VII. Jaws
When the cleft anomaly has occurred on the framework of a face which, without the cleft, would have been prognathic (Angle class III) or retrognathic (Angle class II), it tends to increase or decrease, respectively, the absolute occlusal discrepancy between the two jaws. Edward Angle of Pasadena was the modern father of orthodontics in the early 1900s.

Cephalometric analysis may aid in the defining of the deformity, but in the final analysis, the decision as to which structure is deformed and which should be operated upon—the maxilla or the mandible—will need to be made on a clinical basis, with an understanding of what would constitute the most pleasing esthetic relationships for the particular patient’s face. Cephalometric analysis takes the sella-nasion (SN) line as the fixed line against which to measure the most anterior point of the maxilla (point A) and the most anterior point of the mandible (point B). Dingman and Dodenhoff’s cephalometric x-ray tracings demonstrate the differences between normal relationships, pseudoprognathism, and true prognathism.

In severe maxillofacial deformities, the cephalometric baselines themselves become affected and invalid, as in the patient with Crouzon’s disease with a steeply tilted anterior base, or in the patient with hemifacial microsomia, who has a short cranial base on the affected side. The majority of adult postoperative cleft patients will have class III malocclusion due to maxillary hypoplasia, and generally the maxilla—the blighted structure—should be moved forward rather than the mandible backward, to obtain both proper dental occlusion and a satisfactory facial profile. When from cephalometric determinations the mandible is more
protuberant than the maxilla is recessive, the mandible may be moved back.

Any major discrepancy in the sizes of maxillary and mandibular arches is usually caused by the maxillary deformity. As a rule, the maxilla should be expanded, but again, in some cases the deformity will be predominantly due to an overlarge mandibular arch which will need to be reduced by a body or symphyseal ostectomy.

**Correcting priorities**

In 1959 Heinrich Köle of Graz made this sound observation:

The choice between orthodontic and surgical treatment is based on the severity of the deformity and the age of the patient. Generally surgery is preferred when the malformations are very pronounced or when bone growth has ceased.

It is the opinion of Obwegeser, Tessier, Dautrey, Pruzansky, Aduss and others, as well as Wolfe and Berkowitz in our unit, that mandibular prognathism, as we define it by cephalometric analysis, is not more common in the cleft lip and palate group. Furthermore, our unit has not had gratifying results in treating mandibular pseudoprognathism (i.e., retromaxillism) with orthodontics when there was a skeletal discrepancy between the basal alveolar bone of the maxilla and mandible. Many of our patients, although they end up with "satisfactory" dental occlusion, have required onlay bone grafting to these maxillae, which still possess their recessed, hypoplastic appearance.

The surgeon must work closely with the orthodontist in defining the deformity and planning the proper procedure. The orthodontist, in turn, must know which cases should not be treated by orthodontics alone. Orthodontics treats the malalignment of teeth, but when the supporting skeletal structures—the alveolar ridges of the maxilla and mandible—are in poor relationship, surgery must be performed before a satisfactory dental and facial result can be obtained.

Surgical procedures most commonly used in cleft patients are:

1. Segmental procedures.
2. Procedures for mandibular recession.
3. Procedures for maxillary advancement.
4. Onlay bone grafting procedures for patients with orthodontically obtained class I occlusion but persistent maxillary hypoplasia.

A modern, premier hard tissue surgeon for correction of the postoperative cleft lip and palate, mandible and maxilla, is Hugo Obwegeser of Zurich. In the introduction to his 1971 chapter for *Cleft Lip and Palate*, he stated:

Various degrees of residual jaw deformities and displaced teeth are usual sequelae to primary closure of clefts of the lip and palate. They have been present in the past, they are still seen, and, I believe, some of them will still occur in the future. New surgical techniques notwithstanding, there is no panacea in cleft surgery. The cause of these anomalies is attributable to four factors: (1) genetic, (2) type of surgical procedure used, (3) skill of the surgeon, and (4) the orthodontic treatment.

Most patients with malposed jaws have an altered, often severe facial disharmony.

In cleft cases, some supplementary correction may be required on the soft tissues; however, this should follow the correction of the bony parts. As in any type of maxillofacial surgery, especially in the correction of secondary jaw deformities, one must adhere to the principle, "first the bone, then the soft tissues."

Obwegeser generalized:

I believe that in a cleft case it is extremely difficult for one to postulate exactly what the interrelationships of the facial bones would have been had they not been changed by both the cleft deformity and the further disruptive forces of surgical intervention. For this reason, the surgeon’s treatment planning is greatly influenced by imaginative and intuitive factors.

Create the best possible occlusal relationship; this is a basic guide. Most of these patients have an Angle Class III type of appearance. In the past, I operated primarily on the mandible, and the results were only marginally satisfactory. The operation on the mandible only, often created a pronounced retrodisplacement of the middle third and lower third of the face. Today in cleft cases I usually operate on the upper jaw only. I seldom operate on both the maxilla and mandible and very infrequently on the mandible exclusively. For profile considerations, when the maxilla is moved forward, I strive to create a Class II occlusion, thus slightly overcorrecting the occlusion.
Mandibular surgery, although not indicated as often as was initially thought, has an important place in the total correction of secondary cleft deformities. The original cleft with its varying degrees of discrepancy and distortion, which occur in addition to the secondary effects of trauma, scar contracture and their retarding influence on early bone growth, places the main surgical problem in the maxilla. Some faces, however, are destined by genes to grow prognathic mandibles. This factor, of course, compounds the problem but also necessitates mandibular corrective surgery. Should genetic destiny produce a retrognathia, although it may blend better with the hypoplastic maxilla of the cleft deformity, the end result is a deficient face which might conceivably deserve both maxillary and mandibular correction.

Not surprisingly, some of the great maxillofacial centers of the world that have contributed to the treatment of mandibular prognathism have been located in the Hapsburg belt. As pointed out by Grabb, Hodge, Dingman and Oneal in 1968 in *Plastic and Reconstructive Surgery*, Charles V was the first of the Hapsburgs to rule Spain. His portraits show a severe mandibular prognathism with Angle class III malocclusion. Historian Rhea Marsh Smith wrote that Charles' protruding lower jaw caused his mouth to hang open and gave him the appearance of an imbecile. It is reported that when Charles first came to Spain from Ghent, a Spanish peasant shouted to him:

Your Majesty, shut your mouth, the flies of this country are very insolent!

Genetic studies of the Hapsburg family have shown that their facial characteristics were transmitted as a single dominant trait.
The genetic inheritance was practically assured by the family tradition of close intermarriage as a means of preserving the house of Hapsburg. Charles and his relatives suffered from realistic artists of their day, who painted what they saw without regard for flattering their subjects. Since members of royalty were painted frequently, it was possible to trace the effect of aging on their faces—beautiful and delicately featured children acquired the grossly distorted features of the Hapsburgs by the mid-teens, more pronounced with each passing year.

Mandibular prognathism is not always transmitted by a single dominant gene, as shown by Schulze and Weise, who found transmission by an irregularly dominant mode of inheritance with variable penetrance.

**TIMING OF SURGERY**

In 1971 R. O. Dingman and T. G. Dodenhoff of the University of Michigan stated:

Operations should be deferred until patients have attained practically full mandibular development. In females this occurs by 18 years of age and in males usually by the age of 20. Growth may be considered complete when identical cephalometric X-ray studies, taken at 6-month intervals, can be superimposed exactly. Growth after age 20 is uncommon. Earlier operation may be indicated in patients with severe deformities and a serious psychological reaction to their deformity. The best results from osteoplastic operations upon the mandible are noted in the young adult age group. Patients beyond the age of 40 may have slow or incomplete healing as a complication.

**MANDIBULAR BODY OSTECTOMY**

In 1848 Simon P. Hullihen of Wheeling, West Virginia, was faced with a 20-year-old patient who had an elongation of the mandible caused by a burn contracture of the lower lip and neck, present since the age of 5 years. Hullihen carried out a V-shaped ostectomy of the anterior body of the mandible bilaterally, which allowed the distal portion to be moved back into its proper position.
In 1896 Edward H. Angle advised bilateral resection of the mandible through the entire body for a patient with a progressive type of prognathism. This patient, however, came under the care of Vilray P. Blair of St. Louis, who resected a quadrilateral section from either side of the jaw, brought the teeth in occlusion, wired them in place, but had difficulty holding the jaw fragments in occlusion.

In 1907 Blair discussed his mandibular ostectomy:

This operation presents three distinct problems: 1. the cutting of the bone, which is the easiest of the three; 2. the placing of the jaw in its new position; and 3. holding it there.

Blair discounted the seriousness of injury to the nerve:

We need not concern ourselves with the consequences of cutting the inferior alveolar nerve and artery. Normal sensation eventually returns to the teeth after their section.

Blair wrote in 1915:

Before operating upon my first case of mandibular protrusion, I carefully considered the best site of attack. It would be a natural procedure for a simple forward position of the body of the mandible to make a cut in the ramus and push the jaw back to its proper relationship, but the fear of crowding the retroramal structures and thus possibly to interfere with free opening, decided me to remove a section from the body itself.

This operation was first done by Blair in 1907:

The result was obtained not only by taking out a section of bone on each side and setting back the mental piece, but the premolar teeth had to be crowned to bring them into occlusion.

To avoid opening into the mouth and the infection that invariably followed, Blair developed the subperiosteal osteotomy, passing a needle around the mandible carrying a wire saw which he used to divide the bone.

This approach was advocated later by C. Henschen and R. Schwarz in 1928–1929 and V. H. Kazanjian at Harvard in 1941. The refinements of the method were introduced in 1912 by W. Harscha and J. Eisenstaedt, independently of each other and both in Surgery, Gynecology and Obstetrics. They described short-
ening the horizontal ramus through a 2½ inch incision beneath the border of the mandible. Subperiosteal saw resection of the determined amount of bone, without entering the mouth, was followed by wire sutures to the bone and immobilization with interdental wiring.

In 1941 Gordon New and John Erich of the Mayo Clinic, Rochester, Minnesota, reviewed the various methods of treating mandibular prognathism. They expressed preference for bilateral resection of a segment of the mandible in the bicuspid or first molar regions. . .

and described division of the segment of the mandible with a motor-driven circular saw from below up, near the mandibular canal, and from above down near the canal with a Gigli saw. Then the bone was chipped out with a chisel, leaving a small amount around the nerve and vessels which was carefully picked off with a rongeur. They were more concerned about the nerve than infection from suturing the oral cavity, claiming:

Many surgeons consider severance of the mandibular nerve to be of little consequence, but those of our patients who had the mandibular nerve cut complained bitterly of subsequent numbness, and in some instances, normal sensation in the lower lip never was regained entirely.

Reed O. Dingman of the University of Michigan, Ann Arbor, while an undergraduate at Wayne State University, served one summer as the boxing and wrestling coach at a boys' camp in northern Michigan. He soon made friends with one of the other counselors, Freddie. When this young entrepreneur discovered that Dingman, besides playing football, was a middleweight on the university boxing team, he conned him into taking on all comers at the Saturday night fights in the small lumber mill.
towns. At $50 an appearance plus side bets, Dingman fared well until matched against the promising local champion, a lumberjack. After six tough rounds, a loss by a close decision and a look in the mirror at his bruised face and fractured nose, he decided to bypass the prize ring and proceeded to get his dental and medical degrees.

His firsthand knowledge of giving and receiving jaw trauma especially prepared him to pioneer the specialty of jaw surgery. In 1944 he described a two-stage procedure for correction of mandibular prognathism which removed bone of the horizontal ramus without interfering with the inferior alveolar nerve and its associated structures. In his first stage, under local anesthesia, through an incision along the crest of the alveolar ridge, the mucoperiosteum was elevated on the buccal and lingual surfaces. This maneuver allowed a resection on each side of the mandible with a bone drill, usually in the second molar region, the desired amount for removal being predetermined by the orthodontist. The saw cuts were not carried down to the nerve but extended on the outer surface of the mandible as a guide for the second stage. If necessary, a tooth in this area was extracted, but the bone was retained and the mucoperiosteum closed to seal off the oral side. Four to six weeks later, the second stage, usually under local anesthesia, was carried out through bilateral incisions parallel to and 1 cm. below the inferior border of the mandible in the area marked for resection. Subperiosteal resection of the bone block with drill and chisel, taking great care to stay clear of the mandibular nerve, was followed by removal of the medullary bone surrounding the nerve, including a hollowing out around the nerve to provide a safe resting place for excess nerve when the mandible was shortened. The bone fragments were approximated with 27-gauge stainless steel wire, and the orthodontic appliances, with the teeth held in occlusion, were secured by intermaxillary rubber band fixation. After several weeks, the bands were replaced by stainless steel wire.

In 1960 Dingman called attention to the possible use of his mandibular ostectomy in secondary cleft deformities:

A patient with underdevelopment of the middle third of the face and a normal mandible may give the appearance of having a prognathic jaw. Ostectomy of the mandible may be helpful in such cases.
After 14 years' experience of 95 cases, Dingman had reduced the operation to one stage, carrying out the intraoral portion exactly as previously described and closing this wound. Then, at the same time, he entered through the skin and carried out the previously described second stage, following it with the same fixation. In *Plastic and Reconstructive Surgery* he presented his one-stage ostectomy procedure:

He also presented a favorable step ostectomy for the patient with an edentulous posterior mandible.

In 1971 Dingman and Dodenhoff noted the advantages and disadvantages of the ostectomy of the mandibular body:

Advantages: (1) accessibility of the operative field, (2) the section of bone can be removed without injury to the inferior alveolar neurovascular structures, (3) the operation does not interfere with the physiological action of the muscles of mastication, (4) the fragments can be positioned and secured accurately and firmly, (5) a dental splint can be used to hold the fragments in place after only a short period (4 to 6 weeks) of immobilization, (6) open bite is less likely, and (7) good cosmetic results are usual. Its disadvantages are: (1) removal of bone, (2) removal of functional teeth, (3) not as applicable in extreme cases of prognathism, (4) the obtuse mandibular angle is not corrected, (5) if more than one tooth is removed on each side, the disparity in arch size makes bony appositional surface less than optimal, (6) if a gap of more than 2 or 3 mm. exists, the possibility of nonunion is present, and (7) the depressor group of muscles may cause open bite. . . .

. . . We believe the advantages far outweigh the disadvantages. We have corrected a deformity as large as 27 mm., and we do not feel limited in severe cases.

**POSTOPERATIVE CARE**

The ostectomy site is wired with a No. 24 stainless steel wire through drill holes in the bone. Intermaxillary fixation with 906
rubber bands initially will, by one week, have settled the lower jaw into optimal occlusal relationship. This allows replacement with stainless steel wire which will be maintained about six weeks.

Dingman's postoperative regimen is practical. The patient is placed on a high-protein, high-vitamin liquid diet and is usually discharged from the hospital on the second to fourth postoperative day. Oral hygiene is facilitated by the use of a small toothbrush or water pick and mouthwash irrigations every four hours.

Here are two of Dingman's cases, with Ponitz as the orthodontist.

1. South American teenage girl, who had unilateral lip and palate cleft closed in infancy in New York, revealed a tight lip, typical nasal deformity, scarred palate with contracted maxilla, and class III malocclusion when first seen by Dingman in 1955.

In 1957, lip revision, pharyngeal flap and rhinoplasty were performed, followed in 1959 by Dingman's one-stage bilateral mandibular ostectomy.

Intraoral: Flaps elevated from cuspid area of the mandible on both sides, first permanent molars removed, parallel bone cuts 7 mm. apart allowed removal of upper portion of bone and intraoral wounds closed. Extraoral: Skin incision 1½ cm. parallel with and below the angle of inferior border of mandible allowed exposure for continued resection of inferior mandible 9 mm. wide, salvaging the inferior alveolar nerves. The fragments were fixed
with #25 stainless steel wire and the teeth brought into occlusion with rubber band traction. Six weeks later, unilateral rotation of the cleft nostril with alar lift improved nasal symmetry.

2. This 13-year-old boy had his unilateral cleft lip closed at 1 month and palate cleft closed in two stages at 18 and 24 months by oral surgeon Kemper at University Hospital, Ann Arbor. When seen by Dingman in 1960, he revealed velopharyngeal incompetence and class III malocclusion.
He had a setback palatoplasty and a pharyngeal flap and, at age 18 in 1965, a Dingman one-stage ostectomy resecting 1 cm. at the superior mandibular border and 1.5 cm. at the inferior border on the right, and 1 cm. superiorly and inferiorly on the left. The inferior alveolar nerve was preserved and the bone hollowed out to bed the excess nerve. Fixation was the same as in the previous case.

In 1977 Dingman acknowledged that in the past mandibles had been moved back when in fact maxillae should have been moved forward. He noted, however:

I think there are still some cases that have reasonably good maxillary development, with a true prognathic mandible deserving osteotomy.

SUBCONDYLAR OSTEOTOMY

In 1897 Berger resected the mandibular condyles to treat prognathism. In 1898 M. Jaboulay and L. Berard reported their method of subcondylar osteotomy.

In 1921 Leon Dufourmentel of Paris, one of the early pioneers of plastic surgery, advocated condylectomy and mandibular retropositioning for prognathism. During my 1948 peregrinations as a plastic surgery student, I had the pleasure of dining with the senior Dufourmentels in their luxurious apartment, and at one time they had five different wineglasses at my place. It was impossible to lift one without striking another, and my side of the table began to sound like noon chimes in Notre Dame.
Leon Dufourmentel was chief of l'Hôpital Saint-Louis and did his mandibular work there. Today his equally famous son, Claude, is chief of this same hospital. It is 400 years old, having been set up by King Louis XIV as a stopover first aid station for him and his court on their way back to Versailles in case of accidents during hunting trips.

Francis Kostecka of Czechoslovakia was another contributor to mandibular surgery. Born in South Bohemia, trained in general surgery and specializing in stomatological surgery, he traveled to most of the important oral surgical centers in the world, including Vienna, Berlin, Geneva, Paris and London, with three months in Chicago with Brophy, studying cleft surgery. He returned to Prague to head the stomatological clinic at Charles University, and in 1926 at the Eighth International Stomatological Congress in Philadelphia, he presented his surgical treatment of prognathism. In 1931 Kostecka simplified the subcondylar osteotomy by the use of the Gigli saw. This method became known as the Kostecka osteotomy and enjoyed some popularity.

Dingman's evaluation of this procedure is of interest:

A fascial interposition prevented union and resulted in a false joint. Destruction of the temporomandibular joints plus the abnormal pull of the pterygoid muscles makes this an undesirable procedure.

**EARLY CONDYLECTOMY**

In 1976 dentist Edmond A. Adler of West Perth, Australia, published a paper on "Early Condylectomy to Prevent Prognathism" in the *Journal of Oral Surgery*. It described how, through a standard endaural incision, stripping of the lower head of the lateral pterygoid muscle from its mandibular insertion and section of the condyloid process at the junction of the head with the neck were accomplished. Adler noted:

Bilateral condylectomy in young patients brings about cessation of anteroposterior growth of the mandible. If the condyles reform before body growth is complete, anteroposterior growth of the mandible recurs. Preliminary observations indicate that the procedure, used in ten young patients, reduces or prevents mandibular prognathism.
The *Journal* editor warned:

One must be careful in drawing a positive conclusion about the effectiveness of such a procedure from the current series of cases, since six of the ten patients were children with cleft palate and the correction involved adjusting a normal mandible to a retrusive maxilla, rather than the treatment of true prognathism.

In 1977 Harold K. McComb, also of West Perth, who cooperated in the surgery, added:

We have been halting mandibular growth in some of our cleft lip and palate patients if and when cephalometric studies show that their mandibles have already reached adult size, and that they are heading for an absolute, as well as a relative mandibular prognathism.

This has proved to be a very simple and effective way of forestalling gross malocclusion, and particularly for avoiding the traumatic effects of disfigurement during adolescence.

**HORIZONTAL OSTEOTOMY OF THE ASCENDING RAMUS**

In 1907 Vilray P. Blair of St. Louis first described division of the ramus of the mandible and shifting of the body of the bone backward. Blair, as evidenced by the many surgical innovations noted throughout *Cleft Craft*, was one of the pioneering geniuses of plastic surgery. He enjoyed the fringe benefits of genius, paying little attention to material things as long as they served their purpose, carrying out everyday necessities with varying degrees of rapidity while thinking of more important things and not always concerned with technique per se. A few lines from a 1972 letter from Blair’s talented artist, Gertrude Hance, which accompanied her portrait of him, are pertinent:

Dr. Blair was driving a very old, dilapidated Pierce Arrow, faded to what I called pink. We went to Jefferson Barracks several times a week and he was the world’s worst driver.

In 1913 and 1915, Blair reported more on his horizontal osteotomy of the mandibular ramus, carried out percutaneously with a Gigli saw. A Blair needle was passed anteriorly from the
posteromedial border on the medial surface of the mandible and out through the soft tissues of the cheek anterior to the mandible. The Gigli wire saw was passed through and the ramus sectioned horizontally between the inferior alveolar foramen and the notch, allowing the body to be moved posteriorly.

As early as 1909, W. Wayne Babcock of Philadelphia noted:

An ingenious method has been suggested by Dr. V. P. Blair, who makes a vertical incision one half inch in length posterior to the ramus, through which a heavy needle is passed into the incision behind the ramus, and then brought out through the cheek. By means of the needle, a Gigli saw is pulled through the tissues. A small metal tube is slipped over the saw through the puncture in the cheek so as to prevent lacerations of the face, then by simply pulling the saw backward and forward the ramus is divided.

Babcock then presented his own operation, using

a skin incision over the posterior border of the ramus of the jaw from zygoma to a point under and anterior to the angle of the jaw. . . . The outer fibers of the masseter muscle were separated and the external surface of the middle of the ramus exposed. With a small chisel a transverse section was then made through the ramus. The operation was repeated on the other side, and the body of the jaw then forced back, and the teeth placed in the best possible occlusion. . . . Certain of the lower teeth were wired to the upper.

In the illustrations of his osteotomy, Babcock presented an ivory or metallic button to fix the fragments. He also defended his external skin incisions as opposed to Blair's "scarless" Gigli saw osteotomy:

"The Gigli saw, as used by Blair . . . is very ingenious. . . . In my operation it was my desire to see the ramus. I wished to see how the fragments looked after the reduction, and I wished to use wedges also.

In Sweden, Allan Ragnell of Stockholm, in 1938, and K. E. Hogeman of Malmö, in 1951, performed horizontal sectioning by means of a saw introduced through a postauricular incision, temporarily severing the external auditory canal in order to obtain a more adequate approach to the ramus.

In 1950 J. Barrett Brown, with Minot Fryer and J. B. Templeton, noted:
There are, however, some late deformities in patients with cleft lips and palates that show such disproportion as to appear prognathic, and to have occlusions that are not adequate for mastication. When these patients are too old, or otherwise not suited for orthodontic expansion of the upper arch, then the lower jaw can be recessed to proper proportion with the upper, so that an external balance of appearance is obtained.

He advocated the horizontal osteotomy operation Blair described in 1907, with minor refinements.

In 1954 V. H. Kazanjian of the Massachusetts Eye and Ear Infirmary, Harvard University, recommended a beveled cut with the chisel, sectioning the ramus obliquely from below through an external approach. This method increased the surface of contact between the bony fragments and decreased the tendency for separation of the fragments brought about by the pull of the lateral pterygoid muscle. The lovely drawings of this method for Converse were done by the famous artist Daisy Stilwell.

Dingman evaluated the advantages and disadvantages of the horizontal osteotomy of the ramus:

It is short and simple, no scar is involved, a good cosmetic result can be achieved, and there is no sacrifice of bone or teeth and no disturbance of the mandibular arch. The disadvantages, which may be serious, are: injuries to the facial nerve, to the internal maxillary artery with severe hemorrhage, to the parotid gland and to the mandibular nerve because of the blind approach. The failure rate is high due to lack of control of the proximal fragment. The strong pull of the lateral pterygoid and temporalis muscles may cause displacement or overriding and eventual nonunion or malunion. The thin cortical bone in this area contributes to poor healing. The strong muscles of mastication are positioned out of functional alignment, and with spasm, there is shortening and overriding of the fragments. With the molar teeth in occlusion, the resulting Class One lever forces the anterior teeth
into an open-bite position. These muscles are so powerful that the anterior teeth may be extruded from the maxilla or mandible regardless of the type of appliance or intermaxillary fixation used.

**OBLIQUE SUBCONDYLAR OSTEOTOMY**

In 1967 Edward C. Hinds and W. Girotti of Houston, Texas, advocated the oblique subcondylar osteotomy of the mandible through an external incision. They have had good results over a large series. Also in 1967, M. Robinson, simultaneously with Hinds, published a similar method of extraoral section of the ramus from a point behind the gonial angle to the sigmoid notch. The chief advantage of these procedures was simplicity, which has been responsible for much popularity of the principle.

Hinds and I have been friends since my residency days in Houston in 1951. He has continued his work in the Dental Branch of the Texas Medical Center, and his only true escape from jaws has been his snowmobile in northern Minnesota. I wrote him for an example of a cleft palate case in which he had used his oblique subcondylar osteotomy. He kindly forwarded this case, noting:

This young lady was a 15-year-old Latin American with a history of operated cleft lip and cleft palate. She was wearing a maxillary plumper to hold the upper lip out. A bilateral subcondylar osteotomy was performed on March 12, 1962. No direct wiring of the fragments was performed in accordance with my policy in management of prognathism by this procedure. In most
other osteotomies I do use direct wiring. We felt that setting the mandible back would give her much more acceptable facial appearance and certainly better oral hygiene. At that time, as you know, we were not involved in maxillary surgery to any significant degree.

In 1961 in *Plastic and Reconstructive Surgery*, Nicholas G. Georgiade, with Galen W. Quinn, of Duke University evaluated the reported satisfactory results of Hinds and Robinson, with variations of vertical osteotomies through the ramus of the mandible, and then modified the procedure, commenting:

The use of a vertical osteotomy that extends from the coronoid notch down to the angle of the mandible, rather than a short osteotomy high on the condylar area, we feel, has many advantages and practically none of the disadvantages of the older procedures. . . . Splinting of the bony fragments after section of the muscles of mastication, we feel, aids considerably in their eventual rapid healing of the osteotomy sites. Treatment postoperatively by means of intermaxillary wiring and fixation is all that has been found to be necessary for satisfactory stabilization of the mandible.

One of their representative cases was a patient with a severe maxillomandibular disproportion due to cleft palate and associated retardation of maxillary growth. The modified sliding angular ramus osteotomy improved the relationships. They noted the importance of preoperative cephalometric studies and preoperative equilibration. The advantages of their modifications are italicized. A *short* procedure in *one* stage under *direct* visualization through *small* submandibular incisions, with the line of sectioning from the coronoid notch to the angle of the mandible always proximal to the inferior alveolar nerve and vessels, avoided any damage to these structures.

J. B. Caldwell pointed out, however, that these techniques were not applicable in moderate or severe cases of prognathism because the temporalis insertion on the coronoid process prohibits retrodisplacement of the anterior fragment more than 10 to 12 mm. This difficulty may be partially overcome by transection of the coronoid process of the mandible.

Open bite, non-union or malunion, and the long period of immobilization required are disadvantages, according to Dingman.
ARMY ORAL SURGEON JACK B. CALDWELL 

Gordon Letterman

Army oral surgeon Jack B. Caldwell served at Walter Reed General Hospital in Washington, D.C., prior to transfer to Letterman General Hospital, San Francisco. While in Washington he collaborated with Gordon S. Letterman, son of the Letterman of the Army Hospital, who had trained in plastic surgery under Blair. In 1954 Caldwell and Letterman introduced vertical osteotomy of the ascending ramus. Through a submandibular incision which allowed elevation of the masseter muscle with the peristeme, the entire lateral surfaces of the ramus from the sigmoid notch to the inferior border of the mandible were exposed. The outer cortex was perforated with a dental drill and the ramus sectioned vertically from the sigmoid notch to a point 1 cm. in front of the angle of the mandible, posterior to the mandibular foramen. The coronoid process was sectioned to release the pull of the temporalis muscle. The outer cortex of the anterior fragment was removed by osteotomy with a dental bur, and the anterior fragment was placed posteriorly, residing on the medial side of the posterior fragment. The teeth were then held in occlusion with intermaxillary fixation.

In 1977 Caldwell, now of Denver, recalled the patient and circumstance that prompted the development of this method:

A young staff sergeant had been reduced to the rank of corporal within 6 months. Investigation revealed he was extremely concerned about his appearance due to acceleration in the growth of his mandible, which caused such deterioration that he was found drunk on duty. After a period of observation of the patient and the arrival of a Broadbent cephalometer along with orthodontist E. P. Suchard, a protégé of Broadbent, we came up with the idea of a vertical section in the ramus to correct this growth deformity in this patient, who had a protrusion of slightly over two centimeters with a tendency to open bite anteriorly. I had been unable to figure out how to treat him with methods known to us at that time. Faced with this dilemma, we made cut-outs of tracings of the patient's profile and finally decided on the vertical section which has been universally adopted since then.

MAXILLOFACIAL FOUNTAINHEAD

A young staff sergeant had been reduced to the rank of corporal within 6 months. Investigation revealed he was extremely concerned about his appearance due to acceleration in the growth of his mandible, which caused such deterioration that he was found drunk on duty. After a period of observation of the patient and the arrival of a Broadbent cephalometer along with orthodontist E. P. Suchard, a protégé of Broadbent, we came up with the idea of a vertical section in the ramus to correct this growth deformity in this patient, who had a protrusion of slightly over two centimeters with a tendency to open bite anteriorly. I had been unable to figure out how to treat him with methods known to us at that time. Faced with this dilemma, we made cut-outs of tracings of the patient's profile and finally decided on the vertical section which has been universally adopted since then.
families of friendly squirrels romp when not better occupied accepting nuts from visitors and cracking the shells with tooth and jaw efficiency that must inspire the entire little world of maxillofacial surgeons. Possibly coincidentally, Graz has had an impact on the reparative surgery of the jaw, having produced more than its share of ranking maxillofacial surgeons beginning with Trauner, then Obwegeser, Köle and the many others who traveled there to study.

In 1955 in *Oral Surgery, Oral Medicine and Oral Pathology*, Richard Trauner, with Obwegeser, described his L-shaped ostectomy of the ascending ramus:

To avoid any possible damage to the mandibular nerve, it is best to perform a vertical section in the frontal plane of the ramus, immediately posterior to the mandibular foramen which lies about 15 mm. in front of the posterior border. Vertically, it is situated between the upper and middle thirds of the ascending ramus; and in certain cases a little lower. . . . We prefer a rectangular osteotomy of the ramus, an inverted L with its angle facing anteriorly.

Heinrich Köle, at present of Linz and winner of the 1959 Martin Wassmund prize, while with Trauner in the Graz University Dental Clinic, noted the disadvantages of Trauner's L-method in 1965 in *Oral Surgery, Oral Medicine and Oral Pathology*:

1. The angle of the jaw remains too far forward.
2. The extraoral incision produces a scar which is especially visible in cases in which there is a deep impression of the retromandibular area.

Therefore, the esthetic results do not satisfy all demands. . . . I decided to try an ostectomy (that is, effective removal of the surplus bone) in the ascending ramus, thereby saving the angle of the jaw as far as possible.
To save the mandibular nerve and to improve the angle of the jaw, Köle performed an arched osteotomy. This method was especially indicated, he felt, in cases of extreme protrusion in which there were broad and long ascending rami and an obtuse angle of the jaw.

In 1964, in his book *Reconstructive Plastic Surgery*, John Marquis Converse, with S. L. Horowitz and D. Wood-Smith, described a simplification of vertical osteotomy which has become quite popular. Through a submandibular incision avoiding the marginal branch of the facial nerve, the ramus of the mandible was sectioned with a Stryker reciprocating saw. The medial pterygoid muscle was raised from the medial aspect of the posterior fragment, and the anterior fragment was moved posteriorly until the desired occlusal relationship existed. Excess bone in the posterior fragment was trimmed. In severe prognathism, a portion of the posterior border of the anterior fragment was resected to avoid impingement upon the mastoid bone or facial nerve. The teeth were held in fixation for six to eight weeks.

Dingman’s evaluation is of interest:

Advocates of this procedure consider its major advantages to be: a safe approach, effectiveness in severe prognathism, no intraoral contamination, arch moved as a unit without sacrifice of teeth or bone, avoidance of injury to the inferior alveolar nerve, normal temporomandibular joint relationship assured, and achievement of a good cosmetic result. Some of the same disadvantages of transverse osteotomy apply to the vertical osteotomy—that is, facial nerve injury, hemorrhage, parotid fistula, and prolonged immobilization. The muscles of mastication are thrown out of balance, and non-union, malocclusion and open bite can occur.
SAGITTAL SPLITTING OF THE ASCENDING RAMUS

In 1954 Karl Schuchardt of Hamburg described a short step osteotomy of the ramus that was the precursor of the true sagittal osteotomy.

The champion of the true sagittal splitting of the ascending ramus is Hugo Obwegeser of Zurich. With both dental and medical degrees, he received his early training in maxillofacial surgery with Trauner in Graz, then came to Rookesdown House to study under Gillies about 1952–1953, while I was writing the book with Sir Harold. He was a young, gentle, blond, blue-eyed Austrian, eager to learn the principles of plastic surgery and fascinated by them set out as “Ten Commandments.” It was apparent even then that Obwegeser would become a leader in his chosen field, but there was no hint he would become the dogmatic advocate of mandatory acquisition of both dental and medical degrees for all maxillofacial surgeons. Ideally he is right, for only those who have obtained a dental degree have the trained capacity to appreciate the true ecstasy of achieving a perfect occlusion of the teeth. There have been, however, notable exceptions.

Less than five years after his time with Gillies, Obwegeser, with Trauner in a 1957 Oral Surgery, Oral Medicine and Oral Pathology, presented the first true sagittal splitting of the mandibular ramus. This is his original description of the procedure:

The incision is made in the mucosa and periosteum, extending along the external oblique line. The lower end of the incision should be directed farther away from the molars toward and into the moveable tissue so as to facilitate closure. Next, the periosteum of the outer surface of the ramus is elevated. A wide-blade periosteal elevator with a deep curvature is hooked behind the posterior border just above the angle of the jaw. With the soft tissue thus kept out of the way, the bone is incised with a Lindemann burr. The cut should be carried horizontally. It should penetrate the cortical bone only. Next, the periosteum, together with the soft tissues between the mandibular notch and the lingula, is elevated medially. The contents of the mandibular canal are protected by again hooking the aforementioned periosteal elevator below the neck of the condyle. Now the bone is cut just below the mandibular notch to a depth that will leave only the lateral cortex.
intact. This cut should be about 25 mm. above the first cut. For correction of mandibular prognathism, the bone cut will have to be inclined upward and backward, whereas for correction of a mandibular retrognathia it should take a downward and backward trend. . . . Then an osteotome about 20 mm. wide is inserted and, in order to avoid damaging the contents of the mandibular canal, it is forced backward along the outer cortical plate. . . . When the osteotome is twisted, the ramus splits in two. Thus, a steplike splitting results in the sagittal plane of the ramus, with large cancellous bone surfaces facing each other. . . . By this method, three types of correction may be made. First, by retrusion of the large anterior segment, mandibular prognathism may be corrected; second, the jaw may be set forward to correct mandibular retrognathia; and third, rotating of the anterior segment will correct an open bite. . . . The next step in the procedure is fixation of the mandible by intermaxillary wiring.

In 1964 Obwegeser, concerned about damage to the skin, nerves and vessels, and the parotid gland sometimes incident to the external approach, in addition to the problems of non-union, continued to promote his sagittal splitting technique utilizing the intraoral approach. Fixation was held for six weeks. Obwegeser contended logically that the large surface contact area provided greater bony union. The obtuse angle of the jaw can be corrected, thus improving a major part of the deformity.
Dal Pont

Giorgi Dal Pont of Belluno, Italy, made a contribution in mandibular osteotomy. His basic interest in philosophy and mechanical sciences has influenced his work in stomatology. It is his feeling that in science, methods and theories often lead to blind alleys which prevent progress.

He explains his own “breakthrough”:

The technique of horizontal section of the ascending ramus, developed from Blair to Obwegeser, was bound to the concept of the horizontal section. Maybe because I was facing the problem the first time, it was not difficult for me to realize at once that the optimal solution was to abandon the external horizontal section and substitute a vertical section.

In 1959 Dal Pont suggested extension of the sagittal splitting osteotomy up to the third molar region. In 1961, in the *Journal of Oral Surgery, Anesthesia and Hospital Dental Service*, he presented a case of cleft lip and palate before and after his retromolar osteotomy and pointed out the advantages of this approach:

(1) a better and easier adaptation of the fragments; (2) broader contact surfaces; (3) greater possibility for correction of prognathism, micrognathia
and open bite; and (4) avoidance as much as possible of muscular displacement.

He noted (in b) that the masseter muscle was left on the distal fragments, whereas the internal pterygoid muscle moves together with the displaced larger fragment. In the other possibility (c), both muscles remain on the distal fragments.

Dal Pont described a sound sagittal procedure for retromolar osteotomy in which bone incision lies on a plane that starts near the edge of the linea obliqua and extends sagittally between the cortical plates from the retromolar region up to the mandibular angle. . . . To correct the prognathism, a piece of cortical bone is removed on the buccal aspect and in the anterior border of the ascending ramus, for proper adaptation of the fragments.

Tony Wolfe points out that this procedure increases the length of bony contact but warns that it also brings the third molar into the field. If the third molar is impacted, it can be difficult to remove without fracturing the proximal fragment and may well merit preliminary extraction.

In 1966 Dal Pont charted the evolution of ramus osteotomy with simplicity.
By 1971 Obwegeser had incorporated the Dal Pont extension in his procedure. It was well illustrated in his chapter in *Cleft Lip and Palate*, where he presented the versatility of the principle.

In 1974, at the Second Congress of the European Society of Maxillo-Facial Surgery in Zurich, Walter Pepersack and Hugo Obwegeser presented long-term analysis of their results in cases of sagittal splitting. They reported a 30 percent incidence of early anesthesia of the lower lip. This technique requires a skill beyond that of some surgeons. In 1972 Stanley J. Behrman of New York reviewed 600 patients receiving the sagittal splitting procedure by 64 oral surgeons and reported such complications as regression and relapse, hemorrhage, trauma to the mandibular nerve, edema, fragmentation of the ramus, necrosis or sequestration of bone, and infection. He warned that it required great technical skill, specialized instruments and assistants, and that because of the difficulty of exposure, it was not easy to teach. Because of the excellent bony apposition and remarkable freedom of movement
of the mandible afforded by sagittal splitting, however, he concluded that it was superior, and with experience, complications would decrease.

After completing his plastic surgery training at the University of Miami, S. Anthony Wolfe went to Europe for a year of postgraduate training in craniomaxillofacial surgery. No sooner was he overseas than he discovered the three centers of excellence in "hard tissue" surgery: Paris with Tessier, Zurich with Hugo Obwegeser, Hans Peter Freihofer, and Walter Pepersack, and Nancy with Jacques Dautrey. Nancy is a city situated right in the center of the prognathism belt stretching all the way to the Hapsburgs' Vienna and midway on the road between the other two cities.

Dautrey

Jacques Dautrey started as an orthodontist and stomatological surgeon with Ginestet at Foch Hospital, Paris. He and Tessier are old friends; in fact, Tessier insists his assistants and visitors drive three hours to the dreary industrial town of Nancy to see Dautrey work in his operating room on ground level at Clinique Saint-André. He limits his surgery to procedures on the maxilla, mandible and temporomandibular joint and carries out each with perfection and finesse in an atmosphere of tranquility. His two large operating room windows overlook rolling fields dotted with cows grazing peacefully.

Dautrey has done more than 500 sagittal splitting procedures of the mandibular rami and has reduced the incidence of numbed lip postoperatively to virtually zero. Patients leave the hospital two to three days after the surgery. Here is Wolfe's outline of Dautrey's refinements:

1. Instrumentation: All retractors used in the mouth are matte, and have outward-curved edges to avoid injury to the lips. Note also his modified Smiley osteotomes which when twisted will not crush the nerve. Fibre-optic aspirator is important for lighting, and Kerr drill with irrigating attachment prevents bone burn.

2. Ballooning of mucosa with dilute vasoconstrictor solution, and separate periosteal incision at a slight distance from the mucosal incision allows for a two-layer closure.
3. After drill holes are made through the anterior cortex, and medial and lateral cortical cuts made with a Lindemann burr, the modified Smiley osteotomy is used to hug the lateral cortical plate.

4. Ramus split delicately without using heavy instruments which crush the nerve.

5. He keeps the condyle seated in the glenoid fossa (which must be done to prevent postoperative anterior open-bite) by several tricks:
   
   (a) Before the osteotomy, he scores a vertical line, beginning on the maxilla behind the last molar, and running down on the lateral surface of the mandible. These marks on the maxilla and condylar fragment of the mandible are made with the teeth in their initial occlusion and should line up at the end of the operation.

   (b) Another method is to push the condylar fragment forcefully back against the posterior wall of the glenoid fossa, compressing the capsular cartilage, then allow it to come forward 2-3 mm. before trimming the excess bone from the distal portion of the condylar fragment. The two fragments would then fit exactly and are held together by a fine wire through the lateral cortices.

A final refinement developed in 1977 by Dautrey is the keeping of a small spur on the proximal fragment which fits into a pocket in the distal fragment, giving further stability by auto-contention.

In 1976, in *New Concepts in Maxillofacial Bone Surgery*, Bernd Spiessl of the University of Basel, Switzerland, described a touch of finesse he adds to the method by permanently fixing the two sagittally split fragments with three lag screws which can be inserted percutaneously through small stab wounds. The advantages claimed by Spiessl included a guaranteed position of the fragments, early mobilization and a shorter period of intermaxillary fixation.

In 1965 C. C. Knowles analyzed the remarkable change in facial contour after osteoplastic procedures on the mandible in cases of relative prognathism. It is his belief that preoperatively many of these patients have shortness and eversion of the upper lip and absence of the rolled outline of the vermilion border of the lower lip. Their appearance postoperatively gives the impression that the upper lip has been lengthened and has lost its eversion while the lower lip, previously undefined, now has a natural fullness. Knowles contends that this improvement is due
to an alteration of the muscles of facial expression, particularly
the depressor anguli oris inserting into the mouth. The origin of
the muscle from the lower border of the mandible tends to pull
the mouth downward as the mandible is moved back. The
backward movement of the risorius and platysma transmitted to
the orbicularis may be responsible for the improvement in the
lower lip roll.

MANDIBULAR RETROGNATHISM

According to Dingman in his section in *Cleft Lip and Palate*,
edited by Grabb, Rosenstein and Bzoch:

Eighty to 90 percent of children born with the Pierre Robin syndrome
(glossoptosis and micrognathia) have clefts of the soft palate or soft and
posterior hard palate [B. E. Bromberg, R. Pasternak, R. W. Walden, and
potential of the micrognathic mandible is inconsistent; while normal
growth is eventually seen in most of these patients [S. Pruzansky and J. B.
Richmond, 1954; B. Douglas, 1956], a significant number of them will fail
to reach full mandibular growth and have a retrodisplaced mandible with
Angle Class II malocclusion. If occlusal abnormalities are minimal or
orthodontically correctable, facial contour can be improved with onlay chin
implants of autogenous bone or cartilage, irradiated cartilage, synthetic
materials, or horizontal advancement osteotomy of the mandible below the
apices of the teeth. For severer degrees of retrodisplacement, a step osteot­
omy through the molar region, with advancement of the anterior fragment
and insertion of a bone graft, has been our choice of treatment. This
operation can be carried out in the teens any time after mandibular growth
has ceased.

According to Converse, oblique vertical section of the ramus
was described by A. A. Limberg of Leningrad in 1925 in the
treatment of micrognathia with open bite (A and B). Later, in
1928, Limberg proposed the addition of a costal bone graft for
the micrognathia. In 1927 Wassmund described a vertical section
with a forward angulation above the lingula, extending through
the base of the coronoid process.

In 1936 and 1942 O. Hofer described a method of correcting
anterior alveolar retrusion in the normal mandible by advancing
the entire alveolar fragment. In 1959 H. Köle modified the
mucosal incision and presented cross-section diagrams of this osteotomy with the correction fixed with circumferential wiring, as shown.

In 1948, in *Plastic and Reconstructive Surgery*, Reed Dingman presented his favorable step osteotomy for correction of mandibular retrusion in a two-stage procedure, with the first stage a single vertical cut above, at the point of lengthening. Two weeks later, through a skin incision 1 cm. below the inferior border of the mandible, a vertical cut well forward of the initial cut, and a horizontal cut below the inferior mandibular nerve joining the vertical cuts, produced a step osteotomy which allowed forward advancement of the mandible. Dingman noted that advancement of the mandible 1 cm. was possible without tearing the nerve. Bone wires and intermaxillary fixation were used.

In 1948 Pichler and Richard Trauner of Austria described a step-like osteotomy of the body to bring the mandible forward in microgenia.
In 1957 Trauner, again with Obwegeser, readvocated his cartilage graft of 1955:

For mild forms of mandibular prognathism I prefer the retrocondylar cartilage implantation because it is a minor surgical intervention which does not require a postoperative intermaxillary wire fixation. . . . Between the anterior wall of the auditory meatus and the glenoid fossa lies a bone suture, the fissura petrotympanica. Just before and above it, the bone is perforated with a small drill. The piece of cartilage is tied to the bone with wires going through this hole. The cartilage is situated close to the anterior wall of the bony auditory meatus.

In 1957 Hugo Obwegeser called attention to the fact that his sagittal splitting osteotomy of the mandibular ramus was also applicable to the correction of retrognathia.

In 1958 Karl Schuchardt of Hamburg utilized this type of osteotomy and inserted an L-shaped bone graft for the elongation of the mandible in micrognathia.

In 1976 Herbert Mehnert of the University of Innsbruck, Austria, presented his variation of the vertical osteotomy of the mandibular rami for retrognathism. He explained:

(a) After forward movement of the mandible to an Angle class I occlusion, the ramus is vertically osteotomised. (b) The condyle-bearing segment can then be replaced in the glenoid fossa. (c) Creation of a step with a bur to wedge in the condylar segment, so that the mandible does not slide back into distoclusion.
In 1977 Broadbent and Woolf of Utah reported 26 cases using the Obwegeser-Dal Pont sagittal split osteotomy for retrognathia. They noted that complications, especially relapse, weakness of the lower lip and numbness of the lower lip, were common enough to encourage them to look for another surgical approach with less morbidity, possibly the methods of Hinds, Trauner or Mehnert.

In our Rag Bag chapter in Gillies' and my *Principles and Art of Plastic Surgery*, a case of Treacher Collins syndrome presented a mandible of abnormal vertical length with a receding chin. An advancement osteotomy pivoted on a Gillies periosteal hinge was beneficial.

Method: An osteoplastic flap was cut from the lower margin of the mandible, leaving the periosteum along its upper border. This large block of bone could then be folded over to rest in front of the mandible to give the necessary prominence and contour.

Along the same principle but as a free graft rather than a flap, Obwegeser, advanced a V-shaped segment of inferior mandible to increase the mentum projection. By minor osteotomy or osteotomy of the anterior angle, he regulated the shape of the advancing arch.

Finally, here is Tony Wolfe's modification of mandibular advancement for receding chin in a 35-year-old schoolteacher with a bilateral cleft lip and Crouzon's disease. Extensive ortho-
odontic treatment gave her "satisfactory" occlusion, but she was left with considerable facial disharmony.

As Wolfe noted:

It would have been vastly preferable not to have had the preliminary orthodontics, so that a Le Fort III osteotomy alone would have corrected all the problems at once. Now if a Le Fort III advancement were done to correct the exorbitism and maxillary hypoplasia, she would end up with a Class II malocclusion, and either reverse orthodontics postoperatively or a simultaneous Le Fort I would be needed to maintain her present occlusion. The patient declined these two possibilities, so an orbital expansion, onlay bonegrafting to the anterior maxilla, and modified sliding advancement of the mandibular symphysis, retaining muscular attachments, were performed. She also had an Abbé flap and a corrective rhinoplasty.
Hemovac® was used for drainage and the wound closed in layers. Four circummandibular wires were passed and used to fix a previously fabricated Vitallium splint (Berkowitz).

An uneventful recovery was followed by removal of the splint and circummandibular wires after 8 weeks.
MODERN maxillary surgery has become an important part of secondary rehabilitation of the cleft lip and palate deformity, and it all began when a brilliant and curious Frenchman started hammering on cadaver skulls to see where they fractured.

René Le Fort of the University of Lille, France, served for years as a military surgeon at Val de Grâce Hospital in Paris. In 1901 he published the results of his cadaver experiments, which followed the principles of the scientific method laid down 50 years before by Claude Bernard. His work involved positioning cadaver heads, striking them with a piano leg, and then, by dissection, discovering the extent and type of the maxillary fracture. Here are some of his notes, as translated by Tessier:

The upper jaw, despite its multiple connections to the base of the skull, enjoys a considerable independence from it. . . . A great number of weak points (or better said, lineae minoris resistentiae) cause the facial bones to break into fragments so that the stress is exhausted by the effect produced, preserving the integrity of the bony envelope of the brain.

His first great weak line, or Le Fort III fracture, passed through the nasal bones, cribiform plate, upper part of the frontal process of the maxilla, upper part of the lacrimal bone, medial walls of the orbit, into the intraorbital fissures, across the orbital floors into the sphenoid and even frontal bones, and down across the base of the pterygoid processes. His second great weak line, or Le Fort II fracture, crossed the lower part of the nasal bones, frontal processes of the maxilla, lacrimal bones at the nasolacrimal canals, infraorbital rims at the junction of the malar bone and the maxilla, through the infraorbital foramen, around the malar bone
respecting it, across the upper nasal septum, into the pterygo-maxillary fissures, and across the base of the pterygoid processes. The third weak line, or Le Fort I or Guérin's fracture (1866), started from the lower part of the pyriform aperture, crossed the canine fossa below the malar bones, rising posteriorly to cross the pterygomaxillary fissure, and cut the pterygoid process. He acknowledged:

This third line is the one involved in Guérin's fracture, one of the most frequent forms of upper jaw fracture.

**USE OF LE FORT I IN TREATMENT**

Martin Wassmund of the Rudolf Virchow Hospital, Berlin, was the first to create a Le Fort I fracture for treatment purposes. Wassmund, the son of a preacher and a fiery, temperamental surgeon with degrees in dentistry and medicine, would go into battle at the drop of a glove to defend his methods. During World War II he was a chief of the Military Hospital for Maxillo-Facial Surgery, and over the years he carried out a phenomenal amount of maxillary, mandibular and palatal surgery. His favorite adversary was Axhausen. As early as 1927, he was the first to perform an osteotomy and repositioning of the entire maxilla in a case of anterior open bite. His osteotomy was performed along the lines of a Le Fort I fracture, extending completely across the maxilla and including the pterygoid plates of the sphenoid.

In 1934 Axhausen used elastic traction postoperatively to pull the maxilla forward into the desired position. In 1942 Karl Schuchardt was the first to suggest sectioning of the maxilla in the pterygomaxillary groove, thereby leaving the pterygoid plates intact.

**FORWARD MOVEMENT OF THE MAXILLA THROUGH LE FORT I OSTEOTOMY**

In 1952, Gillies and I wrote of Gillies' planned Le Fort I osteotomy:

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When a mandible has been retroposed following osteotomy, the pouting lower lip can be nicely tucked in behind the upper. Yet the harelip-cleft palate deformity is merely a relative prognathism of the lower jaw because of a true agenesis of the upper. For this reason protrusion of the maxilla by osteotomy would seem a more direct approach. Confidence in this technique has been developed through familiarity in dealing with floating fractured maxillae.

It is now freely admitted that the stresses laid on the maxillary arch by the early surgery of palate and lip lead to gross maldevelopment and agenesis of the maxilla and its teeth. We here follow the principle of “replacing normal into normal position,” and in the maxilla, therefore, we very much favour the bold osteotomy of the tooth-bearing segment. The fragments can now be held in predesigned positions to give maximal function and appearance.

The example case was Joyce, who had had nine operations for a bilateral cleft lip and palate, including three attempts at palate closure. The maxilla was contracted and the cleft still present, with the soft tissue remnants so tiny that even a Gillies-Fry procedure was not planned. An upper buccal inlay and nasal correction improved the lip and nose moderately, and the patient was able to speak more or less intelligibly with the aid of a huge obturator. Being a girl of great determination, Joyce was dissatisfied and eager to have maximum treatment. The plan was to correct the distorted maxilla and replace her obturator with a tube pedicle. The Rooksdown House chief of oral surgery, dynamic Norman Rowe, made dental models and the necessary splints and planned the fixation. Then, with his co-author H. C. Killey, Rowe made demonstration models which Gillies and I used in The Principles and Art of Plastic Surgery to show osteotomy and bone grafting of the deficient cleft palate maxilla. This was our description:

The upper buccal sulcus is incised, the mucoperiosteum reflected and nasal saw cuts are made in the maxilla on a line above the apices of the teeth. It is not always possible to avoid opening into the antrum, but when this occurs it does no harm. Remember that the principal blood supply of each maxilla following osteotomy is derived from the greater palatine artery, and preservation of this artery is essential. Therefore no attempt is made to divide the tuberosity with the saw. The final sectioning is achieved by inserting the chisel into the distal end of the saw cut, and after a few cautious taps the maxilla is levered downwards and outwards until the
remaining bony attachment of the tuberosity is fractured in a greenstick manner. It may also be necessary to pry open the original hard palate cleft before the segment is free enough to go into satisfactory occlusion with the corresponding lower teeth. The gum may go blue but the circulation has been found quite adequate. The casual hospital onlooker is often impressed by the fact that the patient suddenly takes on a more normal contour. The two maxillae are now fixed by plates and bar in the position they might have taken had their development been normal.

Care must be taken to relate the occlusion to the mandible and to the cranial base. Cancellous chips from the ilium are packed into the hinge, but a strong one tapped into the apex of the bone cut serves as the main wedge to keep the new position. Others are added to consolidate.

Initially it was feared that the bone graft, being exposed to the nasal cavity or possibly the antrum, might become infected. Experience has shown that this is not the case, for to date no graft has failed to achieve bony union. The integrity of the graft is probably preserved by the excellent blood supply, which is derived from the adjacent bone and muco-periosteal covering—the mucosal closure should be meticulously performed.

The sparks of Gillies' original work in osteotomies of old facial fractures and forward positioning of the maxilla in cleft cases, as well as his osteotomy design for correction of the oxycephaly of Crouzon's disease, kindled Tessier's interest in the new field of craniofacial surgery. Indeed, Tessier made many visits across the Channel to observe the work of Sir Harold Gillies.

It is now well recognized that the forward movement of the maxilla is much more frequently indicated to correct the prognathic appearance in cleft patients than retropositioning of the mandible. Gillies spearheaded the early work in this shift in clefts, as already described.
John Converse has been interested in forward advancement of the maxilla. In 1952 in *Plastic and Reconstructive Surgery* J. M. Converse and H. Shapiro described advancement of the maldeveloped maxilla with malocclusion (A). Their line of osteotomies extended from the pyriform aperture to the maxillary tuberosity on each side (B), crossing the hard palate (C), through the septum at the level of the nasal floor (D). Advancement of the maxilla reestablished dental occlusion (E, F). The illustrations by Stilwell were explicit.

By 1971, Obwegeser and his co-workers had carried out the Le Fort I osteotomy in over 100 cases, and it had become routine. Here are the steps in his approach: (1) vestibular mucoperiosteal incision from one infrayzygomatic crest to the other; (2) osteotomy of anterior wall of the maxilla and lateral wall of the nose, and separation of the nasal septum from the hard palate; (3) mucoperiosteum on the palate not elevated, transverse bone cut on the palate (Converse, 1952; Köle, 1965), and cutting the pterygoid plate avoided; (4) separation achieved with a heavy osteotome at the pterygomaxillary fissure; (5) tilting of maxilla forward with fingertip, fracturing the posterior part of the lateral wall of the nose and the posterior wall of the maxillary sinus; (6)
forward movement of maxilla facilitated by incision of soft tissue scarring.

Intermaxillary fixation with skeletal suspension, either circumzygomatic or percutaneous by wire to headcap or to pins in the frontal bone, is used, but direct wiring between osteotomy lines has been satisfactory in some cases.

In 1969 Obwegeser stressed the importance of placing bone blocks in the interpterygomaxillary space (IPM), wedged between the buttress of an intact pterygoid plate and the tuberosity to maintain the advanced position of the maxilla. In 1971 he readvocated insertion of this bone block, noting:

Failure to do so permits the scar tissue to contract and pull the maxilla backward.

He also recommended the insertion of bone where there is insufficient bony contact along the path of the anterior maxillary osteotomy. In spite of exposure these medullary bone grafts survive, as noted by Gillies and others. To correct any flatness in the areas of the infraorbital rims, subperiosteal bone onlays are inserted.

Here is a unilateral cleft case with retromaxillism and a humped nose that was corrected by Obwegeser, as shown in preceding diagrams (A, B and C) and partially presented in *Cleft Lip and Palate* with his technique of advancement in two sections. Models show preoperative occlusion and model operation for accurate planning (D).
Occlusal views are shown of preoperative (E), postoperative (F) and final dental bridge work by patient's dentist (G). Cephalometric x-ray films show preoperative condition and result four months postoperative with huge retromaxillary bone graft still visible. The before and after profiles show correction of the humped nose by forward movement of the maxilla only, without nasal surgery.

Tenacious Joseph E. Murray of the Peter Bent Brigham Hospital and Boston Children's Medical Center, the premier pioneer in kidney transplantation, has also been fascinated by craniofacial deformities. He fashions his plan of treatment according to the patient's desires and enjoys shifting and shaping bones. Once in the Brigham operating room while visiting as a Monks Lecturer, I watched Murray tailoring an iliac graft. He glanced up with a twinkle in his eyes.

Imagine getting paid for doing something as much fun as this!

Murray is challenged by deformities of the skull and facial skeleton as much as by the bleak face of a bad mountain. Whether on a wedge ascent of a chimney in the Alps or on the treacherous Nepal footpaths leading to Tibet high over the Kali Gandaki River running in the deepest gorge on earth, he faces each crisis with conditioning, caution and courage. He warns:

While wondering about the next hand, foot or rope hold there is danger; doubt is dangerous. Decisiveness in decision is followed by decisiveness in action and a secondary decision can be just as vital. . . . After a very difficult
traverse half way up Mt. Darwin in the Sierras we were trapped in a cul-de-sac with no escape. Here admission of our fault and retracing the tough traverse to a better alternative route was chosen over chancing an improper, unplanned new route.

In 1977 Murray forwarded a secondary cleft case in which Robert Gross had closed the lip in the early 40’s. The patient had been lost to follow-up for 20 years.

In November 1972, Murray, with Paul Tessier assisting during his first operative visit to Boston, carried out a mandibular setback (Obwegeser ramusotomy), maxillary advancement (Le Fort I) and onlay bone graft to the maxilla.

Murray reported:

bilateral paresthesia in mental areas, realignment of maxillary dentition and fixed prosthesis and excellent psychosocial rehabilitation. The patient married one of the nurses caring for him and now has a child and a successful real estate business.
Ian R. Munro of Toronto trained at Cambridge University and St. Thomas’s Hospital, London, and took his postgraduate study at the University of Toronto, where, as a resident at the Hospital for Sick Children, his interest in craniofacial deformities was first stimulated. From 1971 to 1974 he peregrinated between Tessier and Obwegeser, and now returns regularly for further observation. He always has classical music playing in his operating room, with his best work created during Wagner. Here are two of his secondary cases corrected by Le Fort I osteotomies:

**Case A:** Preoperative—15 years old. Unilateral cleft lip [LeMesurier] and palate with superior flap pharyngoplasty. Postoperative—1 year later: Le Fort I maxillary advancement in 2 segments and simultaneous lengthening of pharyngeal flap.

![Case A Preoperative and Postoperative Images]

**Case B:** 1973: Preoperative—15 years old. Unilateral cleft lip [Blair-Brown] and palate. 1976: 3 years after Le Fort I maxillary advancement and 2 years after secondary operation of Neuner bipedicle visor flap of mucosa from lower to upper lip and rhinoplasty.

![Case B Preoperative and Postoperative Images]
The blood supply to the maxilla during these advancements can become somewhat impaired. Gillies noted this situation, as has Obwegeser, who warned:

Often [gingival and palatal tissues] appear cyanotic during surgery, and, therefore, the suturing must be meticulous and the tissues handled with the utmost gentleness. The true fate of the palatal blood vessels is not known, but in a forward movement of up to 20 mm. it is improbable that they still function. However, in my experience, I have not seen necrosis of a bony segment.

Intermaxillary fixation is maintained for four to six weeks, and for two or three weeks after release of fixation forced opening exercises may be necessary. The first signs of a possible relapse will already be apparent during this period.

A WARNING

It has been noted that in patients in whom cleft palate surgery has included ligation of the greater palatine vessels, partial maxillary necrosis can occur when major maxillary advancement (2 cm.) is carried out subsequently. In 1979 Rainer Drommer of Gottingen, Germany, with Obwegeser studied 12 cleft palate patients being considered for Le Fort I osteotomies, using external carotid arteriography to show presence or absence of vessels. All but 1 of the 12 revealed the descending palatine artery and its branches to be intact. In the one exception a Le Fort III osteotomy was used. They concluded that in the absence of the greater palatine vessels, Le Fort II or III osteotomies, in preference to Le Fort I, may be indicated for a safer advancement since these more radical procedures at least preserve the needed anterior vestibular blood supply.

Multilingual Stephen Anthony Wolfe of the University of Miami, as the son of a military attaché (a legitimized spy), spent his childhood in Russia, France and Switzerland. As a Harvard medical student, during a visit to a state institution for the mentally retarded, he saw several patients with acrocephalosyndactyly (Apert’s syndrome) with near normal intelligence. He
learned that one of these patients, with the usual grotesque and monstrous facial appearance, had had to take the institution entrance exam three times to get a low enough I.Q. test score to qualify for admittance and relegation to a hiding place. While a surgical resident at Boston’s Peter Bent Brigham Hospital, Wolfe came upon Paul Tessier’s first corrective craniofacial publication including Apert’s disease, in the Annales de Chirurgie Plastique. In 1968 he saw Tessier give a presentation in Montreal. After completion of a plastic surgery residency at the University of Miami, Wolfe went to Europe to study for a year at the hard tissue centers of excellence, working primarily with Tessier in Paris, but also visiting Obwegeser in Zurich. Wolfe was impressed with the importance of Obwegeser’s IPM bone grafts. He noted:

In the Le Fort I osteotomy, these IPM bone grafts are more crucial than in the Le Fort II or III osteotomies, since only in the IPM space and across the anterior maxillary osteotomy lines are bone grafts put to maintain position against subsequent soft tissue pressures. In the Le Fort I osteotomy, even if there is good intercuspation of the teeth in their new position, intermaxillary fixation for six weeks is necessary. If there is not good intercuspation, an overcorrection of 2–3 mm. should be done.

Wolfe outlines his Le Fort I osteotomy:

1. Nasal intubation, with tube sutured to septum.
2. Infiltration of alveolar mucosa with 1:400,000 epinephrine high near upper buccal sulcus to facilitate later closure.
3. Mucosal incision stops near the first molar and further dissection into pterygomaxillary space done by tunneling to permit later closure.
4. Mucosa dissected free from pyriform aperture and septum. In cleft cases, a more thorough dissection of the nasal floor in the cleft side is necessary.
5. Medial anterior maxillary cut well above pyriform aperture ("Le Fort 1⅔") and slightly up on beginnings of malar prominence to avoid tooth roots.
6. Pterygomaxillary disjunction done gently with butt of hand on a sharp, curved osteotome. The pterygoid venous plexus may bleed vigorously, but generally this can be controlled with packing. Reoperative surgery in this area can be particularly bloody.
7. The septum is cut submucosally with a guarded osteotome.
8. At this point, firm downward pressure on the maxillary alveolus will open up a gap in the maxilla through which the medial and posterior walls of the maxillary sinus can be cut under direct vision.

9. The Rowe forceps, or Tessier “de-Crouzonizing” grapnels achieve a completely free maxilla which can be brought into the desired occlusion.

10. Bone grafts placed in the IPM space if there has been an advancement of more than 2 to 3 mm., and wired along the anterior maxillary cut. Fresh iliac cancellous bone is preferred to all other materials. In cleft cases there is often a differential movement of the two segments. Bone grafting of the nasal floor on the cleft side gives bony continuity to the palate, which can be continued anteriorly to close the alveolar arch.

11. Suspension and immobilization with circumzygomatic wires. If there is any mobility at the maxillary osteotomy line, further stability can be obtained with a wire passed percutaneously around a screw in the glabellar region (Kutner suspension).

12. Nasogastric tube passed at end of the case.

13. Intermaxillary fixation 6-7 weeks.

Here is a girl born with a unilateral cleft of the lip and palate, treated in infancy in South America, who developed a retro-maxillism which, in turn, was treated by another service with a Le Fort I osteotomy at the age of 11 years with apparent correction of occlusion. When seen at age 15 years, she revealed a moderately severe class III malocclusion requiring a 10 mm. advancement. This postoperative relapse is a common occurrence in cleft cases, but it was exaggerated by continued growth of the mandible while the osteotomized, bone-grafted maxilla remained stationary.

Tony Wolfe, with the assistance of orthodontist Sam Berko-witz, undertook maxillary correction. He noted:

Re-doing a Le Fort I osteotomy is not as easy as the original operation. When a bone graft has been placed in the pterygomaxillary space, the pterygoid venous plexus becomes adherent to the bone graft and considerable bleeding can occur during dissection of the soft tissues from the bone. This occurred in this case during the pterygomaxillary disjunction but fortunately was controlled with patience and by packing with Surgicel. This bleeding can be far more serious, and indeed deaths from sanguination at this stage in a Le Fort I osteotomy have occurred (D. Wood-Smith verbally reported one at the Duke Cleft Palate Symposium in 1973). Therefore, one
should wait until mandibular growth is complete before advancing the maxilla.

This timing of maxillary surgery pertains to other craniofacial procedures. Those advocating early maxillary advancements in the first half of the first decade of life for Crouzon's and Apert's syndromes to "spare these poor little children and their parents any psychological stress" will markedly increase risks when reoperation becomes necessary.

Nine months after maxillary advancement and correction of malocclusion, I performed a cleft lip rhinoplasty including nasal reduction, alar cartilage lift and overlap, septal cartilage struts into columella and alar base advancements (Volume I). Three months later the alar rim was revised and upper lip scar excised with transposition of a narrow vertical flap from center of lip to lengthen the short left side. A shield-shaped Abbe flap was transposed into the defect.
In cleft palate patients, once the Le Fort I has been performed, the two halves of the maxilla will be independently mobile. Transverse palatal expansion can be achieved and maintained by bone grafts in the cleft space.

Excellent occlusion by a skilled but overenthusiastic orthodontist can prevent the best treatment and force second-rate onlay grafting. S. A. Wolfe considers this a frequent and frustrating situation, one of the greatest crosses the maxillofacial surgeon is being forced to bear. He noted:

Orthodontists who do not work closely with a surgeon can fall into the trap of treating skeletal deformities with orthodontics. In essence, they burn the bridge for a monobloc advancement. This patient had maxillary hypoplasia and class III malocclusion, but underwent extraction of teeth and orthodontic therapy instead of a Le Fort I. Onlay bone grafting gave considerable improvement, but was clearly the procedure of second choice.

She later had some nasal correction and a midline, shield-shaped Abbe flap.

In 1977 Hans Freihofer of Zurich emphasized the wisdom of waiting to do bone surgery:

Based on the experience of 100 cases, I would strongly suggest that before performing orthodontic surgery, one should wait until growth is completed. This applies especially to Le Fort I osteotomies so important for many cleft patients. The comparison between non-cleft and cleft cases has shown that the results in young non-cleft patients are very bad whereas the results in cleft patients are even worse. Among patients being operated below the age of 16, there are 71% non-acceptable results, and among patients being
operated between 16 and 17 years, the percentage was 27%. In non-cleft patients the respective figures are 29% and 12%.

Of course, this is very bad news for cleft patients because, according to our philosophy, “first the bone and then the soft tissues.” This means that secondary corrections can only be undertaken very late and often cannot be terminated at the age of 20.

**NASAL CHANGES WITH LE FORT I MAXILLARY ADVANCEMENT**

In 1977 in the *Journal of Maxillofacial Surgery* Hans Peter M. Freihofer, Jr., of Zurich elaborated on the nasal effect of maxillary advancement first noted by Obwegeser:

Based on 25 cases with unilateral clefts of lip, alveolus and palate with retromaxillism (CLAP) and 25 cases with pure retromaxillism (RM) the effect on the nose of advancing the maxilla by a Le Fort I osteotomy is analyzed. It can be shown that on average the base of the nose which is at the same time the base of the upper lip, follows the base of the maxilla in a ratio of 4:7 while the nasal tip is advanced in a ratio of 2:7. This means that to achieve a specified advancement of the nasal base, the maxilla has to be brought forward about twice this amount. A planned advancement of the tip of the nose can, on average, only be obtained by an advancement of the maxilla by three times this amount. The tangent to the columella is tilted considerably forwards and upwards. The movement is a little more marked in CLAP than in RM. . . . Leaving the nasal spine intact and tilting the maxilla forwards and upwards have a favourable influence on the advancement of the nasal tip. . . . On the other hand, if the nasal profile is required to stay unchanged as far as possible, the nasal spine should be removed and the maxilla should rather be tilted downward.

**FORWARD MOVEMENT OF THE MAXILLA WITH LE FORT I AND OPENING THE CLEFT**

Forward advancement of the maxilla while simultaneously opening the cleft is most often used in unilateral complete clefts, combining the techniques of rotation and advancement of the maxillary segments. Obwegeser has been a pioneer in this maneuvering.
Here is an interesting segmental Le Fort I osteotomy by S. A. Wolfe, who refers to this type of Le Fort I as a "Le Fort \( \frac{1}{2} \) plus \( \frac{1}{2} \)." The patient was born with a unilateral cleft lip and palate. A LeMesurier closure of the lip and a von Langenbeck palate procedure had been carried out in Alabama. I did some lip and nose revisions at age 6 years and a cleft lip rhinoplasty at 16. Subsequently, the patient's orthodontist wrote from Georgia stating that he was unable to obtain a satisfactory occlusion and that an oral surgeon had recommended a mandibular setback. Tony Wolfe was consulted and this is his report:

The patient's soft tissue result was reasonable and the profile acceptable but there was still moderate flatness of the midface. Analysis of the dental models showed class III malocclusion at the molar level of both of the maxillary segments, but with a left segment which was also in crossbite, and anteriorly had an open bite of 13 mm. Thus, the left maxillary segment was making very little contact with the mandible, and was almost useless to the patient for mastication. There is no way that moving the mandible back would correct this. It would only give a better occlusal relationship to the teeth of the right side and would do nothing for the flatness of the patient's midface.

Before osteotomies

Operation: Anterior maxillae sectioned well above the level of the pyriform aperture. On the left, there was no pyriform aperture since the bony cleft extended into the nasal floor. A large oronasal fistula present on the left, running up through the cleft alveolus. Careful sectioning of bone connections between pterygoid plates and maxillary tuberosities. Nasal septum and vomer cut from palate (attached on right only). Fracture of medial and posterior walls of maxillae then produced by firm posterior pressure. Maxillary osteotomy line then opened up with distraction forceps, and remaining
small bony connections, clearly visible through the now-opened maxillary sinus, sectioned with a small osteotome. Both greater palatine vessels clearly seen from above, through the sinus. Soft tissue stretching carried out with Rowe forceps and Tessier grapnels until both maxillary segments could easily be moved beyond their intended positions with only slight traction from a tissue forceps. The right segment was moved 6 mm anteriorly and 2 mm laterally. The left segment was brought forward 8 mm, laterally 4 mm, and rotated inferiorly 13 mm. Circumzygomatic suspension attached to the circummandibular wires to avoid excessive traction on teeth, and intermaxillary fixation obtained. Nasal lining had been separated from the palate the entire length of the palatal cleft on the left, and this was closed. Cancellous iliac bone used to fill the palatal cleft, rebuild a nostril floor and pyriform aperture on the left, and close the alveolar cleft. Corticocancellous chunks placed in pterygomaxillary spaces. The oronasal fistula was easily closed.

Intermaxillary fixation was maintained six weeks and dental models obtained to show the results clearly. Such a result could have been obtained only by very great difficulty and extensive postoperative orthodontics if the mandible had been set back and the cleft bone grafted, as suggested, and he still would have had a flat face.
In the bilateral cleft, forward advancement of the maxilla, while opening the cleft, poses a danger because the blood supply to the premaxilla enters only through the vestibular mucosa. Obwegeser advised:

In the first operation the lateral alveolar segments only are advanced; in the second operation, when the re-opened cleft is being closed, I advance the premaxilla and do a simultaneous bone implantation.

Jacques Dautrey of Nancy has added a modification. For cleft lip and palate cases he no longer does a complete Le Fort I, having noted that the second superior molar almost always occupies the normal position. He therefore performs a unilateral segmental osteotomy which mobilizes the incisors, if present, and the canine, the two premolars and the first molar. The positioning of this limited segment is much easier and is satisfactorily immobilized with a simple arch bar (without the use of intermaxillary fixation) since the second molar of one side and the entire hemi-arch of the opposite side remain intact. Three months later he does the other side, if necessary.

Here is a fantastic case. The premaxilla had been excised at the time of closure of what was probably an incomplete bilateral cleft. Dautrey achieved advancement of the maxilla and opening of the cleft using his modification. When the patient was first seen at the age of 20, the mandibular arch was normal and the two remaining maxillary segments were in severe crossbite, with dental contact only at the right second molar. Cephalometrically the mandible was in relatively normal position, but its prognathism can be explained by the fact that, with a maxilla contracted in the vertical plane, the mandible had to go beyond the normal closing angle before making contact with the lonely molar, reminiscent of the pseudoprognathism of the edentulous elderly.

Dautrey moved the mandible back within striking distance by sagittal split with intermaxillary fixation. Then with extraction of a first molar, keeping the second molar and the maxillary arch on the other side as stable fixation points, he freed one two-tooth segment and rotated it into relation with the mandible. The movement was lateral and posterior and put the teeth into a usable maxillary arch. Fixation was achieved by a rigid arch bar from the shifted segment to the stable segment of the opposite side. In the second stage, the opposite maxillary segment was
shifted and fixed in similar fashion. The final result shows the patient without any soft tissue surgery but with a fixed anterior bridge in place.
FORWARD MOVEMENT OF THE MIDDLE THIRD OF THE FACE BY LE FORT III OSTEOTOMY

Gillies was the first to accomplish this maneuver, having become interested during the wars in maxillary refracture. As we wrote in 1952, and published in 1957:

A plethora of these upper jaw fractures since 1916 enables our War Office report to state categorically in 1939: "Malunion has occurred, interfering with mastication and/or appearance. Treatment—an attempt should be made to obtain union in a more favourable position by osteotomy.

An important case for Gillies was Airman Forbes, who crashed coming in from an operational flight, crushing his face against the dashboard with a type of Le Fort III fracture, plus splitting the hard palate and sustaining a symphysis fracture of the mandible. Immediate disimpaction and fixation resulted in a remarkable recovery which was exciting to Gillies.

LATE OSTEOTOMY

Another historic case concerned a Hurricane pilot who crashed, suffering severe fractures of the face with everything below the eyebrows pushed back. His spinal injury caused facial correction to be postponed one year. Then in 1941, with neurosurgeon Cone, Gillies made chisel cuts through nasal arch to floor of orbit—out to fronto-nasal synchondrosis—over to zygomatic arch—down spheno-maxillary suture (with osteotome)—lever behind last molar—entire maxilla rocked free. Forward retention maintained by 1-lb. weight and pulley attached to maxillary splint. . . . After a bone graft was implanted in the floor of the right orbit, the diplopia was reduced.

FIRST OSTEOTOMY IN CONGENITAL CASE

In 1949 Sir Harold Gillies performed the first osteotomy of the facial bones along the lines of a Le Fort III fracture to advance the mid-face in a nurse with Crouzon’s disease.
There was considerable postoperative loss of the maxillary advancement gained surgically in this case. In 1954, with Norman Rowe, Gillies acknowledged that bone grafts in the osteotomized spaces were necessary to maintain the advanced position of the maxilla.

Although Gillies was first with a Le Fort III, Paul Tessier of Paris has developed principles which now allow movement of any part of the upper half of the facial skeleton into any position.

Reed Dingman of the University of Michigan stated in 1977:

In the past, we have done mandibular setbacks when we should have been doing maxillary osteotomies with advancement.

He forwarded this interesting case of a 16-year-old boy who had his cleft lip closed at 1 week and his palate at 1 year in Detroit. He noted:

The nose had a large dorsal hump with a bulbous drooping tip and flattening on the side of the cleft. The upper lip was short and tight transversely with notching at the site of the lip repair. The middle one-third of the face was underdeveloped and recessed. There was relative mandibular prognathism and Class III malocclusion. The palate was very short but moved very well. The teeth were in fairly good condition and speech was satisfactory.
After consultation with orthodontist Ponitz,

On July 9, 1969, the patient had a tracheostomy followed by a Le Fort III-type maxillary osteotomy with mid-face advancement and bone grafts from the right iliac crest [Tessier]. Intermaxillary fixation was maintained by means of Erich appliances and rubber bands. Five days later a Georgiade halo appliance was added to apply forward traction on the maxilla. The patient was discharged on the 8th postoperative day.

After 4 1/2 weeks, the halo apparatus was removed as well as the rubber bands. One week later the arch bars were removed. His occlusion was satisfactory. However, the patient’s speech showed a great deal more nasality than before his operation. This was thought to be due to advancement of the palate leaving a larger velopharyngeal gap. Therefore, the patient had a superiorly-based pharyngeal flap and palatoplasty performed on November 18, 1969. Following this, his speech was again excellent.

In 1970 the patient had an Abbe flap and submucous resection for a deviated septal cartilage and later a corrective rhinoplasty.

Wolfe suggests that in a case such as this, without exorbitism, it may be preferable to use a Le Fort II osteotomy, since a Le Fort III can result in enophthalmos.

In the Le Fort III osteotomy, Wolfe noted:

There are enough points of osteosynthesis that the maxilla is often so stable in its new position that IMF is not necessary. This has been done in two patients now with no appreciable relapse over a 2 year period, and Tessier has had a similar experience.

The major monobloc shift of a Le Fort III corrects many problems simultaneously—retromaxillism, exorbitism, nasopharyngeal atresia, with often a dramatic improvement in facial appearance.
As taught by Obwegeser, it is important to keep the pterygoid plate intact to serve as a buttress against which a bone graft block can act to hold the advanced mid-face in the forward position. Here is a case by S. A. Wolfe in which a Le Fort III osteotomy had the advantage of a bone graft block placed exactly the same as in a Le Fort I. The tomograms show the bone graft in the space between the pterygoid plate and the maxillary tuberosity.

**SEPARATE FORWARD MOVEMENT OF THE MIDDLE THIRD OF THE FACE BY COMBINED LE FORT I AND LE FORT III OSTEOTOMIES**

When there is a disparity in the retroposition of the upper half and the lower half of the middle third of the face, each half poses a separate problem. Primarily, the upper half has an aesthetic deficiency with pseudoexorbitism, while the lower has functional impairment of occlusal imbalance. This calls for Le Fort I and III osteotomies simultaneously. The gaps are filled with bone, and fixation is maintained with intermaxillary wiring plus inter-skeletal suspensions.

Here is a dish-face deformity in a bilateral cleft case corrected by Obwegeser by advancement of the middle third of the face in two layers after Le Fort III and Le Fort I osteotomies, anterior
positioning of the premaxilla with bone grafting and closure of remaining fistulae and elongation of the columella and complete rhinoplasty. Cephalometric x-ray films show patient before and after surgery, but before dental prosthodontic work.

Professor Hugo Obwegeser is constantly involved in clinical teaching. In 1971 in *Cleft Lip and Palate* he set as the goal in hard tissue surgery of the maxilla in postoperative cleft lip and palate cases the old Gillies edict: *Replace into normal position what is normal and retain it there.* He noted that adhering to this principle required the following:

1. Correct the axes of inclination of the teeth with the alveolar process; create a normal arch, which may be done by surgery or by orthodontic treatment or by both methods.
2. Reposition the alveolar process so that its axis is properly aligned with the base of the jaw.
3. Establish acceptable intermaxillary and occlusal relationship; the new position should, of course, harmonize with the other parts of the facial skeleton.

4. Some cases require additional facial contour alterations. The main procedures are: onlays, recontouring a bone that is too prominent, or using a dental prosthesis.

Obwegeser’s aids to preoperative planning are:

1. Photographs (front and profile views of the face and intraoral views—occlusal, palatal, and any special views needed).
2. Extraoral radiographs (cephalograms, standard views, orthopantomograms, and tomograms).
3. Intraoral radiographs (periapical and occlusal).
4. Dental examination: carious lesions, vitality, and periodontal tissues.
5. Study casts: one stone set to record the preoperative occlusion and the jaw relationship; two plaster of paris sets to be used for model operations.
6. Observe the functional movement of the mandible and the motility of the muscles of the facial expression; check the trigeminal nerve.
7. Record the patient’s speech.
8. Evaluate the patient’s total health.
9. Secure any additional indicated consultation of other specialists: e.g., speech therapist, orthodontist, prosthodontist, otolaryngologist, etc.

MALPOSED TEETH

In the presence of a good jaw and an acceptable alveolar relationship, malposed teeth can be corrected with orthodontia. Orthodontic treatment should be limited to aligning the axis of the teeth with the axis of the alveolar process. Creating an overjet by orthodontia results in little improvement in the patient’s outward appearance—the teeth and/or alveolar process inclining too far anteriorly while jeopardizing periodontal tissues—and renders subsequent surgical correction of the profile more difficult.

SOPHISTICATED SEGMENTAL PROCEDURES

Corticotomy

It often takes a long time to move adult malposed teeth by conventional orthodontic methods alone. Corticotomy combines
surgical and orthodontic treatment and, by decreasing bony resistance, shortens the time factor. In 1958 Heinrich Kōle of Graz described this technique. A gingival margin incision allows reflection of the mucoperiosteum in the selected area. A thin bur is used to make vertical cuts through the cortical plate of the alveolar bone on the buccal or palatal side, depending on which direction the surgeon desires to move the teeth. The vertical cuts are placed on both sides of each tooth selected for movement and extended to a level just above the apices of the teeth. The mucoperiosteum is replaced, sutured and allowed to heal about 10 days before orthodontic movement is begun.

**Unilateral rotation of small alveolar segment**

A common deformity in clefts of the alveolus and hard palate is the upward and inward displacement of the alveolar process and its teeth on the cleft side. As noted by Gillies and Millard in 1957 in *The Principles and Art of Plastic Surgery*, this segment has to be tilted downward and rotated laterally. As pointed out by Norman Rowe in 1954, the axis for both movements is an imaginary line extended through the maxillary tuberosity. In Obwegeser’s diagrams for *Cleft Lip and Palate*, the broken line marks the mucoperiosteal incision and the bone cut by bur as a horizontal osteotomy from the pterygomaxillary fissure anteriorly to the pyriform aperture at the level of the infraorbital foramen (A).

An osteotomy is also done on the lateral wall of the nose just below the level of the inferior concha. Bony connections, between the halves of the hard palate and mucosa of the nasal floor, are cut with a small osteotome. A heavy elevator is used to pry the segment into the desired position. This rotation creates two
fractures: The posterior wall of the sinus will fracture, and the pterygomaxillary fissure will greenstick fracture (B). The mobile fragment should be held in corrected position for six weeks by a preoperatively applied splint fixed to the other side of the upper arch. The upper arch and palate is shown before operation by Obwegeser (C). The upper arch and palate is seen after lateral rotation of a small segment and closure of reopened cleft using a vestibular flap as oral layer in the anterior palatal area and after definite bridgework constructed by patient's dentist (D).

Obwegeser noted:

The goal of all these procedures—the osteotomy, the repositioning of the displaced alveolar segment, cleft closure with bone grafting, and postoperative orthodontic treatment—is to create normal occlusion, and to create more favorable conditions for the construction of a denture or a fixed bridge. All of these, of course, improve the appearance of the face.

**Rotation of bilateral alveolar segments**

The management of a bilateral case is similar to that of a unilateral case. Both sides are rotated simultaneously with greenstick fractures in the tuberosity areas. In addition to intermaxillary fixation, interskeletal suspension, usually by circumzygomatic suspension wires, is required. If the premaxilla needs repositioning, this is done later with bone grafting, at the same time that the cleft is closed.

**Unilateral complete clefts**

The smaller segment is moved as already described. The incision for the larger segment is carried across the midline and extended into the cleft. The mucoperiosteum is reflected, the nasal spine removed and the vomer separated from the palate. The bone cutting and repositioning are similar to those on the other side. As soon as the fragments are mobile, the smaller segment is positioned laterally first. If the mucosa of the vomer prevents lateral rotation of the large segment, it is incised at its junction at the floor of the nose under direct vision. Fixation and intermaxillary immobilization are essential.

**Reducing broad maxillary arch**

As noted by Hugo Obwegeser, an orthodontically overcorrected
maxillary arch may be too broad, with the teeth flared. Also, in cases of retromaxillism, surgical bilateral rotation of the alveolar segments without forward repositioning may produce an arch that is too broad. To compress such an arch, tissues must be removed from the cleft area of the hard palate and the alveolar process. With limited reflection of palatal mucoperiosteum, the planned amount of bone and soft tissues along the margins of the palatal cleft is removed. The broken lines mark the bone cuts, which are carried out as in the outward rotation technique. The arrows indicate the direction the palatal segments are moved in order to compress the arch.

**Osteotomy for tilting premaxilla**

When the premaxilla is tilted palatally but lateral occlusion is satisfactory, the base of the premaxilla is fractured. Obwegeser varies the incision. With an open cleft, the bone cut is made through the cleft; with a closed cleft, it is made on the palatal side. After the soft tissues have healed, the orthodontic tilting is quite quick and easy with the soft tissues stretching. He noted:

If the teeth are to be used as bridge abutments, the premaxilla should have bony union with the lateral segments. . . . Therefore, it is usually wise to do both the osteotomy for the tilting and the bone implantation all in one stage.

**Severe maxillary deformities in bilateral clefts**

Obwegeser admitted that he, as well as Barsky, Kahn and Simon (1964) and Pfeifer (1966), followed this sequence in a three-stage procedure: (1) retropositioning the lateral alveolar segments, (2) closing the reopened cleft and (3) carrying out the premaxillary osteotomy, repositioning and secondary osteoplasty. He hailed Perko’s 1964 plan for premaxillary osteotomy and cleft closure with simultaneous bone grafting in one operation as the second stage, after repositioning of the lateral alveolar segments. His series of diagrams demonstrates this two-stage design.
He presented an impressive case in *Cleft Lip and Palate* treated in this manner.

Various movements of the anterior segment of the maxilla

As noted by H. Obwegeser of Zurich:

Whether an anterior segment of the maxilla is to be moved forward or backward, the principles of planning and of operative techniques are similar. Also, the methods of bracing or stabilizing it are the same. One very seldom sees a true maxillary protrusion in patients with clefts. In such patients the planning and the principles for the correction of maxillary protrusion are
similar to the techniques used with noncleft patients. Since the reopened cleft provides better access to the operative site, it is simpler.

Backward segmental movement

In 1935 Wassmund of Berlin developed a technique of segmental ostectomy to correct open bite by retrusion of the maxillary median fragment, thus causing a deep bite.

Here is a case of premaxillary protrusion, or "proalveolie." The patient had had the upper first bicuspids extracted, and even after years of orthodontic treatment she still had a premaxillary segment that was 8 mm. too far anteriorly and 6 mm. too far inferiorly.

Wolfe described his one-stage surgery:

First, extraction of the remaining upper bicuspids. A transverse incision 1½ cm. in length made across the area of the nasal spine. Subperiosteal dissection carried up from the dental extraction sites across the premaxillary alveolar bone to the nasal spine incision bilaterally, enough to allow a small retractor to reflect the mucoperiosteum enough to permit the vertical osteotomy to be done with a small burr. The vertical osteotomies were carried up from the dental extraction sites, and the required 8 mm. of bone removed without damaging adjacent teeth. Transverse osteotomies were made just above the level of the pyriform aperture, but the nasal spine was left attached to the septum, which was then sectioned. A curved osteotome could then be introduced through the space beneath the nasal spine, and the palatal bone sectioned from above, with a finger held against the palate from below to be sure that the palatal mucoperiosteum was not damaged. The premaxillary segment was then free, and remaining segments of bone of
palate and alveolus could be removed under direct vision. The segment was moved into its predetermined position and was fixed to a prefabricated acrylic splint which was solidly attached to the stable posterior maxillary segments. Intermaxillary fixation was not required. A sliding genioplasty was performed at the same time.

Comment: This procedure preserves almost all of the mucoperiosteum on both sides, palatal and labial, of the premaxillary segment, and is thus much safer than the original Wassmund-Wunderer method.

In 1959 Köle of Graz described the posterior and vertical repositioning, avoiding deep bite by splints. The maxillary median fragment was elevated; thus normal occlusion was obtained posteriorly. Elastics were later replaced by intermaxillary wires.
In 1964, in *Reconstructive Plastic Surgery*, John M. Converse, with Sidney L. Horowitz and Donald Wood-Smith of New York, described a simple surgical advancement of the anterior portion of the maxilla by bilateral extraction of premolar teeth with the line of osteotomy extending through the site of extraction to the pyriform aperture and a further osteotomy of the vomerine attachment to the floor of the nose. . . . Advancement of the anterior maxilla and maintenance of advancement by orthodontic fixation appliances and interposition of split rib bone grafts.

In 1971, in *Cleft Lip and Palate*, Obwegeser presented his technique for forward retropositioning of the anterior part of a large alveolar segment in a case of unilateral cleft. As noted, this approach was much like that of Wassmund (1935) and Wunderer (1962). The moving maxillary segment received its blood supply through the narrow pedicle of vestibular mucoperiosteum. The defects were filled with bone, and the gingiva was moved to cover portions of the bone graft, as the arrow indicates.

**Moving posterior segment of maxilla**

In 1959 Schuchardt of Hamburg described a posterior maxillary osteotomy in which the posterior maxillary alveolar segment was freed and impacted into the maxillary sinus. This is a useful procedure in cases of anterior open bite in which the vertical facial height deserves reduction that can be achieved in one stage through a short buccal incision. The medial osteotomy must be done with accuracy, since the distance between the tooth root and the nasal cavity is only about 3 mm.
**Contour Correction of the Upper Half of the Middle Third of the Face**

When there is a marked flatness of the middle third of the face, giving a "dish-face" effect, but dental occlusion is satisfactory, the preferred methods of correction are:

1. Mobilization and forward motion of the upper half of the middle third of the face, according to the method of Tessier.
2. Use of onlays of bone or cartilage inserted through an intraoral approach to the canine fossa and the paranasal areas. Even if surgical repositioning of the maxilla or mandible, or both, has achieved satisfactory occlusion, there may be residual flatness of the profile. Here onlays can be of great value.

**Correction of Profile with Cover Denture**

If enough teeth remain, a special cover denture can give support to the lip. Often this will require buccal inlay procedures to facilitate application of the denture with especially overbuilt flanges to alter the profile in specific areas.

**Moving Both Maxilla and Mandible**

Of course, all the methods described for moving the maxilla and the mandible can be used in simultaneous combinations in an
But it is not easy to decide where the bloc should be positioned in relation to the remainder of the facial skeleton. This is especially difficult because one can move this bloc in all directions.

Obwegeser's upper and lower jaw juggling mastery is superbly demonstrated in four of his cases.

attempt to achieve satisfactory occlusion and ideal skeletal contour. There are certain specific rules that have been found useful by experience.

When movement of the alveolar processes of both the maxilla and the mandible is indicated, they should be handled at the same operation.

When the entire maxilla and the mandibular alveolar segment are to be moved, they can be advanced simultaneously or the maxilla advanced in the first stage and the lower alveolar segment later.

When a maxillary segment and the entire mandible must be moved, the operations can be executed simultaneously. An intact section of maxilla is useful for establishing a good occlusal position and stabilization of the movable mandible.

When the entire maxilla and mandible are to be moved, they can be moved separately or simultaneously.

Obwegeser prefers to mobilize both maxilla and mandible and fix them in occlusion with intermaxillary wiring. Then with the teeth locked, the entire maxillary-mandibular unit can be moved en bloc. He did admit:

But it is not easy to decide where the bloc should be positioned in relation to the remainder of the facial skeleton. This is especially difficult because one can move this bloc in all directions.

Obwegeser's upper and lower jaw juggling mastery is superbly demonstrated in four of his cases.
The first reveals retromaxillism and severe ectropion of the lower lip, corrected by advancement of the maxilla and retropositioning of the anterior mandibular alveolar segment (A, B). Models show preoperative occlusal situation and details of planning. (C) shows preoperative circular non occlusion, (D) occlusion after surgery, and (E) final occlusion with replacement of missing second upper right incisor. (F) shows collapsed maxillary dental arch before surgery, (G) upper dental arch after advancement of maxilla in 2 sections with reopening of palate cleft, and (H) upper dental arch after orthodontic treatment by P. Stöckli, University Dental School, Zürich. Cephalometric X-rays show before and after bone surgery using homologous deep frozen bank bone. Profiles present before bone surgery, after bone surgery, and after columella elongation using Millard’s forked flap.

This unilateral cleft case with retromaxillism and mandibular prognathism was corrected by Obwegeser and partially published in Deutsche Zahnärztliche Zeitschrift, 1973. Surgery involved:
(1) Advancement of maxilla in 2 sections and simultaneous retropositioning of the whole mandible using sagittal splitting procedure. (2) Re-operation of palate with bone grafting for closure of remaining cleft fistula. (3) Rhinoplasty for correction of nasal deformity and revision of lip. Models show plan of osteotomies and cephalometric X-rays show progress of surgery.
This bilateral cleft case with mandibular prognathism and collapsed maxilla with severe nasal deformity was corrected by Obwegeser and presented in the Transactions of the Fourth International Congress of Plastic and Reconstructive Surgery, Rome, 1967. The following procedures were used:

1. Lateral rotation of lateral maxillary segments with reopening of cleft according to Gillies.  
2. Closure of reopened cleft with simultaneous bone grafting.  
3. Repositioning of premaxilla.  
4. Retropositioning of whole mandible using Obwegeser’s sagittal splitting procedure.  
5. Elongation of columella by Millard’s forked flap and simultaneous reoperation of bilateral cleft lip correcting whistle defect without an Abbe flap.

Models (A) show preoperative occlusion and plan of corrective surgery. Also shown are the preoperative circular non-occlusal view (B), the perfect occlusion after repositioning of maxillary
segments and mandible (C), the occlusal view after final prosthodontic reconstruction by J. Wirz, University of Zürich (D), and the palate view (E).

This bilateral cleft case with mandibular prognathism, anterior open bite and retrusion of the premaxilla was treated by M. Perko and E. Steinhauser according to planning by Obwegeser.

(1) Mandibular osteotomy through oral route by Obwegeser method.
(2) Repositioning the premaxilla, closure of remaining palatal fistulae with simultaneous bone grafting and retropositioning of anterior mandibular alveolar segment and (3) revision of bilateral lip scars. (4) Elongation of columella.

(A) Models show preoperative condition and model-operation for osteotomies presents plan.
(B) preoperative occlusion.
(C) postoperative occlusion.
(D) occlusal view after prosthodontic work by J. Wirz, University of Zürich.
(E) palate view.
Converse's case of mandibular prognathism combined with maxillary retrusion is a 33-year-old female who had a cleft lip closed at birth and cleft palate closed at 18 months. This was his summary:

At 32 years of age, she underwent a Le Fort 1½ maxillary advancement of 10 mm. and six months subsequent to this, the correction of malocclusion was finalized by a vertical osteotomy, with an 8 mm. set-back. The combination of these two procedures was necessary in this patient because of the wide occlusal disparity. Included with the photographs are the cephalogram tracings.

Preoperative and postoperative cephalometric views and patient's profiles show the result.
Occasionally patients with cleft palate who have had surgical correction of dysgnathia—maxillary and mandibular abnormalities—suffer partial relapse. If the cause of the dysgnathia deformity is still present at the time of the surgery, partial relapse is a possibility. Other factors include the higher tendency for relapse in the growing patient, insufficient bony union and failure to obtain complete mobility of the fragments at the time of repositioning. Obwegeser warned:

Palatally malposed lateral maxillary segments that had been treated by the combined surgical and orthodontic (expansion plate) method [W. Widmaier, 1960] showed a very pronounced tendency to relapse if, at surgery,
the segments had not been made completely mobile. In these cases only a tilting, not a true lateral movement, had been achieved. This is similar to the procedure of the forced expansion without osteotomy [H. Derichsweiler, 1955; E. Nordin and B. Johanson, 1955]. This non-surgical forced expansion affects the base of the maxilla very little [L. Rinderer, 1965]. . . . The tendency for relapse is much less if the surgeon places bone along the path of the bone cut. This precaution seems to ensure a better bony union. . . . Defects between the margins of a repositioned segment and its host site do not always become filled by bone automatically; soft tissues may fill in, and these contract, which may result in a dislocation. To obviate this the defects are closed with a bone transplant, which is pressed snugly into the defect. The iliac bone is my choice of donor sites for the bone grafts and the medullary paste. In some cases, however, rib grafts or bone from the chin prominence are used. Occasionally we have also used autologous or homologous frozen bone with good results.

Additionally, after the fixation is removed, a retention denture is inserted. This counteracts the scar contraction in the cleft area. Also, after a secondary osteoplasty for stabilization of the segments, a temporary denture should be provided until the definitive denture or bridge is inserted.

In some cases my co-workers and I have performed the procedures described above in patients aged 10 years and older. We have the impression that there is a higher tendency for relapse in the younger patients' cases than in those patients operated on after the age of 17 years. This seems attributable, in part, to scar formation in the soft tissues; the scar dislocates the segment and interferes with further growth. It seems that even the surgical intervention itself adversely affects growth. However, the number of cases operated upon in youth is too small, and we cannot yet judge definitely whether these operations can be done during the growing period with the same final results as when they are performed when growth is terminated.

In 1977 Hans P. M. Freihofer, Jr., summarized the experience of 100 cases in relation to timing osteotomies of the facial skeleton in adolescence.

1. Generally speaking, osteotomies in adolescence have to be refused before growth has ceased. Exceptions to this rule are very marked functional and psychological indications. In these special cases, however, the patient and his parents have to be told of the likelihood of changes in the postoperative result due to further growth. The necessity of a second later operation cannot be excluded.

2. It is difficult to give a precise age limit for operations because of the variation in time to growth completion. The cases presented, however, show that the 17th year of age is frequently too early. Boys are more at risk in this
respect than girls and cleft patients more than non-cleft patients. We would suggest a rule of thumb, namely, that girls should have reached the age of seventeen and boys the age of 18 at least before osteotomies are performed. As an exception again, we would like to cite those cases for which a series of cephalometric X-rays can be presented proving earlier termination of growth, with a very high degree of probability with respect to accuracy.

3. The main reason for clinically unacceptable results is further forward growth of the mandible. The combination of partial true relapse and further forward growth of the mandible influences the results disastrously. True relapse of the operation alone seems to play a secondary role.

4. The osteotomies have no influence on the growth of the mandible.

5. A negative influence of osteotomies on growth of the maxilla could not be proved. However, several indications are given that it does in fact exist.

6. Comparison with data in the literature proves that particularly in the treatment of Angle class III cases more unfavourable results are obtained in adolescents than in adults. There is thus a danger of true relapse and pseudo-relapse following a retropositioning of the mandible, backward displacement of the lower anterior segment, advancement of the whole midface and advancement of the maxilla.

7. Retropositioning of the maxillary anterior segment and advancement of the mandible as a whole are the only operations which can be performed without risk before growth is completed. In these groups, results are comparable to those obtained in adults.

8. The treatment of open bite is accompanied by special problems. Residual growth plays a part, but results are also unsatisfactory in adults if certain surgical techniques are applied.

Osteotomy of the premaxilla and its stabilization, on the one hand has to be seen in the context of the complete treatment plan of a cleft patient, and on the other hand has to be considered in the light of the experiences gained in the advancement of the maxilla. To achieve good results in the rotation of the small maxillary segment in cleft patients, operative technique and post-operative treatment have to occur under optimal conditions.

9. Most questions which had to be left totally or partially open, can be answered by specific studies. The most important and difficult problem to be solved is the question of negative influence of osteotomies on maxillary growth.

10. It is to be hoped that the number of osteotomies performed during adolescence will decrease markedly as a consequence of the results presented. Patient and surgeon would therefore be spared the disappointment of failure and further strain of reoperation. However, exceptional cases will always be found in which a special indication is present for surgery during growth. Surgeon and patient must then be aware of the problems involved.
TEETH VITALITY AFTER SURGERY

In reconstructive dentistry, the vitality of the teeth is an important aspect. Obwegeser's experience is encouraging:

Pulpal injury is rare, even in cases in which the segment has been moved as much as 20 mm. Though the immediate postoperative vitality test is negative, after a time the response becomes positive. This means that within 6 to 9 months, the teeth in a repositioned segment will usually respond positively to the vitality test. The positive response appears earlier in maxillary teeth than in teeth in a mandibular segment.

EFFECT OF MAXILLARY ADVANCEMENT ON SPEECH

One of the possible side-effects of forward advancement of the maxilla after osteotomy is velopharyngeal incompetence. Pulling the soft palate forward to its attachment to the hard palate may render the velum unable to participate with the pharyngeal wall in the sphincteric action during phonation. If there was minimal contact prior to osteotomy, the effect could be devastating to speech. The risk, however, does not seem to be large, as noted by those who are following maxillary surgery in cleft palate patients.

In 1977 Ralph Bralley and Z. G. Schoeny of the University of Virginia reported a 19-year-old patient with a surgically closed submucosal cleft palate who was evaluated following a Le Fort I osteotomy, to determine the effects of the surgery on his speech. Preoperative and postoperative tape recordings during administration of an articulation test, casual conversation and repetition of standard sentences, along with preoperative and postoperative spectrographic analysis of standard sentences, revealed that maxillary advancement had no adverse effect on articulation ability or voice in this case. The authors stated:

However, an unexpected and substantial reduction in the magnitude of the third formant in the postoperative recording was noted. The existence of hypernasality in speech has been shown to be associated with increased magnitude of the third formant (Hattori, Yamoto, and Fujimura, 1958). The observed reduction in magnitude of the third formant may have resulted from an increase in the oral cavity size giving added resonance to lower frequencies. The increase of resonance in the lower frequencies may exert a second-
ary benefit to speech and, therefore, deserves consideration in the evaluation of the patient who is being considered for maxillary advancement.

Mutaz B. Habal of the University of South Florida, Tampa, trained by J. Murray in Boston, reported at the Florida Cleft Palate Association meeting in Miami, 1978, that Le Fort I osteotomies had been carried out on a series of 25 secondary cleft palate cases. He noted that all had normal speech preoperatively and none developed velopharyngeal incompetence after maxillary advancement.

In 1979 Joseph G. McCarthy, P. Coccaro, M. Schwartz, D. Wood-Smith and J. Converse noted in reference to velopharyngeal function following maxillary advancement:

A prospective study of 40 patients, who underwent maxillary advancement, included preoperative and serial postoperative cephalometric analysis, aerodynamic evaluation of velopharyngeal orifice area and Templin-Darley articulation testing. The group was subdivided into those with (11) and those without (29) a cleft palate. Distinct anatomical differences in the velopharyngeal area between the cleft palate and craniofacial dysostosis group was detected. Consequently the cleft palate group is more at risk for the development of postoperative velopharyngeal incompetence. No patient developed hypernasality after maxillary advancement. On cephalometric analysis there was a definite postoperative change in the posture and position of the velum; nasopharyngeal volume was also increased. Hyponasality was eliminated in 4 patients with Crouzon’s disorders.

Industrious Kenneth E. Salyer of the University of Texas Southwestern Medical School, Dallas, extensively involved in craniofacial surgery, expressed some thoughts in 1978 on maxillary advancement and velopharyngeal competence:

The Le Fort II maxillary advancement is an excellent procedure in cleft patients as it allows the advancement of the nasal spine and nose as well as augmentation of the hypoplastic maxilla and correction of the occlusal problems to be accomplished in one procedure. In both cleft and non-cleft
patients, it is important to assess the velopharyngeal mechanism as incom­petency may result following facial advancement. Contrary to some of the literature on this subject, we have found that patients with adequate touch closure prior to surgery on occasion develop velopharyngeal insufficiency after facial advancement. Correction of this condition with a pharyngeal flap should be postponed until one year following advancement as the pull of the flap can contribute to relapse of the maxillary advancement if performed earlier after facial advancement.

To overcome or circumvent this possible untoward result, we have found it advantageous to utilize a one centimeter osteotomy across the palate just anterior to the edge of the bony palate, leaving the horizontal palatal bones intact in patients where we do not want to alter the existing velopharyngeal anatomy. In Le Fort II advancement, exposure is provided by a mucoperiosteal bilateral palatine flap. This type of surgical approach offers main­tenance of the position of the hard palate. Another advantage lies in the facilitation of advancing the maxilla, particularly in the cleft patient where palatal scarring hinders and makes it difficult to maintain the advanced position of the maxilla. Elimination of tethering of the maxilla is but another advantage to this type of surgical procedure. Due to possible interference with the blood supply of the maxilla, it is not possible to use this approach in a Le Fort I advancement in the cleft patient.

In patients undergoing maxillary advancement subsequent to the inser­tion of a pharyngeal flap, it is important to advance the pharyngeal flap for length as advocated and performed by Tessier and reported by Whitaker. This subject is treated in more detail in Chapter 42.