abbot then reported lengthening the tibia and the fibula in 1927. These early efforts were complicated by edema, skin necrosis, infection, and delayed ossification of the expanded bone.<sup>20</sup>

### Mandibular procedures

Osteotomy of the mandibular corpus was also advocated for advancement of the retrognathic mandible. According to Limberg, Brown in 1918 and Bruhn-Linderman in 1921, each performed a vertical osteotomy of the mandibular body followed by acute advancement of the anterior segment. The ensuing defect usually healed by new bone ingrowth. However, the amount of advancement with these osteotomies was limited and often associated with instability of bone segment fixation.

In 1927, Rosenthal performed the first mandibular osteodistraction procedure by using an intraoral toothborne appliance that was gradually activated over a month. In 1937, Kazanjian also performed mandibular osteodistraction using gradual incremental traction in-

stead of acute advancement. After performing modified L-shaped osteotomies in the corpus, he attached a wire hook to the symphysis, thereby providing direct skeletal fixation to the bone segment to be distracted.<sup>19</sup>

### Skeletal fixation

The application of external skeletal fixation for craniofacial fractures was first reported by Haynes in 1939. Using a number of pins connected to a rigid bar, he applied this technique to a comminuted, compound fracture of the mandible. In 1941, 2 other external mandibular fixation devices were developed based on appliances for external skeletal fixation of the lower extremities.<sup>19</sup> Crawford, in 1948, applied gradual incremental traction to the fracture callus of the mandible. A patient presented 2 weeks after a mandibular symphyseal fracture in which a mandibular central incisor was lost. By using a jackscrew appliance, the fracture callus was stretched over a 3-day period to reestablish the original jaw position, which remained fixed with a sectional occlusal splint.

### Ilizarov's influence

During the 1950s, Gavriel Ilizarov, a Russian orthopedic surgeon, began the modern era of DO, applying it primarily to lengthen limbs. He was the first to align fractured long bones and, later, to elongate them without bone grafts.<sup>17</sup> He is credited with pioneering the use of corticotomy with preservation of the periosteal and medullary blood supply to the bones, and using slow expansion.<sup>21</sup>

At first, DO procedures did not gain immediate acceptance, primarily because of the lack of control over bone segment manipulation, the inadequacy of distraction appliances, and the instability of osseous fixation. Instead, corrective osteotomies remained a principal treatment modality for the management of mandibular deformities, especially after the introduction of sagittal split osteotomies by Trauner and Obwegeser.

The first description in English of DO in a human maxillofacial application was reported in 1992 by McCarthy, in lengthening a congenitally hypoplastic mandible.<sup>17</sup> Later studies in the early 1990s demonstrated that DO with an external device could be used successfully to lengthen the human mandible.<sup>20</sup> In 1998, Razdolsky et al demonstrated an intraoral, toothborne distractor for lengthening the mandible.<sup>21</sup> What the LeFort I can do by cutting, DO can do by increasing the maxilla in all 3 planes of space by growing bone.

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