II. Surgical Closure of the Cleft
8. **Cautery or Paring and Suturing the Edges of the Cleft Palate**

**JUST** 10 years before the 13 North American colonies united to divide themselves from the British Empire, the first cleft palate was united, and both events were accomplished with French assistance. It may be true that Jacques Houllier, as reported by Rogers in 1971, sutured the edges of a traumatically split velum in 1552. Yet credit for the first closure of the congenital cleft palate must go to a French dentist named Le Monnier of Rouen. Believing that this most conspicuous and distressing deformity was amenable to successful surgical treatment, in 1764 he proposed an operation in three stages:

1. Introduction of sutures.
2. Cautery of cleft edges.
3. Bringing the freshened edges together and fixing them.

According to Robert, Le Monnier was the first to perform the operation, sometime between 1762 and 1764.

A child had the palate cleft from the velum to the incisor teeth; M. Le Monnier, a skillful dentist, endeavored and succeeded in reuniting the borders of the cleft, first inserted several points of suture in order to keep them approximated and afterwards abraded them with "the actual cautery." An inflammation supervened which terminated in suppuration and was followed by reunion of the two lips of the artificial wound. The child was perfectly cured.
VON GRAEFE

Carl Ferdinand von Graefe, born in Warsaw, schooled in Dresden and Leipzig, at the age of 23 became professor of surgery at the University of Berlin. Three years later, in 1813, he became surgeon general to a division of the Prussian army during the Napoleonic Wars, received many medals and was consulted by royalty. In 1816 he introduced to the medical profession the first comprehensive surgical method for closing clefts of the velum. He presented his case most casually before the biweekly meeting of the Medical-Surgical Society of Berlin, and it was reported, in third person, early the following year in the *Journal of Practical Therapeutics*. This seemingly unimportant paragraph was translated from the German in 1971 by Karl Schuchardt for the journal *Plastic and Reconstructive Surgery*:

Geheimrath Graefe spoke about clefts of the soft palate, which could be congenital or acquired. He had tried several times in vain to cure the evil or to replace it artificially until finally, in the case of a cleft so extremely severe that it reached to the bone, he conceived the idea to unite it by suture and by an artificially caused inflammation. For this purpose he invented special needles and needle holders. With these he made a suture which, in conjunction with spreading it with *Acidum Muriaticum* and *Tinctura Cantharidum* (which latter he preferred for the excitement of the plastic process), achieved such perfect healing of the cleft that the person afterwards could swallow quite well and speak distinctly.

ROUX

Philibert Joseph Roux, born into a family of French surgeons, in 1802 competed with Dupuytren for an important surgical position to the famous Hôtel-Dieu. As the story goes, a new post of Second Surgeon at Hôtel-Dieu was created specifically for Dupuytren, who was fast gaining renown. An upstart named Roux competed brilliantly and tied. In the playoff, each candidate was required to deliver a public lecture on some subject proposed by the faculty but not communicated to the contestants until four hours before the appointed lecture. One of Dupuytren’s friends in the faculty secretly informed him of the subject 24 hours ahead, and on this basis he presented the superior lecture and won the post.
There is a more intriguing story about the competition, told by E. Warren in 1860 and quoted by Goldwyn, telling of Dupuytren's visit to an influential friend in a frantic effort to win this post:

Rushing into his room, he burst into tears, struck his head violently with both hands and cried out, "I am lost!" His friend tranquillized him and said, "Take courage. Go this evening to Madam B. She thinks favorably of you; will be flattered by your application, and gratified to exert her influence in the medical intrigue. She can turn the scale in your favor, if she chooses. Kneel to her. Pray to her. Say everything you can think of to excite her interest, and you will obtain the prize. Fly! There is not a moment to be lost!"

Although Dupuytren managed to defeat Roux in this competition, he lost in the next, as Roux married Dupuytren's fiancée. Roux later became full professor on the faculty of medicine, University of Paris, was surgeon-in-chief at La Pitié, received the Legion of Honor and finally succeeded Dupuytren as surgeon to the Hôtel-Dieu. In 1819, in the *Journal Universel des Sciences Médicales*, appeared his most famous work, "Observations on a Congenital Division of the Soft Palate and Uvula Cured by Means of an Operation Similar to That for a Hare Lip." This paper was translated from the French in 1971 for *Plastic and Reconstructive Surgery* by Daniel Morel-Fatio. It began with an acknowledgment by the editor that a Dutch surgeon named Itard had several years before proposed closing a woman's cleft palate with stitches but the surgery had not been carried out because a more distinguished surgeon considered the chances of success nil. It was then explained that the operation by Roux had been a complete success and that details of the operation were of interest. The patient was a young medical student with a cleft of the soft palate and uvula who had typical cleft palate speech and was most anxious to correct it. Roux noted that the patient's mouth was big and that the edges of the cleft could be brought together easily. Yet, realizing the operation was risky and fearing failure, Roux performed it almost in secrecy, with only assistants present. The report continues:

M. Roux passed 3 wax-threaded loops, using a curved needle placed in a handle. Then he drew together the wax-threaded loops so as to bring
together the two edges of the division, and thus evaluate exactly the extent of the loss of substance that he would have to inflict upon them. Half a line [*] of the soft palate and of the uvula was taken with great dexterity; the ligatures were drawn tight and the wax-threaded loops cut close to the knots.

Immediately after the operation, the voice returned almost to normal—with hardly any change. The patient was put on a strict diet for 3 days; complete silence was enforced. In a few days the two parts had come together completely, but the two lips of the uvula were not completely touching.

The editorial comment concluding this report hints at the beginning of a medical sophistication that would eventually give plastic surgery its great chance:

Although without danger for the patient’s life, the operation corrected a malformation in an organ whose integrity is vital for normal swallowing and speech. It must be considered amongst those successful innovations which have increased the field of the curative art. It would be wrong to call attention only to operations which endanger the life of patients.

**PATIENT’S POINT OF VIEW**

Possibly of even greater interest than the medical report in third person of Roux’s operation was the report in first person by his patient, John Stephenson, a Canadian who was studying medicine in Edinburgh. Stephenson wrote a graduation thesis in surgery in 1820 in which he explained:

The report will be authentic for the subject is one which I perhaps am best qualified to discuss, since I am myself the patient.

He then commented on his early loss of milk through his nose, the discovery of his palatal fissure, improvement in feeding with an upright position, a family history of one brother with a cleft uvula, pronunciation of *th* like *s*, his nasal speech, how because of its quality he found the French language easier than English and his inability to blow up a football or play on a wind instrument without closing his nostrils with his fingers.

*A line is the twelfth part of an inch, its use dating back to A.D. 1665, early in the reign of King Charles II of England, who “never said a foolish thing, and never did a wise one.”—R. H. Ivy*
While on a study visit to a hospital in Paris, Stephenson had occasion to speak with Dr. Roux, who immediately noted his abnormal voice and, with more candor than tact, asked if he had ever had a syphilitic ulceration of the palate. Whereupon Stephenson opened his mouth, and Roux, noting almost complete closure of the velar cleft during active movements of his fauces, pronounced the congenital cleft operable. Stephenson decided to have the operation while he was in Paris, for, as he said, a war might have prevented his return to Paris and a clever surgeon be deprived of well-deserved distinction.

At 4 P.M., September 28, 1819, the operation was performed. This is Stephenson's own report:

I adopted a sitting position which seemed best to facilitate breathing and the flow of blood out of the mouth. . . .

Three interrupted sutures, stout enough to avoid laceration of the tissues, as far as possible, were introduced with two surgical needles alternately from behind forwards, each suture being thus drawn three times. Since fingers are too short to do the work at such depth, and the needles were rendered slippery by the constant flow of saliva, use was made of a stylus-like instrument (porte-aiguille in French) with what we call in English a slider to grasp the needles. . . . I suffered less from the pain than from the irritation and tickling caused by the introduction of the needles, a sensation that would run up to the ear like the pain of toothache. . . .

Before the edges were freshened the sutures were put in place in order to see whether the fissure could be closed. . . . The edges were thereupon cut with forceps and a guarded scalpel. The sutures were separately tied and severed.

The ligatures had been placed in position before the incision not only to see that the fissure could be closed, but also because the oozing of blood from the freshened edges, especially in the next stage, would have been troublesome both to the operator and to me. The union seemed to be as firm as skill could make it and nature's healing inflammation would perfect the cure. . . .

Stephenson continued:

Immediately after the operation, in order to satisfy an inconvenient but understandable curiosity, I spoke a few words in the presence of Dr. Roux and some others. Everyone declared that my voice was considerably altered.
Thirteen days after his surgery, Stephenson, at Roux’s request, read a report of his case before the Royal Institute of Paris. He then set forth on his return to Scotland and during the Channel crossing from Ostend to Dover experienced seasickness and a dividend of his operation. To his great joy, he was able to stand at the rail 22 days postoperatively and vomit without his gastric contents being projected through his nose.

Stephenson concluded his thesis by admitting to some persistent nasal escape in his speech and justified it with

Who can deny the all importance of habit?

He suggested the operation be carried out between 4 and 6 years of age and

certainly before puberty to avoid all the disadvantages of habit.

He also suggested the name *velosynthesis*.

John Stephenson returned to Montreal and had a successful career. Honorable Peter McGill referred to him as

the man above all others to whom we owe McGill College.

Evidently unaware of von Graefe’s earlier, cursory description, Roux gave no credit in his 1819 publication. This omission enraged von Graefe, who had just finished the galley proofs of another palate publication. He attacked Roux for advertising an operation never performed before

and continued his attack with some heated logic:

This remark could hardly come from this physician, who is well read in the medical literature. The first palate suture was successfully performed by me in the spring of 1816.

He elaborated that later in the same year it was presented to the Medical-Surgical Society of Berlin, while lectures to large audiences were given in 1817 and 1819.

News of my operation must have reached Paris by traveling young physicians, as there is a lively exchange of students between the medical schools
of Berlin and Paris. . . . Its existence could not have remained unknown to Herr Roux.

He continued:

I devised this operation in 1816 and performed it on four individuals. The operation was fully successful in only one patient. If I had had more experience, I might not have advised and performed the operation in patients like the one who had a wide cleft of his hard and soft palate, another who was anemic, and another who was cachectic.

Obsessed with gaining unquestionable priority, von Graefe proceeded to accept many more cases. His 1820 publication discussed a modification of his earlier method: denuding the defect borders with a uranotome and applying a bolt and nut device to hold the sutures. Seven years later he discarded these complicated appliances and used waxed, triple twine sutures held with a double knot. He also advised that sutures of catgut might be used.

Thirty years and 140 staphylorrhaphies after his first operation, Roux admitted that three years before this first procedure M. von Graefe had attempted the operation unsuccessfully.

THE FIGHT FOR PRIORITY

The eternal fight for priority was not first fought between von Graefe and Roux and certainly did not end there. Levi Lane said in San Francisco in 1896:

The method of Roux was the better one, and was so acknowledged by Graefe. A further investigation of the subject has brought to light the fact that the operation of closing the soft palate by suture was proposed to the French Academy in 1779 by Beziers. Priority here, as elsewhere, has proved a Protean entity, a fleeting fugitive, which, though sought and temporarily possessed by rival claimants, has in the end escaped their grasp and fled to other hands. Such emulation, however, should be commended, since it is of generous source and is inspired by justice to give the palm to him who has earned it. Gold too often finds its way to the hand of him who has not earned it; the curators, by which the field of science is vigilantly guarded, do not permit such wrong; the earner is secured in his earnings, often through the mutual aid of his competitors.
A G L I M P S E  T H R O U G H  Z E I S

According to Tom Gibson, Eduard Zeis of Dresden, a merchant-banker's son, was one of the great figures in plastic surgical history, having been exposed to the specialty during its period of greatest expansion by enthusiastic practitioners. In this milieu he was stimulated to write the first textbook of plastic surgery, *Handbuch der plastischen Chirurgie*, published in 1838, and later a great 1863 work, *Die Literatur und Geschichte der Chirurgie*, plus an 1864 *Nachträge*, all involving other surgeons' work and experience, defining the scope of plastic surgery much as it is today.

Thomas J. S. Patterson of Churchill Hospital, Oxford, whose book, *The Essentials of Plastic Surgery*, with Peet, has been quoted often in these volumes, has become deeply involved with the Zeis Index for several years. Here is an excerpt from Zeis by Patterson:

Graefe conceived the idea of repairing the soft palate on the same lines as a hare-lip. He carried out the operation in 1816, and reported the first successful case on 27th December of that year to the Med.-Chir. Gesellschaft in Berlin. This arduous undertaking, calling for the greatest cooperation from the patient and perseverance on the part of the surgeon, excited general astonishment... Soon after this, Roux, obviously incorrectly, claimed priority for this discovery, whereupon Graefe defended his reputation by describing his operation in greater detail in 1820. It took a long time for Graefe to achieve full recognition. Finally, however, Roux himself acknowledged that Graefe had preceded him, and excused himself by reason of his ignorance of the German language and literature.

The difficulties of this operation were so great that many surgeons quailed before them. Nevertheless a few soon copied the technique, and tried to make it easier by improving the instruments.

P A L A T E  O P E R A T I O N  B E C O M E S  P O P U L A R

Following the success and rivalry of von Graefe versus Roux, surgical approximation was accepted by the medical profession as the treatment of choice for clefts of the velum.

John Collins Warren, professor of surgery at Harvard Medical School, who helped found the Massachusetts General Hospital, the American Medical Association and the *New England Journal of Medicine*, published a description of
an operation that he performed in 1819 for the cure of natural fissure of the soft palate.

He acknowledged that he had heard of cleft palate operations being done in Poland and Germany as well as by Roux in Paris but had "sought in vain for details of it." Thus, independent of von Graefe and Roux, he closed a soft palate on a 16-year-old girl in Boston, Massachusetts.

Thomas Alcock of London was the first in England to close a palate, an accomplishment that took about seven attempts on the same patient, using single knots and allowing early eating and speaking.

SMITH OF THE IVY LEAGUE

Nathan Smith, who studied medicine at Harvard, taught at Dartmouth and finally became professor of surgery and a founding father of Yale Medical School, noted in 1826:

Everyone must have observed that, when in early infancy the suture of the lip is properly made, the gentle pressure which the lip, then more straight than natural, exerts upon the cleft portion of the jaw, has a tendency gradually to approximate them, for at this time the bones of the face being yet in part cartilagenous, readily yield to little force.

Thus Smith decided to suture the palate and reported,

The operation was accomplished with less difficulty than I had anticipated. The margins of the palate were pared with the knife and a ligature of suitable size, with a needle very much curved, was carried through on one side, a sufficient distance from the margin, and brought back through the opposite. Two threads were employed in this manner, and the parts were brought into contact with very little difficulty.

STEVENS OF P AND S

Alexander H. Stevens was a young American doctor who during the War of 1812, while bearing dispatches to Europe, was overtaken by a British cruiser and imprisoned in Plymouth, England. Upon his release, he studied in London and Paris, and then, while
attempting to return to the United States, was thrown into prison again. After his final release and return to the States he was made professor of surgery at the College of Physicians and Surgeons of New York. In 1827 he was another pioneer in palate surgery and described his operation, but gave Roux credit for priority:

The patient being seated near a window, and his head thrown back and supported by an assistant standing behind, I interposed a handkerchief, tightly rolled up, between the molar teeth on the right side, and depressing the tongue with the left hand, introduced with the right hand a curved needle armed with a thread.

He then placed three sutures and, after paring the cleft edges with a cataract knife, tied and cut the threads. The patient was not allowed to speak or swallow for four days, at the end of which time Stevens removed the sutures and found the wound perfectly united. He reported that

On the fifth day . . . in the afternoon, he ate several pies and began to speak freely, but not with much improvement in his articulation. Supposing it might proceed from the division of the uvula, the parts of which hung like a swallow’s tail from the end of the pendulum, I removed one of them. . . . On the tenth day, the voice was materially improved but far from being perfect.
9. Relaxing Incisions and Mucoperiosteal Dissections

DIEFFENBACH

JOHANN Friedrich Dieffenbach was born in Königsberg, Prussia. In 1813 the lure of the war of independence against France stimulated him to join his classmates in the Mecklenberg Cavalry. The love of horses developed during the war later caused him to have five fine mounts in his stable and his son to enter veterinary medicine. While he was in military service, his sensitivity toward the maimed and dying led him to write of his pity for the returning cripples:

To be handicapped is worse than death itself.

Thus inspired, he started his medical studies at the University of Königsberg at age 25. He completed his studies at the University of Bonn, where he admitted modestly:

I am born for surgery. . . . Technical and mechanical skill in my fingers allows me to do every operation with the experience of an older surgeon. . . . All my patients love me.

Everyone loves a winner, and confidence impresses students. When it came time for Dieffenbach to set off for the University of Berlin, his students gave him an unprecedented farewell. Familiar with his equine interests, they presented him with a horse and walked along beside it more than a mile outside the city gates.

Von Graefe was professor of surgery at Charité Hospital, University of Berlin, and Dieffenbach flourished in this plastic
milieu, eventually succeeding von Graefe as professor in 1840.

Having been drawn to Paris as a young surgeon, he became a lifelong friend of Dupuytren and gained from exposure to Delpech and Roux. At this time the feud between von Graefe and Roux undoubtedly aroused some national partisanship, with German surgeons lining up behind von Graefe against French surgeons siding with Roux. Yet, as so often happens in medicine, the individual and the specialty rose above nationality. In 1826 Dieffenbach, who was under von Graefe, dared to write a small epitome on the Roux operation for cleft velum, of all things, and the illustrations in the back of his little book were quite explicit. They even explain why Roux’s patient, Stephenson, ended up with a split uvula. This act took courage, but, as once was said of Dieffenbach,

He was a bad dissembler, speaking his mind with such freedom and honesty that it kept him from many high places to which men less worthy were appointed.

By 1826, according to translations from the German by Eduard Schmid, Dieffenbach already knew that all mammals, and only mammals, had a velum, it having first appeared in the whale. He also had firsthand knowledge by dissection of the soft palate of mice, horses, camels and apes. It is little wonder that with such interest Johann was destined to make important contributions to the surgery of the palate of man. His 1826 Suture of the Palate mentions special instruments necessary for this surgery, among them a pointed bistoury and purified lead wire of moderate thickness, a precursor of Veau’s suture. Dieffenbach also divided the operation into three parts: (1) freshening the edges of the cleft, (2) insertion of the ligatures and (3) tying the knots.

Relaxing Incisions

Also in 1826 Dieffenbach described how he came upon the relaxing incisions so important in all of palate surgery:

At first the superior, then the middle, and finally the inferior ligatures were
placed. . . . After the sutures were tightened by turning, the wound margins were perfectly approximated. . . . However, palpation of the velum with a finger indicated that it was under such tension that it almost threatened to tear. Indeed, I already noticed a tear in the middle of the right semi-velum. . . . To release this tension, and to ascertain the success of the operation, I transected the anterior mucosa of the velum and the muscle fibers of the *constrictor isthmi faucium* at both sides of the approximated cleft, using an oblique cut with the knife which ascended in a lateral direction. The unpleasant sensation of tension immediately subsided.

Dieffenbach was always striving for surgical excellence. He taught that the skill of the surgeon lay in his hands, not in the instruments. He pointed to the surgeon’s pen as his greatest instrument to note ideas for testing against rules of physiology and confirming with natural healing. What astonished visiting surgeons as much as the design of his procedures was the awesome regularity with which his operations succeeded! The greatest technical contribution to his generation was the extension of Roux’s and von Graefe’s work on the soft palate to the closure of bony defects of the hard palate. This was the operation that Jonathan Mason Warren came to see and carried back to America.

His fame long outlived him and even exceeded the realm of his surgery. Today’s popular dieffenbachia plant was named in his honor; it produces speech difficulties when ingested. A German national holiday, a street and a town all bear his name.

**MASON WARREN**

Jonathan Mason Warren, son of John Collins Warren, Boston, was influenced by his early contacts with Dieffenbach and Roux. His closure of the complete palatal cleft was an important step beyond previous cleft closures and earned him a place in the Dieffenbach-Warren-von Langenbeck procedure of modern times. As he explained in the *New England Quarterly Journal of Medicine and Surgery* in 1843:

I now carefully [dissect] up the membrane covering the hard palate, pursuing the dissection quite back to the root of the alveolar processes. . . . As the dissection approaches to the connection of the soft parts
with the edges of the *osa palati*, where the muscles are attached and the union most intimate, great care must be taken or the mucous membrane will be perforated, and from these causes I have found this part of the operation to be the most embarrassing. As soon as this dissection is terminated, it will generally be found that the soft palate can be easily brought to the median line. If the fissure is wide, and this cannot be effected, French scissors are carried behind the anterior pillars of the palate; its attachments to the tonsil and to the posterior pillar are now to be carefully cut away, on which the anterior soft parts will at once be found to expand, and an ample flap be provided for all desirable purposes.

He used simple stitching logic:

Our next object is to insert the ligatures, and for this purpose an immense armory of instruments has been invented. After the trial of nearly all of them, I have found the most simple to be the most effectual. A small curved needle being armed with a strong silk thread, confined in a forceps with a moveable slide, is introduced.

At a second operation, the remaining hard palate cleft was closed, but Warren admitted the formation of a fistula and directed it to be closed by a gold plate.

Mason Warren became known for his palate surgery and treated over 100 clefts sent to him from all parts of America. In 1863 he summarized his experience, noting that 90 percent of the clefts he had seen had been complete, and added,

I do not remember to have seen a case in which the patient was not benefitted.

Robert M. Goldwyn, scholar, surgeon and ocean swimmer, who in almost all seasons can be seen bobbing in the high seas off Cape Cod, is also director of the Plastic Surgery Archives at Harvard's Countway Library. He has collected and published historical data about pioneer surgeons, and has been of great benefit in further vivifying several of the characters in the evolution of cleft surgery. For instance, it was Goldwyn who pointed out that J. Mason Warren had a remarkable collection of cronies befitting a plastic surgeon. None other than Morton did his anesthesia. Oliver Wendell Holmes, a lifelong friend who had been a student with him abroad, spoke of him warmly. Poet Henry Wadsworth Longfellow, a patient of his, told his father,
Truly it may be said of him that he has a high degree, "the eagle's eye, the woman's hand!" I know he needs no commendation of mine but it is so pleasant for me to say it. I trust it will not be unpleasant to you to hear it.

**Mucoperiosteal Dissection**

Dieffenbach "dissected the mucosa" or moved the mucosa with the bone, and Jonathan Mason Warren of Boston in 1843 "peeled off the mucosa" of the palate from the underlying bone. Yet credit belongs to von Langenbeck of Berlin for suggesting, in 1861, the dissection of the mucoperiosteum from the underlying bone in closing the cleft in the palate.

**Von Langenbeck**

Here are some interesting facts collected by Goldwyn. Bernhard von Langenbeck, born in the town of Padingbüttel near the North Sea, had a boyhood interest in dissecting small animals which stimulated him to study medicine at Göttingen. He soon showed such competence as a clinician that he had to escape his eager clientele by "going out the window on a ladder." His singular abilities on the battlefield during the Holstein wars caused him to be appointed in 1848 to follow Dieffenbach as chief at the University of Berlin. He was a small, precise, energetic man. He rose at 5 A.M. and, after coffee and a horseback ride, taught operative surgery on cadavers to graduates until 10 A.M., when he started surgery on private patients that went on for four hours. Then at 2 P.M. he entered his clinic operating room in his specially tailored, tight-fitting, black-green coat, which was scrupulously cleaned each day.

By 1859 von Langenbeck had resected a maxilla, leaving the periosteum intact, and noted bone regeneration. He extended this principle to cleft palate, using refrigeration anesthesia by applying ice on the palate region. He denuded the borders of the defect by removing a narrow strip of tissue cut on the slant. The levator and palatopharyngeus muscles were sectioned by an incision three-quarters of an inch long and placed at the posterior border of the hard palate with a sickle-shaped tenotome into the velum,
at a point external to the hamular process. The posterior palatine vessels were not divided. One or two lateral incisions were applied, parallel with the alveolar ridge and four lines (one-third inch) from it, beginning with the hamular process, or with the incision already made for muscle sectioning and running forward to the incisors. The mucoperiosteum was then cautiously separated from the bone (by specially devised raspatories) from without inward, extending the dissection backward to separate the velum from its attachments to the posterior border of the hard palate. When the flaps met in the midline, the sutures were inserted and tied. Von Langenbeck advocated silver anti-tension sutures, and he varied his incisions according to the plane of the palatal plates.

A. One palate plate horizontal, one vertical.  B. Both plates horizontal.

Following von Langenbeck’s contribution, success in this operation became more certain. Operators now attempted to restore the entire cleft, both hard and soft, performing a urano-staphylorrhaphy in one stage.

Throughout the evolution of cleft palate surgery, many heated controversies among surgeons have raged over the priority for operations. It is amusing that so much spleen and steam have been vented over procedures, the results of which are faintly heard and seldom seen. Having been involved myself in such, and finding confrontation, whether in the boxing ring or the operating room, both stimulating and fascinating, I shall record controversies whenever possible.
For instance, Frances Mason of London in 1877 noted that G. D. Pollock in *The Lancet* in 1862 had defended his countryman's right to priority with this:

Mr. Avery [1848] . . . was the first surgeon in this country to close entirely a complete cleft of the palate. . . . The operation which Professor Langenbeck proposed [1863], and to which he gave the name of "the operation of mucoperiosteal flaps," appears to be identical with the method of operating introduced by Mr. Avery.

Pollock also noted,

I need not add that the separation of the mucous membrane without including some of the periosteum is well nigh an anatomical impossibility because the two structures are so intimately connected. . . . It is highly probable that Dieffenbach performed a very similar operation many years previously.

Here is some enlightening material Tom Patterson sent me which appears in his *Zeis Index*:

This was the position up to 1860, so that Busch could write: "The surgery of defects of the hard palate gives such bad results that I only advise it for the treatment of tiny holes, by cauterization; it should not be attempted for larger defects, where one should be satisfied with palliative treatment—*i.e.* closing the gap between the nose and the mouth with an obturator."

Zeis reported:

Since then, however, things have completely changed, due to the outstanding work of B. Langenbeck. He transferred his successful experience of rhinoplasty with retention of pericranium to the repair of cleft palate, and achieved such success that he was quite justified in saying that he was the first to have actually reconstructed the hard palate.

The operation, for which Langenbeck used the name "uranoplasty" instead of the older "palatoplasty," is as follows: paring the edges of the cleft in the hard palate down to bone; dividing the palatal muscles (*levator palati* and *palatopharyngeus*); lateral incisions in the soft tissue near the teeth; freeing the mucoperiosteum of the hard palate with raspatories and elevators, so that it only retains an anterior attachment 1/3 inch wide behind the canine and incisor teeth, and a second, posteriorly, in the region of the pterygoid foramen; freeing the soft palate from the posterior border of the palatal bone; insertion of sutures.
In designing this operation, Langenbeck took great care not to disturb the blood supply of the mucoperiosteum which was to be transplanted, in that there were no incisions at the sites at which the pterygopalatine and sphenopalatine arteries send off twigs to the mucosa.

A number of cases on which Langenbeck operated in this way, and which were amazingly successful, prove that the transplanted periosteum forms new bone, as can be demonstrated by needle puncture. If repair of the soft palate is difficult, this operation is much more so, but this will not prevent it being assured of a permanent place in operative surgery.

Langenbeck's statement that no one before him had succeeded in closing the hard palate by bone, caused Hulke to claim priority—partly for Ferguson and Pollock, and partly for himself. Whatever the first two achieved, neither Langenbeck nor I have ever read that they did anything like this. Hulke, however, after the description of Langenbeck's first successful uranoplasty was published in 1861, described his own unsuccessful operation which he alleged he had carried out in January, 1860; his account is so short and incomplete that it is clear that he has no right to dispute Langenbeck's priority.

Up to now Billroth is the only one who has followed Langenbeck's technique, using it even on children.

RELAXING INCISIONS

The permanent closure of the cleft velum by operation was not an easy task. The lateral pull of the palatal muscles interfered with healing and resulted in partial or complete failure in the majority of cases. This pull of the palatal muscles was feared by most operators, and ingenious efforts were made to combat it. Mettauer was one of the surgeons involved in solving the problem.

Mettauer of Virginia

John Peter Mettauer, son of a gallant French physician who had volunteered to serve with Lafayette in the Revolutionary War, after receiving his M.D. degree from the University of Pennsylvania returned home to Prince Edward County, Virginia, and became a plastic surgeon. He is credited with one of the first cleft palate closures in the Western Hemisphere, in 1827. Like others of this time, he was working under some disadvantages; it was 21 years before Lister's aseptic technique and 20 years before Mor-
ton's anesthesia. Mettauer recognized that cleft palate was associated with speech deformity and advised that the most suitable age for the operation was near puberty, when the patient could evaluate the pain and privations of the surgery against the benefits to be gained. He preferred the summer for the surgery and sat the patient in a type of barber's chair turned for a southern exposure between the hours of 11 A.M. and 2 P.M. for the best light. He used a corneal knife to freshen the cleft edges and advocated a cold water gargle for hemostasis.

Horton, Crawford and Adamson attribute the first successful operation for a complete cleft of the palate in the United States to fellow Virginian Mettauer, citing his remark:

We have met with cases of complete division of the palate in which the margins were separated to so great a distance as to defy every effort to approximate them, and to remedy them we were compelled to draw upon our inventive resources.

One of his resources was the protection of his suture line from tension with a series of small lunate relaxing incisions. He changed the axis of these incisions for palatal lengthening, stating:

Should the parts be deficient in length, the method which we have been describing may be employed in a transverse direction, guided by the views just submitted, but not to divide the tensor palati muscle.

Like most plastic surgeons, he was sensitive to deformity and even revealed this sensitivity in himself. Prematurely bald, he refused to be seen without his tall black stovepipe hat. One of his 17 children admitted never having seen her father without head cover since he always blew out the light at bedtime before he doffed his hat. He lived to the age of 88 and on his deathbed gave explicit directions that a coffin be constructed of sufficient length (8 feet) to allow him to lie in state comfortably with his top hat on and with a few of his special instruments by his side.

Liston

The Scotsman Robert Liston, professor of surgery at University College, London, was another early palate surgeon using relaxing
incisions. Liston was reputed to have tremendously developed arms and hands like those of Hercules or even another Liston, the "bad boy" boxer of the twentieth century. More amazing was the earlier Liston's delicate dexterity in spite of the size of his upper extremities. In 1837 he described ambidextrous incising of the cleft edges, placement of relaxing incisions and suture of the palate halves. He advised that

Before the ligatures are finally secured, the parts being put upon the stretch, an incision should be made on each side towards the alveolar ridge [by which] method the edges come together more easily, and the strain is taken off the threads, so that there is less risk of these making their way out by ulceration.

Addison

A more radical type of relaxing incision, still used in a modified form by some British surgeons, was proposed in 1925 by Addison. As he pointed out:

Tension in cleft palate surgery favors failure and sepsis assures it.

He threw all of his energy into relaxation:

The incision begins on the lower jaw and is carried up the ascending ramus on to the upper jaw behind the last tooth, then, turning inward, it is continued immediately internal to the teeth, as far forward as may be necessary.

Hullihen

Simon Hullihen of Wheeling, West Virginia, called a "Father of Oral Surgery," in 1845 reported on cleft palate and its treatment. From research by R. Goldwyn in 1973, interesting facts are available about this surgical pioneer. He was familiar with the work of Le Monnier and Roux and confined himself mainly to closure of clefts of the soft palate, being content to fill the osseous palate cleft with a gold obturator. Without the advantages of anesthesia, he had to wait until the child was 9 or 10 years old. The patient was placed on a low seat in a reclining position, in a good light. When he opened his mouth to its full extent, a cork was popped in between the last molar teeth. The
surgeon, kneeling in front, grasped the edge of the uvula with forceps in the left hand and, with a spear-shaped knife in the right introduced the point into the velum half an inch back from the palate-bone and the sixteenth of an inch from the cleft-edge, and then plunged through to the guard backwards and towards the pharynx. Thus, in an instant, the edge is severed in a straight narrow strip.

The cork was removed, bleeding allowed to subside, cork replaced and opposite cleft edge pared. The next step was to insert the ligatures.

TRANSVERSE INCISIONS

When the cleft extended through the hard palate arch, Hullihen considered closure difficult and explained his approach:

In such cases, a transverse incision may be made along the posterior edge of the palate-bone on both sides of the cleft, and through the entire thickness of the velum, and to such an extent as to permit the raw edges to be properly approximated.

Julius Wolff in 1885 stated that all suggested operative procedures for cleft palate up to that year could not replace the original formula laid down by von Langenbeck. He even went so far as to say:

Perhaps no procedure could ever replace it.

Three years later, however, he modified it himself, using two stages, first elevating the palatal mucoperiosteum, then, five to eight days later, denuding and uniting the cleft edges with sutures. With these improvements Wolff postulated that children operated upon in early life would learn to speak better by the age of 6 years.

FRACTURE OF HAMULUS (BILLROTH III)

Billroth used von Langenbeck’s method but added a new relaxing adjunct to facilitate closure with less muscle violation. Lenbach’s
Theodor Billroth, born on the island of Rügen in the Baltic Sea, the son of a pastor, was a mediocre student with a desire to become a musician. He was skilled at playing the piano and violin, composed music himself and became a close friend of Brahms. Yet he was destined to become one of the great surgeons of his time. He studied medicine at Göttingen and Berlin and became a disciple of von Langenbeck. After seven years as professor of surgery in Zurich he took the chair at the University of Vienna. In 1881 he performed the first gastric resection and in 1873 did the first laryngecetomy. Billroth was known for his sincerity in openly discussing his successes and failures. As he said:

One unhappy case is better than 10 good ones, if one does not hide the mistake but (rather) analyzes it.

In 1889 Billroth wrote of his modification of the von Langenbeck uranoplasty:

In many cases, the results of staphylorrhaphy and uranoplasty, introduced by B. v. Langenbeck, did not fulfill the expectations for speech improvement. To achieve this goal, a number of trials were made. In congenital defects, the muscles moving the soft palate are not just cleft, but powerless. This is the reason for the minimal postoperative speech improvement. In clefts of the soft palate alone, this muscle deficiency is minimal and, therefore, the postoperative functional result is best.

In clefts of the hard palate, the entire musculature of the soft palate, corresponding to the width of the cleft, is missing. In addition, these rudimentary muscles are transected by the lateral incisions.

During healing, the soft palate is pulled with the united soft tissues of the hard palate toward the vault of the hard palate, which, in these patients is usually quite high. These factors explain the functional insufficiency of the muscles and the slight improvement postoperatively.

To avoid this bilateral sectioning of the muscles by the lateral incisions, I did not divide the entire thickness of the soft palate in my last operations. After the mucosa was incised, the medial plate of the wing of the pterygoid, above the hamulus, was cut with a narrow chisel. In this way, the hamulus was rendered somewhat mobile and could be moved (from either side) toward the midline, with its uninjured musculature.

Despite all this, the ability to completely separate the nasal from the oral
cavity during speech was not achieved, in most cases, by the operation alone. Therefore, an attempt was made to close the remaining communication by a well-fitting obturator.

According to A. W. Schwartz, Billroth was so respected by the Austrian people that a two-shilling silver coin bearing his likeness commemorated his 100th birthday, and in 1937 his portrait appeared on an Austrian postage stamp.

In 1925 Dorrance fractured the hamulus and then dislocated the tendon of tensor muscle, claiming that this transformed its function from a tensor to a levator muscle.

**Mechanical AIDS to Relaxing Incisions**

Other, more mechanical methods of reducing tension on the suture line were developed:

Champenois in 1868 packed the lateral relaxing incision with charpie and then covered the entire palate with a perforated gutta percha plate wired in place.

In 1879 Dudon inadvertently broke his curved needle. Not having another, he conceived the idea of holding the palatal flaps in apposition by embracing them with ribbon sutures passed through the relaxing incisions.

David Prince in 1884 took up the tension with beads.

Charles Dalton Fillebrown in 1906 carried the effort for relaxation even farther. He used special curved relaxing incisions and reinforced his cleft closure suture line with anti-tension wire sutures tied over silver disks.

Nitch applied aluminum plates at the site of lateral incisions to relieve tension in 1912.

MacKenty used retention hooks and retention retractors.

Federspiel in 1916 used anti-tension plates; Thompson in 1921...
MacKenty used anti-tension sutures over lead plates; Sprague in 1926 used "tension relief pins."

Of course, all of these anti-tension maneuvers were superseded by the famous intramuscular silver suture of Veau.

DORRANCE

In 1933 Dorrance described, with superb drawings by W. B. McNett, his modification of the von Langenbeck procedure, used when there was adequate tissue allowing sufficient length to be achieved without his more radical pushback procedure.

AXHAUSEN

Georg Axhausen of the University of Berlin was a Prussian aristocrat with a dictator complex who, it is said, when not operating was fighting with Wassmund, the second maxillofacial surgeon in Berlin. In 1936 Axhausen wrote a book on cleft palate describing his use of the von Langenbeck procedure. He dissected the mucoperiosteal flaps through the standard lateral incisions, ligated and divided the posterior palatine vessels and achieved a careful two-layer closure of the nasal and oral mucosa.
Frank McDowell, now of Honolulu, Hawaii, recalled in 1976 how the von Langenbeck principle was used at Washington University, St. Louis, during the 40’s:

All of us, Brown, Byars, myself, including Blair, closed total clefts of the palate by a modification of the von Langenbeck procedure which Blair called the Dieffenbach-Warren operation—and which was called by others “the Blair-Brown operation.” The arteries were dissected out well, stretched from their foramina, and cut loose from the mucoperiosteum a little ways, if necessary, to allow closure without tension in the area of the junction of the hard palate with the soft palate. (This was the forerunner of the setback operation for partial clefts.) The soft palate was closed in layers, paying as much attention to a precise closure of the nasal mucosa (from the anterior gum to the tip of the uvula) as to the closure of the oral mucosa. When done successfully in one operation at about the age of 18 months, about two-thirds of these would spontaneously develop normal speech (providing attention was paid to their incisor dentition so they could make sibilant sounds). About one-third had varying degrees of speech abnormalities—and they represented the real problem. We did see upper jaw retrusion in some of these patients—even in some who had not had the palate operated on—even in a few who had never had the lip or palate operated on. Early and persistent orthodontics seemed to be the best answer.

Another to use or guide his residents through thousands of von Langenbeck cleft palate procedures is Truman G. Blocker, Jr., who in size, strength and “smarts” personifies the mythical Texan. A giant in American surgery, brigadier general in the Army, history addict and chief of the University of Texas Medical branch in Galveston, he learned the von Langenbeck operation from Singleton, who in turn learned it from pioneer cleft surgeon J. E. Thompson. Always with a clear view of the entire picture, Blocker developed an impressive residency training program and was the first to start a cleft palate speech program in Texas. Recently he has become president of the University of Texas Health Science Center in Houston, which includes the schools of medicine, dentistry, public health, biomedical science, nursing and allied health science. The Center, having bought the Prudential building, under Blocker’s direction is busy removing the
"Piece of the Rock" sign and installing in its place the University of Texas steer head.

When asked to reflect on cleft surgery, Blocker wrote in 1977:

Sophistication of pediatric anesthesia in the past two decades has resulted in enhanced techniques for repair of cleft palate deformities. The surgeon has more complete freedom from worry for the safety of the patient than in former days and is able to define structures with much greater precision. Antibiotics have almost eliminated post-operative inflammatory breakdowns, and with anatomically correct approximation of tissues, problems in speech training have been considerably reduced.

MODERN POPULARITY

In 1964 Michael Lewin of Montefiore Hospital, New York, published a survey made in 1961 of methods of management of cleft palate in the United States and Canada. He found that over half the surgeons were using a form of the old von Langenbeck repair. This was certainly my experience during my early years of training. In the summer of 1944, as a senior student at Boston Children’s Hospital, I first saw a cleft palate operation. D. W. MacCollum, sitting on his special sponge cushion, pared the cleft edges, used relaxing incisions in a standard von Langenbeck closure, pulled the palatine vessels out of their foramen—as he said, “like an earthworm out of its hole”—and approximated the palatal halves with meticulous sutures. The primary concern was cleft closure without tension, and I do not recall an incidence of wound separation. There was no discussion about or attempt at palatal lengthening. W. E. Ladd had given up doing palates, but Robert Gross, between one patent ductus and another, did a private palate cleft occasionally—whether to keep his hand in or to upset MacCollum, I was never certain.

While finishing up World War II Navy duty in Nashville, Tennessee, I managed “off-duty” scrubbing in the early A.M. with William Core, an able general surgeon who occasionally did a palare operation. He was the first I observed to split the cleft edges instead of paring them, which seemed to make good “Scots” sense.

Through the latter part of 1946 and 1947 on the general surgical house staff at Vanderbilt University Hospital, I mane-
vered my way onto Beverly Douglas’ plastic surgery service. His complete concentration and minutely meticulous technique was beyond the patience of the eager general surgical students. One resident autoclaved the *Nashville Times* and kept up with current events during a prolonged plastic procedure, and Bill Meachum, once a circus performer but at that time more interested in neurons and synapses, faked a grand mal at the scrub sink and was excused from assisting a plastic case. Thus, I had the good fortune to spend many hours with Douglas on numerous Dieffenbach-Warren-von Langenbeck cleft palate operations.

**LINDSAY**

One of the modern champions of the von Langenbeck procedure is William Lindsay of the Toronto Hospital for Sick Children. In the 1971 book *Cleft Lip and Palate* Lindsay mentioned that his operation is identical to that of von Langenbeck, with the only variant being in fracture of the hamulus.

Guided by von Langenbeck’s original text, which had no illustrations, Lindsay has conjured up likely diagrams to depict the various steps in the original procedure. Briefly, the operation includes the following maneuvers:

The edges of the cleft are incised and dissected to produce three layers: oral mucosa, muscle and nasal mucosa. The lateral relaxing incisions start at the maxillary tuberosity proceeding posteriorly along the pterygo-mandibular raphe to just in front of the anterior pillars of the fauces and then, proceeding anteriorly, parallel to the alveolar ridge as far forward as the canine-bicuspid region. The scalpel is carried firmly down to bone and with an elevator the mucoperiosteum is freed, taking precaution to tease the vessels out of the foramen without severing them. The nasal mucosa is transected at its medial margin at a point anterior to the posterior nasal spine and this cut is extended laterally, to try for a “sneaky” bit of nasal mucosal lengthening. This defect is left raw while the nasal mucosa, muscle and oral mucosa are sutured in layers.

A recent study by Lindsay comparing 66 von Langenbeck cases with 45 modified Dorrance pushback cases (also with a raw nasal defect) revealed interesting findings. Lindsay summarized:
The modern critics of the von Langenbeck operation claim that it allows unnecessary fistulas in the anterior aspect of the mouth, produces a palate of insufficient length, and is associated with inferior speech results. The evidence [of the Toronto study] contradicts these criticisms and indicates that patients who have a Langenbeck palatoplasty will speak as well as those who have a pushback palatoplasty by the time of speech maturation [60 percent acceptable speech by von Langenbeck, 42 percent by pushback]. This study has shown conclusively that the former [von Langenbeck] group . . . have a lower frequency of incisor crossbite and buccal-segment collapse. . . . It [also] suggests that it is better to leave residual fistulas in the anterior portion of the hard palate unoperated until after orthodontic correction has been accomplished.

In 1978 Isaac Kaplan, with Labandter, Ben-Bassat, Dresner and Nachmani of Petah Tiqva, Israel, reported long-term follow-up on von Langenbeck cleft palate closures which supported the findings of Lindsay and Blocksma. There was minimal facial growth deformity with slightly more than 20 percent having velopharyngeal incompetence.

Personally, I find the von Langenbeck principle useful in closing the residual hard palate cleft at 18 months to 2 years when the soft palate was closed in the early months. The lateral relaxing incisions can be modified, kept away from the teeth and often reduced to curved releasing cuts around the maxillary tuberosities. This maneuver allows cleft closure with less mucoperiosteal elevation and minimal residual raw areas with far reduced likelihood of maxillary growth disturbance. Since approximately 75 percent of patients with von Langenbeck closures will develop normal speech, the need for secondary pushbacks and pharyngeal flaps is limited to the other 25 percent and after 5 years of age.
According to Dorrance, Krimer was the first, in 1827, to use the important principle of everting soft tissue flaps from the covering of the palatal plates or the adjoining tissue. In his case Krimer made an incision along one side of the cleft. On the opposite side he made an L-shaped incision carried down to bone in the hard palate area. The flap of soft tissue was elevated with its base medially, turned over with the mucosa upward and sutured to the opposite split edge of the cleft. Thus the cleft was closed with one area raw and the halves of the uvula still divergent.

In 1830 Bonfils varied this principle with his turnover flap based posteriorly along the cleft edge to fill the cleft of the velum.

In 1836 Nélaton turned two Krimer flaps so that each filled half the cleft of the hard and soft palate and sutured them to each other in the midline. The wide raw area remaining must have been responsible for extensive scar contracture. The same principle, on a smaller scale, has been used through the years and is still of value for closure of fistulae.
In 1890 Davies-Colley made an important divergence from the popular von Langenbeck approach on a case in which the von Langenbeck method had failed. He combined the turnover flap of Krimer with a mucoperiosteal flap for overlapping. Four years later he modified the original procedure and used it in conjunction with staphylorrhaphy so that the split palate was closed in one operation.

LANE

In 1897 Sir W. Arbuthnot Lane of St. Bartholomew’s Hospital, London, pointed out the importance of establishing the palatal septum between the oral and nasal cavities. He advised operation very early to obtain normal breathing, a function he considered essential for the development of the involved parts.

Lane was Harold Gillies’ chief in the early days and, being interested in palate surgery, used his influence to help Gillies and plastic surgery get started in England. Lane was a general surgeon at heart, however, who was content to create and ignore large raw areas, and for adequate exposure to the palate he did not hesitate to split a normal lip. As an enthusiastic proponent of the "no touch" technique, he used long instruments to manipulate the tissues without once touching them with his hands. As Gillies said:

The old boy used the instruments with such dexterity that he could finish the operation in half the time of the rest of us.

In fact, the medical students affectionately cartooned Sir Arbuthnot Lane working with his famous long instruments through a hole in the dome of his operating theater.
Once Lane got onto the book-leaf turnover flap, he used frightening ingenuity in its application, warning that great care must be taken not to tear away this flap from the margin of the cleft. Here are variations of Lane's turnover flap approach for various clefts.

For a split velum (in Dorrance):

For a complete unilateral cleft (in Dorrance):

For a complete unilateral cleft (in Davis):
For a very wide bilateral cleft in two stages:

First stage

Second stage

Sir Abuthnot Lane did develop a principle which has value. Yet, by carrying it too far, he became known as a bad knight in palate surgery. Our good and sensitive knight, Sir James Berry (a CL&P himself), in 1912 condemned eversion of the mucoperiosteum as practiced by Lane and others. You can almost hear his nasal escape as he made these pertinent comments:

That the [palate] defect can often be closed at the time of operation by this procedure is quite certain, but what is required is to know the subsequent fate of the flap and how the patient speaks. We have seen several cases in which the flap was undoubtedly atrophied and large holes have been left . . . ; in others it has been evident that the whole flap has sloughed and the palate been left in such a condition that further operation was quite impossible. The soft palate is frequently very deformed owing to the contracture of the scar tissue; moreover it is often stiff and rigid instead of being freely mobile. Most important of all, however, is the question of
speech. . . At the demonstration of cases before the Surgical Section of the Royal Society of Medicine (May, 1911) very few patients were shown who had been operated on by this method and who were old enough to talk or to answer questions intelligibly; and therefore we are still left without reliable information on this important subject.

COMBINING TURNOVER FLAP
AND MUCOPERIOSTEAL FLAP

In 1906 Murray used a turnover flap to close the hard palate in infancy and at 2 years medially displaced palate tissue to close the velum.

In 1907 Moszkowicz combined von Langenbeck's mucoperiosteal flaps with the Krimer-Lane turnover flap for palate closure. In 1908 Starr reversed the uses of the two principles, closing the hard palate with mucoperiosteal flaps and the velum with a turnover flap.
In 1917 Harry Shermann reversed Murray’s order of closure by approximating the velum first and later closing the anterior cleft with a turnover flap.

SKIN GRAFTING THE EVERSION FLAP

J. F. S. Esser, during World War I, originated the split-skin graft inlay for reconstruction of the buccal sulcus. He must have spent a good portion of his surgical hours burying skin. In 1916 he described an interesting approach to closing a palatal defect with a turnover mucoperiosteal flap lined on both sides to avoid raw areas. On one side of the defect Esser made a crescentic incision down to bone as near the alveolar ridge as possible, then peeled the mucoperiosteal flap off the bone, leaving the base along the edge of the defect. At this point he had a turnover flap already popularized by Lane. He then fashioned a flat egg of modeling compound, wrapped it with a split-skin graft with its raw surface outward and tucked it into the raw pocket formed as the mucoperiosteal flap was brought back and sutured to its original join along the alveolar ridge. By one to two weeks the skin graft had adhered firmly to the raw undersurface of the turnover flap so that it could be relifted, folded medially, leaf-of-book fashion, and tucked under the elevated mucoperiosteum of the opposite edge of the cleft. This, of course, was an important improvement over other eversion flaps since it avoided one of the main flaws, a broad, raw, contracting surface. Esser recommended this method in all cases of bilateral jaw-palate clefts.
MODERN USES

Large eversion flaps producing huge raw donor areas were popular in the pioneer days of palate surgery. The undependability of the vascularity of these flaps and the severe contracture of them and their donor areas have reduced their use. Today the only turnover flaps being employed are the vomer flap for nasal lining in the hard palate area and various relatively small eversion flaps for closing fistulae.
11. Uranoplasty, Bone Flap and Osteotomies

FIRST URANOPLASTY

PALATE operations had been limited to single clefts of the velum until 1827 when Dieffenbach introduced his operation for uranoplasty or closure of the hard palate. His thoughts in 1826, as translated by Schmid, are of interest:

Several attempts to surgically close the bony gap with the soft cover of the palate have been unsuccessful. However, it might be possible by an operation on the bone of the palate to approximate the bones to one another and thus also the margins of the velum. After incising the soft cover, the palatine bones would have to be cut with a saw along the alveolar process in a curved line from the posterior margin in an anterior direction up... close to the cleft. After this, the freshened medial cleft margins would have to be pulled together by a gold or lead wire. The bone would have an adequate blood supply from its superior attachment; one could also expect later closure of the lateral opening, particularly if one provided some help to nature. After successful healing, suture of the palate would still have to be carried out.

Dieffenbach finally carried out his proposed osteal uranoplasty, demonstrating that his lateral mucosal incisions could be extended through the underlying bone with movement of both mucosa and bone toward the midline. First he punched a hole through the bone with a three-cornered awl on each side at a strategic position along the line of his usual relaxing incision. Then he passed a thick soft silver wire through these two holes, joined the ends across the cleft and began twisting. His lateral mucosal incisions were then made along the line where the palate...
bone meets the alveolus. A smooth, thin, concave chisel was used to chop through the bone along this line. Dieffenbach explained:

The wires are then twisted again, till the edges of the bony cleft approach each other a little or together; the first alone can be generally done.

If he did not first succeed, he twisted again from time to time.

Wutzer, a Swiss, in 1834, and Buehring, a German, in 1850, both used this type of osteal uranoplasty. Loewenhardt combined it with staphylorrhaphy in 1857. Another German, von Langenbeck, although not too happy with osteal uranoplasty, in 1861 pointed out that the procedure should be limited to bilateral lip-jaw-palate clefts and was contraindicated for unilateral clefts in which the vomer was attached to one side of the defect.

By 1868 Billroth was discounting the procedure as no longer being practiced, but in 1873 Sir William Fergusson came back into the act with new vigor and his special osteotome.

He modified Dieffenbach's side incisions, placing them 0.25 inch from the border of the cleft using a chisel for the osteal uranoplasty. Finding that the bony fragments within the flaps became tilted, Sir William made perforations in the bone with a shoemaker's awl to hold the bone flaps together with sutures. In 1874 he combined soft palate and osteal uranoplasty in one operation.

Francis Mason improved on Fergusson's method by boring awl holes along the line destined for bone division. Then with the tap of a chisel the osteal uranoplasty was achieved without splintering. As Mason explained:

The procedure is extremely simple and may not be inaptly compared to the perforated edges of a postage stamp.

Evidently two gentlemen from Philadelphia, Roe and Mears, both did osteal uranoplasties in the late 1800's. By the early 1900's only two surgeons were using the bone flap method, G. V. I. Brown of Milwaukee and Warren B. Davis of Philadel-
phia. This operation has indeed enjoyed a rather discreet lineage, having been handed down almost selectively from teacher to teacher, each of whom, being a gentleman of the old school, always gave due credit to his mentor.

B R O W N

In his 1918 book, *The Surgery of Oral Disease and Malformations*, George Van Ingen Brown, D.D.S. and M.D., of Milwaukee Children's Free Hospital wrote:

This method consists in sawing through the palate bones from behind forward, fracturing with forceps, and wiring in such a manner as to approximate the bone fragments sufficiently to bring the soft parts together. It was devised by Fergusson, and earnestly advocated for years by J. Ewing Mears of Philadelphia.

By 1922 Brown was using this method, pleased that it preserved the nerve and blood supply and did not require the severing of muscles which usually healed with shortening and inflexibility. He considered the bone flap method simpler and more certain of success and taught it to his students.

H Y S L O P

Volney B. Hyslop of Marquette University, Milwaukee, carried on Brown's teaching, used the bone flap and taught it to Sidney Wynn. In 1973 Wynn recalled:

Dr. Hyslop was one of the best intra-oral plastic men I ever knew. It galled him considerably when he heard about all the secondary surgery people were doing on palates as less than 5% of his bone flap cases ever had to have secondary surgery for speech improvement. He was very kindly and did a considerable amount of charity work in the days of the house case and clinic before the time of Title 19 and Medicare.

D A V I S

Warren B. Davis of Philadelphia, in 1928, advocated what a Frenchman named Lannelongue proposed in 1877: the combina-
tion of osteal uranoplasty and the von Langenbeck procedure. In bilateral clefts of the jaw and palate he used the osteal uranoplasty, but in unilateral clefts he used an osteomucosal flap from the free side of the palate and a mucoperiosteal flap from the opposite side which was in connection with the vomer. In either case the resultant flaps were held together by a surrounding tape. Warren Davis acknowledged that William J. Roe taught him the bone flap method.

Warren Davis

PEER

In 1964 scholar and researcher Lyndon Peer reminisced 25 years back when Warren Davis invited him, along with Staige Davis, Kitlowski and Straatsma, to visit Jefferson Hospital. During the morning Davis performed seven one- and two-stage palate operations and in the afternoon presented cases. The speech results and the palatal appearance and function were so impressive that Peer used this operation from then on at St. Barnabas Medical Center in Orange, New Jersey. In starched white coat and with his resonant and carefully modulated voice, Peer recalled Davis as an exceptional, skillful cleft palate operator who with John ["Dermatome"] Reese as first assistant and some adrenalin packs could complete the first stage in three minutes and the second stage in twenty minutes.

In 1954 Peer of New Jersey, with Hagerty, Hoffmeister and Collito, gave his initial description of this two-stage method carried out two weeks apart. First, an incision was made through the mucoperiosteum in the lateral palate at the base of the alveolus. A chisel cut along this line, dividing the bone and nasal mucosa. At the second stage, the bony palatal shelves were fractured toward each other and the mucosa of thin cleft edges
was split so the halves could be approximated with 2-0 silk sutures passed through drill holes in the bone. In complete clefts the anterior fistula was closed at a third operation. Peer believed that this operation produced better speech than the von Langenbeck method.

Peer’s conclusions in 1954 from his study of 133 bone flap cases did not acknowledge deleterious effects on the maxilla. He reported:

1. No fistulae in 113 cases.
2. A majority of patients with very minor retardation in the anteroposterior growth of the maxilla associated with underdevelopment of the mandible.
3. A smaller percentage with "pushed-in" faces with slight underdevelopment of the maxilla but overdevelopment of the mandible.
4. Crowding and crossbite.

Peer considered these deformities typical of the cleft palate and not related to surgical trauma, the bone flap operation or the age at surgery.
Ten years later, in 1964, Peer’s report with Walker and Meijer still advocated the bone flap method, with 70 percent of the patients requiring speech therapy. For those who did not respond to therapy and whose palates were short, a full-thickness soft palate Z was used for lengthening. If even better velopharyngeal closure was required, a Moran type, superiorly based pharyngeal flap was added.

In 1971 Peer reviewed the advantages of the bone flap, emphasizing that it duplicates what nature should have done, for by moving the bones together not only is bony union achieved across the cleft but bone replacement fills in the lateral gaps, which I have seen in hundreds of cases.

He admitted, however, that if he started with a short palate he ended up with a short palate and he could not compare his bone flap method with the von Langenbeck or the Wardill as he had had no experience with either.

Stefan Demjen of Bratislava observed results in New Jersey of the bone flap operation carried out 8 to 10 years before by Lyndon Peer and reported:

The speech results are comparable to other methods presently used. There is no gross disturbance in maxillary growth.

**HAGERTY**

Bob Hagerty of Charleston, a student of Peer and one of the original authors of the early bone flap work, says today that he uses the bone flap technique in wide clefts and usually in older patients 14 and 15 years of age. He admits that some shortening of maxillary growth is seen but feels that this could be inherent lack from the original cleft deformity. Hagerty expresses more concern over the ill effects of dissecting mucoperiosteum off the bone than over osteotomies and fracturing of the maxillae.

**CLODIUS**

In the 1964 International Symposium on the Early Treatment of Cleft Lip and Palate held at the University of Zurich, historian and surgeon Leo Clodius stated his preference for the bone flap
method. Previously a student under Lyndon Peer in Newark, New Jersey, and representing a Swiss branch of the Peer part of the tree, he commented:

Closure of the palatal shelves and the soft palate is carried out between the 12th and 20th month before speech is started. The bone-flap technique originated by Dieffenbach is used. Unless the cleft is very narrow, this is a two-stage procedure, carried out two weeks apart. At the first operation the mucoperiosteal-osteal flaps are delayed, severing the palatal processes with the nasal mucous membrane from the palatal arch. This produces bilateral pedicle flaps. Their length is determined by extending relaxation incisions posterolaterally, as advocated by Ernst, to ensure tensionless palatal closure. At the second stage the flaps are united in the midline. A three-layer closure is performed for the nasal membrane, muscle and bone, and oral mucosa. The advantages of this method, which of course must be carried out carefully so as not to disturb the tooth buds, are as follows: there is minimal denuding of bone, the soft palate muscle attachment to the posterior bony palatal edge is left undisturbed and no raw surfaces leading to possible antero-posterior scar contractures producing velar rigidity result. A technically easy Z-plasty during the second stage may lengthen a congenitally short soft palate. A solid bony palate vault results. The resulting lateral defects are well healed at 10 days. . . . 70% of our patients are given speech therapy, many of these for minor speech defects.

W Y N N

Descendant of the Brown-Hyslop line and the most enthusiastic of them all, Sidney Wynn of Milwaukee Children’s Hospital in 1959 described this method of osteotomy and suturing in one stage and defended its merit:

The bone flap technique provides a simple, relatively safe procedure which restores to the roof of the mouth a new bony vault as nature originally intended.

He further claimed:

Narrowing of the width of the palate is not secondary to early surgery on the palate if the bone flap technique is used.

He cited his work with Hyslop and Zwemer in 1956, which with study casts and cephalometric x-rays showed bone flap cases operated on between 9 and 18 months of age to have:
1. Intermolar width between the first permanent molars within normal limits.

2. The first permanent molars on the side of the cleft in the medial version or Class II relationship.

3. The teeth anterior to the first permanent molar on the side of the cleft in lingual crossbite relation.

4. The incisor teeth in both segments in lingual crossbite in a number of patients.

5. The teeth next to the cleft rotated and tipped toward the cleft.

Wynn continued his defense with:

The anterior crossbite is indicative of the rotation of the bony segments by labial muscular action of the repaired lip and is not due to the growth disturbance subsequent to the palate repair. There is no broad surface scarring over the palate bone as there might be with a von Langenbeck mucoperiosteal type of procedure to interfere with the growth of the palate bones.

Then he went on to claim that not only is there no perceptible shortening of the soft palate but

In fact, it appears that the palate becomes lengthened following bone flap movement toward the midline.

Speech studies by experts such as Leutenegger and Demeter of small samples of postadolescents suggested that speech results following the bone flap method were as good as or better than those achieved with other methods. As noted by Wynn:

From 1936 through 1970 a total of 730 bone-flap operations were counted as having been performed at Milwaukee Children’s Hospital. Only nine pharyngeal flap operations were performed on patients who had [a bone-flap] procedure and whose velopharyngeal insufficiency appeared to warrant it.

"Blind" studies by Pionek of the bone flap method compared with other techniques using measurements taken on roentgenographic cephalograms revealed growth and development to be good, with the gonial angle more normal after bone flaps and increased to an obtuse angle after mucoperiosteal flaps. As Ross observed, cleft individuals with severely collapsed superior maxillae exhibited an increased gonial angle. It was postulated that
the higher vault following the bone flap method provided the unsuspected advantage of more room for the tongue. In 1970 Miller and Wynn reported that children with bone flap surgery had better hearing than those with other types of palate surgery and explained it on the basis of maintenance of better control of musculature essential for good Eustachian tube closure.

Finally, in 1976 Sidney Wynn repeated the advantages of the bone flap method but referred to it as “bilateral osteotomy cleft palate surgery,” justifying this change in name after 30 years to avoid confusion with earlier bone flap methods. He explained:

Our method should not be confused with the earlier procedures described by Dieffenbach, Warren Davis, G. V. I. Brown, and Peer. They actually divided the bone laterally, entirely through the nasal side of the palate, to produce a true bipediced osteoperiosteal flap.

His description of certain advantages of the bilateral osteotomy method deserves consideration.

It consists of simple osteotomy wedging of the bone posteromedially leaving all nasal mucosa intact so actually a three-sided rather than a bipedicle-type flap is involved. The soft palate musculature is left attached completely to the bone and the hard palate is not subjected to mucoperiosteal elevation . . . yet when an osteotomy incision is made into a bone, an actual regrowth of bone may take place such as occurs in a fracture site . . . Bone fill-in happens rapidly . . . Dr. Walter Blount, eminent Milwaukee orthopedic surgeon, has reported that bone deposition has been observed when osteotomies of the bone flap of the pelvis are done in cases of dysplasia of the acetabulum. He stated, “the younger the infant, the more rapidly the bone fills in. This does not produce growth or bone developmental deformity and at times may even produce some bone growth.”

Confident that it is safe to do the bilateral osteomy palate closure as “early as 9 months with good results,” Wynn presented his various osteotomies and made statements that warm the cockles of the hearts of surgeons and speech therapists while constricting the orthodontists’ coronaries:

This over-emphasis on simplicity and trauma minimization to assist the maxillary growth, while completely overlooking the early speech results in a child’s psychologically formative years, seems to demonstrate inappropriate priorities . . . Ortiz-Monasterio et al [1974] have reported that palatal
closure may often be unsuccessful in the older child as compared to what can be accomplished in younger children. . . Early bilateral osteotomy in cleft palates also encourages more normal physiologic patterns both from the standpoint of speech and development by repositioning and restructuring the palate in the manner that nature originally intended.

The surgical technique is carried out through lateral mucoperiosteal incisions inside the alveolar area, starting behind the tuberosity and extending forward three-quarters of the length of the hard palate. The chisel osteotomy divides the hamular process off the perpendicular plate and extends forward as outlined in all types of palate clefts.
The edges of the cleft are stripped of mucosa and freed from the bone for a depth of 2 mm. to ease suturing. No attempt is made at suturing the bone, and packs of Furacin are inserted into the osteotomy sites for five days to relieve tension and control bleeding.

Upon removal of the packs, the large defects fill with granulation tissue in three to five days and are re-epithelialized by mucous membrane after two weeks.

Wynn noted:

Experience has taught us that in very wide (1.5 cm. anterior plus) single and bilateral complete cleft cases, it is easier and probably wiser to precede the osteotomy technique by a single vomer flap technique, as described by Dunn in 1952 [which according to Stenström in 1974 causes minimal maxillary growth interference]. In many cases, the bilateral osteotomy operation can then be used to close the remaining palate at the same operative procedure.

Wynn’s conclusions were enthusiastic as he claimed the following as benefits of the bilateral osteotomy method:

1. Reconstruction of the bony vault of the cleft palate. A photograph of an x-ray showed lateral bone fill-in in the osteotomy sites.
2. A soft, flexible and mobile soft palate.
3. Maximum function of the Eustachian tube, as their audiology studies demonstrated 10.6 dB better hearing levels than in children with cleft palate closed by mucoperiosteal dissection methods.
5. Vertical and horizontal development of the maxilla comparable to an unoperated cleft sample (McGowan).
6. A high percentage of good speech and voice results.

In spite of the experience of 30 years and 730 cases with what was referred to as “minimal complications,” only the nine years from 1966 to 1975 were studied, and out of 298 palate cases only 93 survived the various cuts. The operations had been performed by either V. B. Hyslop, S. K. Wynn or W. Wiviott. Of the 93, 88.2 percent had adequate palatopharyngeal functioning for speech and voice quality purposes. Eleven percent had hypernasal speech related to velopharyngeal incompetence which required secondary surgery; 19.4 percent demonstrated speech and voice deviations unrelated to palatal functioning since they had normal cithophonation findings and were stimulable for normal speech.
and quality with speech therapy; 68 percent presented *normal* vocal quality.

This closure makes no effort to correct malposition of muscle insertions by division and repositioning. Wynn defends the omission:

The muscles of the velum are not cut across and therefore a longer, more mobile palate is obtained. . . . Thus, the entire palatal bone with all of its muscular attachments moves in a posterior direction giving length to the palate. . . . Broomhead demonstrated some years ago that there is a nerve supply which comes through the aponeurosis of the palate. This of course would be disturbed if division of the posterior border of the palate bones from the musculature was done. . . . Recent work by Fisher and Mulliken and Kaplan [all in 1975] of the levator muscle retropositioning, retrodisplacement and reattachment I think should be reserved for secondary speech problem cases or those who have had intact bony palates with velopharyngeal insufficiency.

In 1978 in Hollywood, Florida, Wynn with K. L. Lynch reported gross, radiographic and microscopic studies of hard palate osteotomy sites at 7 days and at 12 months postoperatively. They reported:

The findings showed that successful osteotomy in infant cleft palate surgery translocates autogenous fibrous bone and osteogenic cells into a cleft bridging position. Rapid healing and bone formation bridges the cleft with woven fibrous bone initially, and then matures by lamellar bone replacement and Haversian system remodeling. Both the normal palate and the cleft palate have a rich anastomosis of microscopic blood supply that is vitally important in the remodeling process. These facts may help to explain long-term successful results in early cleft palate osteotomy surgery.
12. Primary Osteotomies

A most important aspect of the cleft deformity which influences the dental occlusion and maxillary platform for the face is the presence of a cleft of the alveolus extending through the hard palate. If the cleft does not go through the alveolus, there is usually enough buttress in the anterior bony arch to maintain occlusion with the mandible and resist distortions caused directly by the surgery or secondarily by postsurgical contracture.

The discrepancies in the maxillary and premaxillary segments associated with clefting present varying degrees of distortion. It is the nature of a surgeon to take up the scalpel or chisel to correct deformity, and, although many were content to use the compression of bandages or lip closure to mold the premaxillary protrusion, some were stimulated to take more radical action.

EXCISION OF PREMAXILLA

In 1814 Xavier Bichat noted that P. J. Desault had removed the projecting bony prominence of the premaxilla in bilateral clefts and by three months all had healed. He also observed:

But the transverse diameter of the upper jaw, diminished by the whole width of the projecting button, did not correspond any more to the lower jaw, and as is often observed in old persons, there supervened a setting of the upper in the lower jaw, which was extremely inconvenient for mastication. This inconvenience, being the obvious result of loss of substance in the superior maxillary bone, changed the practice of Desault on this point.

He turned to external pressure against the premaxilla (presurgical orthopedics) with linen cloth bandages.
OSTECTOMY AND OSTEOTOMY IN UNILATERAL CLEFTS

In 1864 Dambre of Contra closed the breach in the alveolar ridge in a patient with a left unilateral lip-jaw-palate split by pushing the projecting premaxilla into place after extracting the right second maxillary incisor. To promote healing between maxilla and premaxilla, he cauterized the edges with silver nitrate and fixed the parts with an ivory plate and T-shaped rod. In 1873 Duplay closed a unilateral alveolar cleft by pushing the projecting premaxilla into place after sectioning the bones subperiosteally from the right maxilla. He denuded the edges and, after wiring the bone, sutured the mucoperiosteum.

As noted by Conway and Stark in Plastic Surgery . . . One Hundred Years Ago, Gurdon Buck described osteotomy for unilateral clefts of the lip and palate in 1876:

The bony prominence formed by the anterior extremity of the right segment of the alveolar arch was first broken down and reduced into position by the application of Butcher's bone pliers. . . . The prominence, after it was reduced, bridged over and filled up the cleft in the alveolar arch. By previously paring the confronting edges bony consolidation was secured. The removal of this prominence also facilitated the approximation of the two halves of the lip.

In June 1882, in St. Paul, Minnesota, at the Dental and Oral Surgery Section Meeting of the A.M.A. Goodwillie described his method for correcting discrepancy in maxillary alignment in cleft palate:

By means of a small revolving knife and surgical engine, a V-shaped section was removed inside the alveolar process of the intermaxillary. . . . Just enough was taken away by the V-shaped section to allow the alveolus of the intermaxillary to resume its normal position.

After the ostectomy the premaxilla was bent and wired. Goodwillie operated "as early as the twelfth hour after birth."

In 1892 von Esmarch and Kowalzig passed a chisel through the intermaxillary union so that the premaxilla could be turned on its axis and pressed into the cleft with closure of the soft tissue at the same time.
In 1893 Wyeth used an osteotomy to correct the continuity of the alveolar ridge in cases of unilateral lip-jaw-palate clefts when the premaxillary portion on the cleft side was absent. He fractured a segment of the maxillary bone distal to the cleft, moving the fragment forward to fill the gap and fixing it with wire sutures passed through the bone.

In 1896 Julius Wolff emphasized that, in cases of unilateral projecting premaxilla, normal pressure of the surgically united lip sufficed to restore the breach in the alveolar ridge. This same view was championed by Blair in the 1930's.

Yet others continued to correct the premaxillary asymmetry in the unilateral alveolar cleft surgically. Schoemaker removed a horizontal wedge behind the projecting premaxilla in 1911.

In 1912 the gentle James Berry, with T. Percy Legg, suggested that minor unilateral projection could be ignored and the lip closed over it. Nevertheless, for cases in which they recognized that the projection was so great as to make lip closure impossible, they offered two alternatives:

1. Pressure by strapping for long periods, which they dismissed as “slow and not altogether satisfactory.”
2. Partial separation and crushing (with a pair of bone forceps) of the conjoined premaxillary bones from the maxilla in order to press the premaxillary bones back into the cleft.

In a typical example of his sensitive approach to this kindred deformity, Berry stated:

It is not desirable to effect complete reposition of the premaxillary bones. They should, however, be repressed sufficiently to enable the harelip to be closed over them. . . . The subsequent pressure of the lips and the growth of the maxilla will eventually correct the remaining deformity of the alveolar border.

In 1923 Ombrédanne sectioned the premaxilla with a broad, short-handled chisel. He showed some sophistication in his procedure by the way he lifted the mucoperiosteum of the edges of the alveolar cleft to prepare them for apposition and healing. He fixed the new position of the premaxilla with a wire suture passed through the bone.
Also in 1923, Truman Brophy of Chicago, in his book *Cleft Lip and Palate*, mentioned a patient who unfortunately had reached an age where the maxillary bones could not be easily bent and brought into proper relation.

At least the patient was thus saved from suffering the crushing transmaxillary wires over silver plates, a technique into which Brophy directed so much energetic force. In a modification of a method by W. L. Shearer, Brophy divided the external plate of the bone with a chisel, with a greenstick fracture of the internal plate, with the osteotomized fragment reduced into proper position with wires.

**MODERN OSTEOTOMIES IN UNILATERAL CLEFTS**

John Grocott of Stoke on Trent, England, in the 1973 *British Journal of Plastic Surgery*, reported 25 years of experience with primary maxillary osteotomies in clefts of the palate. Using an osteotome, he cut through the bone of incomplete clefts with the descending palatine foramen as the apexes of the triangle and removed the free bone (shaded). This maneuver allowed freeing of the arteries and also upward motion of the flaps, so that the soft palate reached a position much higher in the nasopharynx than it did with the conventional closure.

Grocott claimed flexible soft palates with minimal fistulae and no need for later pharyngeal flaps.

In complete unilateral clefts, to obtain greater symmetry he used an osteotomy to detach the premaxilla from the maxilla, and by prising it he displaced it across the midline, packing the defects with gauze soaked in Whitehead's varnish. The raw bony edges made contact, and the anterior palate was closed with a von Langenbeck procedure. This technique has been used in only a few patients, but the results after two years seemed promising to Grocott. He was pleased with the symmetry of the premaxilla with the maxilla on the cleft side, and the area of the osteotomy has smoothed out, presenting a good alveolar arch.
OSTEOTOMY AND OSTEOTOMY IN BILATERAL CLEFTS

Surgical correction of the projecting premaxilla by Franco in the Middle Ages involved its total excision. Similar drastic action was employed by Dupuytren, Sims, Rose and others. Kilner preferred to keep it as a rack to support the middle third of the face, and if it remained wobbly at age 5 to 7 years he excised it and had the child fitted with a denture.

There have been a few surgeons on occasion who have been willing to scrap the tooth buds and part of the premaxilla and keep one bony plate covered with mucoperiosteum to wedge between the maxillary segments to achieve continuity of the alveolar arch. Gillies and Potter used this approach, and Masters added bone chips to bolster the arch.

Numerous surgeons, among them Gensoul, Pancoast and Innis, have carried out compression fractures of the vomer to force the premaxilla back and allow lip closure.

Then there were the multitude of surgeons who carried out vomer resection in various ways to allow setback of the premaxilla into the maxillary arch prior to lip closure. Blandin resected a pie wedge. Von Bardeleben divided the vomer and forced the ends to overlap. Variations of this approach were used by Pichler, Federspiel, Vaughan and Schultz. Denis Browne resected what he referred to as the "bony overgrowth" between the premaxilla and the vomer and held the premaxilla back in the maxillary arch with a toothed bar wired into position. He claimed a high percentage of bony or fibrous union across the clefts.

In reference to the Browne-type "set-back" of a projecting premaxilla, Matthews of London justified his small concern about this maneuver if bone grafts were added:

The surgeon can be reassured that in the very severe case where there is virtually no alternative, the end-result is not prejudiced by this radical operation. This observation is only pertinent, however, when these set-backs have been accompanied by bilateral grafts... It is doubtful whether a "set-back" operation without bone grafts would produce a similar result. If this is true, it follows that if a set-back is done, a bone graft is obligatory.
Brown, McDowell and Byars resected a portion of vomer, pushed the premaxilla back and held it with a transfixion Keith needle. Cronin also resected the vomer, divided the septum and fixed the bones in setback position with a Kirschner wire.

Kernahan and Burston modified Cronin's procedure by freeing the septum along the vomerine groove to achieve the premaxillary setback.

There is an esteemed Spanish plastic surgeon who favors setback of the projecting premaxilla, considering this the greatest problem in cleft surgery. In 1971, B. Vilar-Sancho Alret of Madrid wrote:

My opinion in connection with surgical retropositioning of the projecting premaxilla is, for the time being, favourable. I consider that those who detract the importance of these techniques, overvalue the surgical action of the anomalous caudal apophysis of these protruding premaxillae, overlooking the fact that the real cause of the retrusion of the middle third is due to hypoplasia of the maxillae.

Most surgeons today avoid vomer resection for premaxillary setback when possible, or at least postpone it until it is absolutely necessary. Clarence Monroe of Rush Medical College, Chicago, avoids resection when possible but has no great concern when he feels it is indicated. In October 1971 he was accosted with:

You remain one of the most radical surgeons when dealing with a projecting premaxilla. In what cases do you set it back, by what approach, and how do you justify this with so much dental "flack" flying at you?

This was Monroe's answer:

In those rare cases—I haven't had to do one in a long time—when the lateral lip elements are so far back of the prolabium I cannot bring them together with my fingers, then in my clinical judgment, the success of bringing them together with surgery is in danger. I am willing to resect 8 to 10 mm. of septum and vomer in the posterior region of the bulge right up to the root of the nose. I stay away from the area just behind the premaxilla which Denis Browne resected as an "overgrowth."

Monroe was then asked:

Even Pruzansky and Burston will tolerate later premaxillary setback in certain cases. When do you execute your resection?
And replied:

In the first 3 months of age at the same time as the lip closure. The setback is in undercorrected position by 2 to 4 mm. and the premaxilla is fixed with a pin as Brown described. It is often tempting to set the premaxilla back into contact with the maxillary elements. I have done this in the past but was sorry. With this undercorrected setback at 3 months, only one out of 20 has shown similar losses. Then, too, twenty cases with premaxillary setback have been comparable in growth and development with twenty cases in which the premaxilla was not set back.

William H. Olin of the University of Iowa wrote in 1978 of his opposition to surgical setback of the premaxilla:

While reading *Cleft Craft II*. I came across your report of the 1949 paper by Huffman and Lierle (page 66) in which they routinely surgically repositioned the premaxilla in infancy.

I observed these patients while they grew and followed them to adulthood and would like to report that they all have a serious mid-third of the face growth problem, as demonstrated in the cases enclosed. Lierle and Huffman recognized this severe underdevelopment and changed their technique.

**OSTECTOMY AND OSTEOTOMY Seldom Indicated**

Early rubber band traction attached to a headcap will usually restrain premaxillary projection enough so that after a few weeks
the lip can be closed over the premaxilla. In a few cases, even with the lip closed over the premaxilla, the projection will continue to be too much, necessitating a resection of the vomer at 5 to 6 years for setback of the premaxilla in undercorrected position. Rarely will the premaxilla project so severely that the lip cannot be closed over it. In such a case, early conservative setback is justified if undercorrected and retropositioned only enough to allow lip closure.
Uranoplasty or hard palate closure by maxillary compression is a procedure as old as any of the operations suggested for treating cleft palate. This compression has been achieved by three general methods:

1. Gradual external compression, exerted continuously by a truss with arms resting on both sides of the cheek over the maxillary bones until the palate edges are approximated.
2. Forcing the edges of the palate together by pressure, denuding bony borders and then passing wires through the bones to pull and hold them together.
3. Orthopedic appliances placed on the teeth with a crossed palate bar which is narrowed by a jackscrew.

External Pressure

In 1772 Levret of Paris elaborated on the importance of an early oral muscle sphincter union, in view of the fact that the edges of the palate are wide apart in adults without lip closure. He observed that in the newborn affected with a complete deformity the maxilla is larger than in the normal. In his opinion the cleft was due, not to a deficit of substance, but to a diastasis of the parts. Brophy, more than a hundred years later, made this the basis for his operation.

In 1836 Montin of Paris described his compression method with newborn children and reported union after three days. The
pressure, he pointed out, could fracture the maxillary bones, an incident he considered of no consequence in the very young. Other external compression appliances were used to push the maxillae together.

On the other end of the earth, Dr. Ziegler in the Medical Record of Australia advocated treating fissures of the palate with pressure. In 1851 he tried the idea on an infant cadaver with a cleft and then proposed:

The operation should be performed as early as possible after birth, when the bones are in their softest condition. . . . The edges of the fissure having been pared, the superior maxillary bone should be embraced by a horseshoe-shaped clamp . . . padded with India-rubber.

The clamp was set with a joint and screw to exert gradual pressure until the maxillary elements were in apposition.

Other "crushers" used ingenious methods to achieve their dastardly deeds. In 1853 Robert illustrated a method of three-point compression of the premaxilla and maxillae. Robert and Bonnafont remarked:

In effect the method of compression, which we stress, cannot be credited with one author, but as always, sums up the ideas which have preceded us.

Garretson had three ways in 1862: a Hoey clamp, a tight, circumferential rubber band around the head with rubber pads on the maxillae or the maxillo-occipital sling. In a collection of lectures delivered to the Bellevue Hospital, New York, in 1883, Sayre described closing a bilateral lip cleft after birth, and then continued:

A compress was placed on either side of the superior maxillae, to bring these bones in apposition and close the cleft in the palate. At the time of the operation the fissure in the palate was wide enough to admit the finger. Compression and lip closure by the time of puberty brought these surfaces so close that further treatment was needless.

Then there followed an army of "squeezers." Hammond used a clamp in 1909; Shea used a bar, gaskets, plates and nuts in 1912; Ulrich conceived this crab claw in 1913.
Truman W. Brophy, D.D.S., M.D., professor of oral surgery at the Chicago College of Dental Surgery, was a forceful, dogmatic leader. He was so dynamic that he managed to be president of the American Association of Plastic Surgeons for 1921, 1922 and 1923, arranging for the meetings to be held in his hometown of Chicago two times out of the three years. Interestingly, in 1904 Brophy attributed to Sayre the following statement:

Gentlemen, you see I am able to almost approximate the edges of the cleft palate. If we had some plan by which we could bring the tissues in contact and hold them there until nature united them we would be able to cure this defect. But we cannot do it.

Evidently Brophy was challenged by this admission. He was also confident in the misapprehension that all necessary tissue was present in each cleft. Thus the persuasive Brophy championed the gradual compression by wiring method. As early as 1904, in a plea for palate operations in early infancy, he declared:

Cleft palate is not the result of arrested development or insufficient tissue to form a normal palate.

Years later Sir Arthur Keith wrote to Truman Brophy:

I agree with you in the majority of cases of complete cleft of the palate there is no deficiency of tissue at birth nor for some time after birth. I also agree that the cleft, however wide, is not due to a deficiency of tissue in the several elements which form the palate, but is entirely due to the fact that when the various embryonal parts are developed and come together in the second month of development, the process of union is delayed and does not take place, hence . . . [they] tend to separate as growth occurs, the cleft increasing during each month of growth. The exact cause of the separation of parts and the enlargement of the cleft is probably due to several factors, tongue pressures, muscle tractions and also the independent process of growth in each part. Theoretically, the best treatment ought to be to bring union at the very earliest date, but theory and practice may not be easily harmonized. Although you [Brophy], Arbuthnot Lane and James Berry have reached diametrically opposite conclusions as to which is the best time to operate, that still does not influence me in agreeing with you that to secure a good palate the sooner the cleft is remedied in complete cases the better the result ought to be.
In 1923 Brophy repeated his stand:

I am sure that anyone interested enough to enter into careful investigation of this subject, no matter what his previous opinions may have been, will be convinced that at birth a cleft palate, with rare exceptions, has in it sufficient tissue to form a normal palate and that the abnormality is only a separation and elevation of well-developed parts.

Having launched a direct attack, Brophy then reinforced his position against any doubters:

I have no doubt that an adult, growing up with a cleft palate, has not the full complement of tissue that forms a perfect palate since this tissue has failed to develop in proportion to other parts, as it has not been subjected to the uses for which it was intended.

In his 1923 book, *Cleft Lip and Palate*, he explained his pressure technique:

The bones of the hard palate are not crushed together or broken but they are bent and moved into correct relation and united.

He suggested that one operate in early infancy on the bones of the hard palate, then, as soon as expedient, upon the lip and finally, when the child is 16 to 22 months old, upon the soft palate.

In describing his method of closing the hard palate, he explained how his pilot sutures of silk guided 20-gauge wire through the maxilla above the hard palate and crossing the fissure. These through-and-through wires were passed through lead plates laterally so that with twisting of the wire the maxillary elements moved together. The mucosal edges of the cleft were split so that a nasal and oral layer of sutures could be accomplished as the bony elements were bent together by wire compression.

**UNDER THE BROPHY SPELL**

In 1909 Vilray Blair of St. Louis described his method of narrowing lip-jaw-palate cleft by forced compression. He passed wires through the maxillae at the level of the floor of the orbit to
avoid penetrating the tooth germs and safeguard them from sloughing. After narrowing the cleft, he closed it by displacing mucoperiosteal flaps mesially.

In 1914 Eastman was using malleable iron wire twisted over aluminum plates cushioned with rubber pads. In 1921 Thompson was using lead plates and silver wire.

To emphasize again the breadth of Brophy’s influence, here is a quote from an article by Sterling Bunnell of San Francisco in 1927, long before he became infatuated with the hand-and-tendon pullout wires:

Brophy, whose experience is great, stresses the need of closing the cleft early. . . . Soon after birth the alveolar processes are pressed into alignment and held there by Brophy’s method of wires and plates.

Bunnell then devised a perforated silver plate with extensive wires fixed to a plaster headcap to act as a false palate and protect his mucoperiosteal flap closure of the cleft.

As late as 1930 Ritchie used thumb pressure to take the spring out of the bone and then with a Brophy awl and No. 20 silver wire he encompassed the wayward maxillae, bringing the wire ends out in front of the cleft. With a few good twists of the wire he forced the bony parts into so-called normal position. He modified his wiring for unilateral and bilateral clefts.

Gerald O’Connor of San Francisco, aged 71 and not long before his death, wrote this of Brophy:

He was a very forceful man, gave many lectures, wrote books, did about 5 to 10,000 cases himself. Dentists, surgeons, and orthopedists, almost everyone fell into line with him and it took about 25 years before the damage was recognized. William Shearer (Omaha), Al Davis (San Francisco), Warren Pierce (San Francisco) were using his method as late as 1930–1935.

REACTION AGAINST COMPRESSION BY WIRING

In 1905 the perceptive Sir James Berry scored another victory as he ruled out closure of cleft palate in infants by forced compression:
The violent operations upon the maxillary bones themselves, I think, may reasonably be left to those who prefer to overcome difficulties by force than by craft.

In 1914 Drachter stopped guessing and got out his calipers. Comparing extensive measurements of the normal and cleft palates of the same age, he showed by these measurements the fallacy of closing the cleft palate by forced compression. Drachter pointed out that, in unilateral and bilateral lip-jaw-palate clefts, adjustments of the projecting premaxilla and closure of the lip cleft sufficed to place the palatal plates at the optimal stage of approximation.

In the early part of the twentieth century Vilray Blair made regular trips to Chicago to observe the work of Brophy and Gilmer. After using the Brophy procedure for some years he became disenchanted and in 1923 dealt the principle a blow with the typical poignant clarity which always set him above his peers. He said, simply:

Wiring of the maxillae is sometimes followed by most distressing distortion and lack of development of the upper jaw. The changes are rarely very evident in early childhood, but when seen at the age of 12 or 15 years may cause the operator to regret that this particular child was not one of those infants the angels had chosen for their own.

According to Sarnat, who was one of his students, Blair eventually turned to the Dieffenbach-Warren operation.

William H. G. Logan of Chicago, Brophy’s son-in-law, at first embraced Brophy’s method but later dared to abandon the compression method and turned to the von Langenbeck procedure.

In 1927 Ernst pointed out that forced compression of the split maxillae as done by Brophy was the most unphysiological cleft palate operation. He designed a kinder appliance.

As one of Brophy’s early pupils, Bill Shearer of Omaha, to the end of his days, was an ardent proponent of Brophy’s theory and techniques in clefts and hotly defended them against all critics. At a meeting of the Association in Boston in 1929, one year after Brophy’s death, Robert Ivy recalled that Shearer, after listening to several rather severe judgments on the Brophy method, was so overcome with emotion that he actually broke down and cried.
Victor Veau in his 1931 book, *Division Palatine*, spoke against closure of the split palate by forced compression. In 1932 Ruppe, while writing about Veau’s approach to cleft palate, said that Brophy’s compression principle in split palate,

in which the two upper maxillaries are approximated, has no anatomical basis. Suitable measurements have shown that division of the hard palate is not due to abnormal separation of the upper maxillaries.

Gerald O’Connor of San Francisco, who trained with Gillies in the late 1920’s, reported:

Pierce and Davis finally changed from the Brophy wire compression after I returned home in 1930 and reported the world-wide feeling against the procedure. In the meantime I had taken out many plates and wire with the usual result of great gaps in the palate with loss of tissue.

**Another Student Who Broke the Spell**

With the help of Robert Ivy, I located oral surgeon J. Orton Goodsell in Pompano Beach. He had trained with New, Figi and Lyons in the early days and later served as director of the Saginaw General Hospital Oral Cleft Habilitation Center. In 1972 Goodsell recalled, 50 years ago, holding retractors around the “oral hole” for Chalmers J. Lyons, professor of oral surgery at the University of Michigan, Ann Arbor. Lyons had trained with Truman Brophy and was doing a large volume of work. While on a European trip, he mentioned in Vienna that he did two or three hundred oral cleft operations annually. This caused an Austrian surgeon, who was certain Lyons was overstating his experience, to follow him back to Ann Arbor, but after several months he returned to Austria convinced and impressed. Goodsell remembered:

Our surgery was the Brophy “silver wire” compressor of the maxillary components that succeeded in destroying dentition and making an inverted “V” instead of a “U” out of the alveolar arch. One of the first innovations by Dr. Lyons was discarding the silver wire technique and, as far as I know, he was the first one to bury submucous sutures in the soft palate muscle. . . . Some of your very competent men—Reed Dingman, Bob Harding and Cliff Kiehn—trained in our University Hospital Oral Surgery program.
The third and most sophisticated dental method for moving the maxillary elements together was achieved with orthopedic appliances attached to the teeth. In 1918 G. V. I. Brown developed a cap splint type of appliance which he cemented to the teeth to pull the maxillary elements close enough so that he could accomplish a von Langenbeck palate closure. He used a maxillary osteotomy to aid the shifting of the bones.

Of course, we know now that all these compressions were being exerted in the wrong direction. Surgeons obsessed with closing the hole stayed awake at night dreaming up ways of collapsing the maxillae to ease their palate closure. Thus, the normal arch was being destroyed, with resultant crossbite and other deformities of malocclusion. Since Brophy’s empire was centered in the Chicago area, it is logical that surgeons and dentists continually facing these collapsed arches would sooner or later begin to react against the principle that had caused such dental disasters, and finally they did!
14. Early Soft Palate and Later Hard Palate Closure and Lip Adhesion

It was inevitable that those seeing the long-term results of constricting wires and surgery too radical and too early would note the damage being done and speak out against it.

Slaughter and Brodie, Then PruZansky

This lot finally fell to Wayne B. Slaughter and Allan G. Brodie of Chicago. Slaughter, chief plastic surgeon to the University of Wisconsin Medical School, Loyola University Medical School and Chicago College of Dental Surgery, inherited not only Brophy's instruments and records but his actual cases! Brodie, chairman of the Department of Orthodontia, University of Illinois, and for over 10 years dean of the College of Dentistry, combined basic science in anatomy, physiology and growth with clinical practice. His research and teaching reflected these interests bringing him many national and international honors. He also took time to reflect, most successfully in August in his cabin at Bear Lake, Michigan, where he waded trout streams casting a royal coachman (Western style) while humming "Pomp and Circumstance."

These two, then, Slaughter and Brodie, joined together and started the pendulum swinging in the opposite direction with their 1948 presentation in Boston to the American Association of Plastic Surgeons. They set the stage for their attack by a review of
the normal. They noted that in the face there is a generalized growth on almost all surfaces of all bones until about the fifth year, after which the surface growth tends to disappear. Certain active sites of growth remain and continue to grow at a high rate almost until the completion of growth. Their longitudinal studies of children with clefting defects revealed the same pattern and they hypothesized that clefts represented a temporary aberration of growth, probably of short duration, during early intrauterine life. Once recovery occurred, however, the various parts pursued now relatively normal paths and rates of growth. The original distortion remained but it became no worse unless a specific growth or adjustment site had been permanently affected.

The tuberosity of the maxilla growing backward against the pterygoid process, a fixed base, is the agent responsible for the forward development of the middle face. An equal amount of growth occurs in the palate at the transverse suture. It occurred to Slaughter and Brodie that reduction in blood supply and constriction by scars in these areas may jeopardize growth. If it does, then unwarranted trauma to soft tissue and interference with blood supply and fracturing of bone and stripping of mucoperiosteum may cause permanent damage to growth sites. For five years Slaughter operated with this idea in mind on 1,349 clefts. Measurements were taken with cephalometric x-rays, the axial ray passing through the external auditory meatuses, head plates, plaster molds and photographs. The Frankfort horizontal plane was used to relate cranial and facial structures. Three examples of their tracings are shown: (1) A normal 12-year-old male; (2) a 19-year-old male whose cleft lip was closed at 19 months and palate at 12 years; (3) a 23-year-old female whose unilateral lip and palate cleft received surgery once a year for her first 14 years.

Simple atraumatic surgery was advised with closure of the lip portion of a bilateral defect in two stages, an obturator being used for the alveolar and hard palate cleft.

They summarized their stand:

Surgery can and does inhibit normal growth. . . . Congenitally deformed parts, unless permanently damaged, grow at normal rates . . . [Thus] surgery poorly executed or poorly timed, can do more damage than good in the long run.
Five years later, Slaughter was joined by Samuel Pruzansky, orthodontist and research fellow from the National Institutes of Health. They presented the rationale for closure of the velum as the first palate surgery at the meeting of the American Society of Plastic and Reconstructive Surgeons held at Coronado in 1953.

Kirkham, Wardill and Psaumé had already shown by hamular measurements that lateral dimensions of the nasopharynx are greater in cleft palate individuals than in the normal. Subtelny had studied pterygoid plates by frontal cephalometric laminography which revealed not only a break in the structures but actual distortion.

In a cleft, without the muscle band of restraint, the tongue pushes the maxillary elements out of mandibular alignment. The dental arch and alveolar processes are normally molded around the tongue by the action of the buccinator and lip muscles. The same distortion is being promoted by the lateral unopposed tension of the levators and tensors pulling on the palatal elements. If closure of the lip muscle molds the anterior arch, thought Slaughter and Pruzansky, why not close the muscles of the velum? This single act would mold the maxilla, reduce unopposed muscle action, prevent tongue entry into the cleft and actually diminish the cleft itself. They proposed merely to pare edges and approximate mesoderm across the cleft to present more normal physiology for growth and development.

In a series of 200 simple velar closures the outcomes varied. In one complete unilateral cleft the lip was closed at 3 weeks, narrowing the cleft with some overlap of the alveolar processes. The septum tended to straighten, and velar elements neared each other and became larger. At age 11 months the palatal parts could be approximated, and a decrease in the hard palate cleft resulted. The alveolar overlap improved as the maxillary segment on the cleft side increased in antero-posterior length. Facial growth continued in normal fashion. There was downward and forward migration of the floor of the nose with uprighting and elongation of the nasal septum. (This is one reason they were against use of portions of the septum in palate closure.) A random study of other cases in the series of 200 showed one case with reduction
of the width of the cleft and increase in the bulk of the soft palate parts to make velar closure possible at 22 months; another was not ready until 3 years of age and another, not until 4 years!

Thus did Slaughter, with Brodie and later Pruzansky, start the cleft surgical pendulum swinging in the conservative direction. Slaughter, having the face of a fighter and qualities of a champion, prompted me to inquire into his sports achievements. I found he had held the Missouri Valley cross-country record and, in 1931, while at Nebraska, had been a member of a world record half-mile relay team. He had another claim to fame, which no doubt had been a source of amusement to him but is appreciated by some surgeons more than others: He trained a tiger in Pruzansky and turned him loose in our midst, where his roars and the rip of his claws have been heard and felt from time to time.

Slaughter and Brodie reviewed their feelings about velar closure 20 years later, for Grabb et al. in 1971. They looked to adequate lip closure for its molding effect and expressed no great concern for "collapse" of the alveolar arch, because with growth this can be overcome. They had no interest in putting bone in the cleft where growth has merely begun to express itself. They felt that undue surgical interference could alter growth and appliances could act to constrict the maxillary segments or impinge upon the palatal shelves. At 12 to 24 months, velar closure was done simply in three layers after cleft edge paring; it can be done in two stages if necessary. They emphasized:

The principal feature of this velar procedure is to establish normal balance of muscle tensions across a defect. Surgical closure of the velum does more than repair a complete congenital defect; it provides a more normal physiological environment in which growth and development may take place.

Lip and velar closure was followed by a reduction in the width of the hard palate cleft. If it was narrow enough for minimal undermining of edges and direct closure, then this was justified. If by 2 years of age the cleft was still too wide, a plastic obturator was "snapped" into position for temporary aid.

In 1961 Luiz A. M. C. Madeira of São Paulo stated his endorsement of the Slaughter plan:

Closure of the soft palate at 18 months and of the hard palate after 6 years of age.
WALKER

In 1966, in the Journal of the South African Logopedic Society, Dennis H. Walker advocated the Slaughter principle of lip and soft palate closure. Walker became James B. Cuthbert’s first registrar soon after Cuthbert migrated from Rooksdown House in England and worked with him all 16 years of his life in Johannesburg, eventually being appointed to follow his chief as head of Plastic Surgery at the University of Witwatersrand. Adhering to the Gillies principle “Never do today what can honourably be put off until tomorrow,” and with respect for growth centers but anxious to harness molding forces of the “mouth muscle ring and palatopharyngeal muscle ring,” he closed the lip and soft palate only, except when a vomer flap was feasible. He noted the gradual change in the residual cleft, “the form of a long, narrow ellipse replacing the shorter, wider oval.” His orthodontist was able to promote quite satisfactory speech with an obturator altered frequently. Under this regimen, the residual hard palate cleft was left until 12 or 14 years of age, when the closure was relatively easy.

SCHWECKENDIEK

It is of interest that 10 years before Slaughter proposed velar closure, Hermann Schweckendiek, an otorhinolaryngologist of Marburg/Lahn, Germany, in 1944 proposed early closure of the soft palate through small incisions which did not necessitate mucoperiosteal dissections or osteotomy or ostectomy of the hamulus. He left the hard palate open and undisturbed, but occluded with a “speech plate” as late as 12 or 15 years. Gradual
closure of the bony cleft was noted from 15 mm. to 2 or 3 mm.
and accompanied by a minimum of orthopedic disturbances. In
the early 1960's his son, Wolfram Schweckendiek, continued to
promote this principle.

Free development of the jaw and palate can be attained if the soft palate is
closed during infancy by primary veloplasty, leaving a residual cleft in the
hard palate. The cleft narrows spontaneously due to the growth of the sides
of the palate, without causing any compression of the jaw.

The edges of the soft palate cleft were pared and side pouches
dissected. A rubber band was passed with a special needle through
the pouches and tamponaded by little foam rubber sponges in the
pouches. The soft palate was united with three-layer suturing and
the tension of the rubber band adjusted and sutured.

At the 1964 Hamburg Symposium the young Schweckendiek
stated:

This procedure usually results in a primary union of the soft palate. The
muscle layer develops well and the palate grows long and mobile. . . . The
majority of the children acquire perfectly normal speech even though a small
cleft remains. Other require a temporary plate to cover the cleft so that the
spontaneous growth of the upper jaw may remain undisturbed for as long as
possible. In case of total cleft, a correction of the position of the teeth in the
area of the cleft is often necessary. During this treatment the residual cleft is
covered by a plate.

The Schweckendieks prefer to operate on the soft palate at 7 to
8 months of age. In the complete cleft, the soft palate is closed
first, and three weeks later the lip is closed, all at about 7 months.
In cases of shortness of the velum, they use a superiorly based
pharyngeal flap. A plate is fitted, and closure of the residual cleft of the hard palate is postponed to the age of 12 to 14 years, when the normal growth of the jaw is virtually complete.

In 1977 at the Third International Congress on Cleft Palate in Toronto, Wolfram Schweckendiek reported 25-year results of normal maxillary and cranial growth, with 60 to 70 percent of the hard palate clefts narrowing and 95 percent of the alveolar edges approximating. Schweckendiek admitted to having some difficulty with speech development between 2 and 5 years of age but reported continued improvement after school age resulting in normal speech in 57 percent and minor problems in 37 percent; 5 percent of his cases required posterior pharyngeal flaps.

In 1964 Professor Burian in Hamburg briefly reviewed his palatal retropositioning and pharyngofixation carried out at age 5 years, which he had used for 40 years. He then informed the Symposium that he had changed to the Schweckendiek method. In the more formal third Gillies Memorial Lecture in 1964, Burian elaborated, recalling his earlier plan of lip closure at 5 months and palate at 5 years:

The patient has to be rehabilitated from the time of the lip operation till the operation of the palate. . . . The treatment lasted a long time and was also expensive. To reduce the sufferings of the patients and the distress of their families . . . I adopted, some years ago, the method of Schweckendiek which consists of the reconstruction at the age of 6 to 8 months of the soft palate alone. The cleft lip, in total, is operated on at the same time or some weeks later. To the hard palate, an occlusive plate is applied. The early construction of the soft palate reduces considerably the frequency of middle ear inflammations, both acute and chronic. The child acquires good speech quite quickly. The cleft in the hard palate narrows visibly and may be closed by an operation later on at any time. This is then a minor affair. The orthodontic treatment is very easy. . . . The Schweckendiek method seems to me to make the primary bone-grafting unnecessary and I hope that it will reduce considerably the need for secondary bone-grafting.

Čupar of Yugoslavia approved of the two-staged operations suggested by Slaughter and Schweckendiek as a really rational procedure. Early soft palate closure creates a more favorable basis for speech development and also avoids maxillary deformities. After lip and soft palate closure there is objective evidence that
the cleft in the hard palate is reduced. Later closure of the hard palate offers less chance of arch distortion.

**PRIORITY**

Regional loyalties and language barriers often dictate the name associated with an operation. In Europe Schweckendiek gets credit, but in the United States Wayne Slaughter's name is synonymous with the primary velar closure principle. At the 1969 International Cleft Lip and Palate Symposium in Chicago Slaughter was challenged. He cleared the air with one thrust and no parry:

That procedure was documented in 1840 and it has been referred to repeatedly. The last written reports were in 1914 by the late John Staige Davis and I had the privilege of seeing him perform some of these procedures before he died.

There had been sporadic expressions of conservatism from time to time. Even Dorrance in 1933 wrote:

The safest age to operate for cleft palate is about the fifth year of life. In our experience operations performed after the fifth year are free of mortality and failures are less frequent.

In 1972 Gustave Aufricht wrote:

I was and I am also against the early closure of the hard palate. Already, Esser advocated only soft palate closure and obturator for the hard palate until patient was fully developed.

The Schweckendieks and Slaughter, heeding the moaning and groaning of the dentists facing the dental disasters following the early traumatic palatal surgery, led a conservative revolution. This new stand stimulated research to try to determine what effects, if any, modern types of cleft palate surgery would have on young growing maxillary bone.

**HERFERT**

In 1958 Herfert, following his work on retardation of maxillary growth after mucoperiosteal dissection and vessel ligation in puppies, designed and timed his surgery in sympathy with his
research findings and according to the principles set by Schweckendiek and Slaughter. In 1963 he reported that since 1955 he had been using Schweckendiek's method. He did not feel, he said, that McNeil "stimulation plates" were necessary in cleft palate children, but he did recognize the importance of providing the infant with an intact velum with which to acquire normal speech and thus closed the soft palate only at 14 to 16 months. He noted:

After closure of the soft palate, contraction of its muscle fibers stimulates growth of bony palatal plates, especially to the periosteum near the rim. This functional stimulation of the periosteum leads to a true growth of bone which was noted in all our cases. Two, three or four years after closure of the velum, the cleft of the hard palate was reduced without any direct operative procedure. . . . By the two-stage operation of the cleft palate, two significant advantages are gained: normal speech is encouraged by early closure of the soft palate . . . and restriction of growth of the upper jaw is avoided, as the hard palate remains untouched. The second stage operation in the hard palate around 5 years of age becomes a relatively small procedure and is performed in ten to fifteen minutes.

CONFLICTING FINDINGS IN ANIMALS

Yet Sarnat, also in 1958, working on monkeys, excised the mucoperiosteal flap and ligated the greater palatine artery. In one group of animals he went "ape" and also excised the bony palatal shelf and nasal lining. These experiments showed no significant gross differences in growth and development of the hard palate, maxillary arch, mandibular arch, maxillomandibular relationship or total face. The implication is that neither the surgical trauma of raising flaps nor deprivation of blood supply is the cause of maxillary and facial lack of growth, a finding in accordance with Foster's 1962 work in humans with complete alveolar clefts.

In 1967 Kremenak et al. showed in puppies that unilateral excision of a 4 mm. wide strip of mucoperiosteum just medial to the posterior teeth caused a very definite decrease of palatal width (27 percent narrower) on that side. In contrast, elevation of a unilateral mucoperiosteal flap or ligation of the palatine artery caused only a 3 percent narrowing of the palate.
Maisels noted that these research contradictions would have thrown a confusing cloud over the decision for timing closure of the hard palate except for the 1966 findings of Latham and Burston. In the human, they showed that the lateral activity in the mid-palatine suture is greatly diminished by 18 months and has, for practical purposes, ceased by 2 years of age. Thus, after 18 months to 2 years, lateral growth of the hard palate takes place as a result of alveolar appositional growth only, and not by separation of the parts along the mid-palatine suture. Consequently, Maisels reasoned that operations on the hard palate at this time could not be expected to inhibit growth by tethering the two sides to each other by a sheet of scar.

Maisels breathed a sigh of relief at the convenience of these findings. British surgeons have long felt that the timing of closure of the secondary palate should be dictated by the need for acquiring normal speech rather than by fear of interfering with subsequent growth.

**DELAYING PALATE SURGERY**

Jack Longacre of the University of Cincinnati noted:

Growth studies have shown that the premaxillary suture closes at the end of the first year, but the sagittal suture separating the maxillae and the two horizontal plates of the palatine bone only closes between the age of four to five. This means that the transverse diameter of the bony palate and the arch is completed at this time. To this must be added the appositional growth on the surface of the bone.

He cited Logan Leven, who had shown that prior to closure of the defect the growth of the maxilla in the cleft palate group was nearly normal, but after closure of the defect there was marked retardation of growth.

Longacre therefore began playing a waiting game, and in 1964 in Hamburg he reported longitudinal results of his delaying policy:

We found that the group where the palate was repaired at or near the time of the closure of the sagittal suture (4 to 5 years) showed more normal facial development and less dental crippling than the other group.
He also noted that even in the older group, when the defect was large, there was some crossbite although to a lesser degree. Thus he proposed that his split rib grafts be interposed between the palatal shelves and the alveolar process to prevent even this amount of deformity. X-ray films taken in the area of the alveolar defect showed tooth buds growing down into the newly grafted bone, allowing for more normal eruption of the teeth.

Finally, in his 1970 book, *Cleft Palate Deformation*, Longacre presented his impression after 22 years with 500 cases. These had been corrected by himself with his modification of the LeMesurier-Hagedorn lip technique at 3 months and closure of the cleft palate by the V-Y procedure of Kilner-Wardill-Veau II. The only variable in the series was the timing of the palate surgery.

Longacre presented his findings with photographs of 24 patients, 11 with early palate repair (1½ to 2 years) with poor results and 13 with late repair (3 to 4½ years) with good results, showing less interference with facial growth, less retrusion of the premaxilla, minimal collapse of the maxillary segments, more nearly normal maxillary arches, less septal deviation, better occlusion and fewer dental caries. Longacre said:

> It would appear from this study that these series had been operated upon by two different surgeons. More correctly, the difference in results may be correlated with the fact that the development of the maxillary arch is essentially completed (85%) by four years of age.

In fact, Jack Longacre often emphasized:

> Comparing results in young adults between a patient with early palate repair and one with palate repaired at four years is almost like comparing Dr. Jekyll and Mr. Hyde.

The greatest criticism of waiting to close the palate for five and one-half years is the probable deleterious effect on the development of speech. In his defense, Longacre summarized the findings of Drexler, his speech pathologist:

> There is no significant difference in nasality, nasal emission and speech proficiency between the different groups. A similar . . . audiometric study failed to show any difference in the two groups with regard to hearing loss.
Professor Reinhold Ritter of Heidelberg, Germany, argued:

If the total cleft palate is operated on before there is a good occlusion in the baby molar region (age 1–2 years) the result is always a bilateral, mostly asymmetrical or unilateral compression of the upper jaw. We see a cross-bite in the side-parts and there is a prognathism or opistognathia. . . . In early operation, the upper jaw and the cavum of the nose are often deprived and the teeth carious because they have no normal function.

He also noted that the children do not speak as well as those without deformity. At the 1964 Hamburg Symposium he discussed patients operated on at 5 years of age with normal occlusion who required only orthodontics for oblique front teeth. He explained his reasoning:

At age 5, the bone of the upper jaw is harder and scar has less chance of causing deformities.

In 1971 Ritter wrote to me to affirm his stand:

I have been interested in the treatment of cleft lip and palate patients since 1928, both orthodontic and surgical treatment. I believe that I was the first doctor who warned of early operations of the cleft palate because of disturbance of upper jaw growth. The best age for operation of the cleft palate is 5 years. The bone is hard enough at this time.

The resonant Joachim Gabka of Berlin acknowledged his use of the Schweckendiek principle. He reported closing the lip at 6 to 7 months, the soft palate at 18 months, and the hard palate at 2 to 3 years. In his view construction of a velum at a relatively early age without deleterious influence on the growth of the upper jaw is important. Gabka’s studies in 1964 revealed that the most rapid narrowing of the cleft occurred within the first six months after primary velar closure and not later, as claimed by Schweckendiek.
LIMBERG

A most conservative surgeon as to age for palate surgery in modern times was the grand old gentleman of Russia, Alexander Limberg of Leningrad. He closed his lips at 1 year and occluded the palate cleft with a plate until the child was 10 years old, when he finally lengthened and closed the palate by his V-Y method.

DINGMAN

Reed Dingman of the University of Michigan, trained as both dentist and surgeon and with vast experience in clefts, has used many methods. At the 1973 Cleft Palate Congress in Copenhagen, with J. E. O’Connor, he reported his change to a conservative approach using a lip adhesion at 1 to 2 months and a definitive lip closure at 9 to 12 months. Then at 15 to 18 months he closes the soft palate, without undermining or incisions over bony portions of the palate, and at 2 years, after complete eruption of the primary molars, he inserts a dental splint to close the hard palate fistula. At 3 to 4 years a vomer flap is used to close the anterior cleft. He reported:

Results in speech and growth and development in these cases appear very favorable.

BLOCKSMA

Ralph Blocksma of Grand Rapids, Michigan, a plastic surgeon of Dutch descent, a dedicated missionary and a man of impeccable integrity, personifies to me the image of the ideal doctor. In 1974, before the American Association of Plastic Surgeons in Seattle with John Burnink, Christopher Leuz and Kent Mellerstig, he presented his conservative program for managing the oral cleft to eliminate radical mucoperiosteal flap procedures. A 10-year analysis of all cleft palate surgery performed at Butterworth Hospital for 1963–1973 revealed

Many patients who had had an early mucoperiosteal flap closure looked excellent at the age of 5 years, but exhibited evidence of serious maxillary
In most cases a virtually complete abutment of the cleft of the hard palate occurs spontaneously with growth. This is not always true. At the age of 4 to 5 years, a simple turnover vomer flap will suffice to close the narrow hard palate fistula, after most of the palatal growth has been achieved. We then determine whether a pharyngeal flap is indicated, whether speech therapy is needed, or whether a Teflon implantation into the posterior pharynx may be required.

Members of our clinic agreed that most of the deformities seen in patients with repaired cleft palates were fundamentally iatrogenic in origin, and we included:

1. The flat face syndrome (hypoplasia of the superior maxilla and a short nose)
2. The bad teeth syndrome (irregular dentition and dental caries)
3. The distorted arch syndrome (malocclusion, with a contracted superior dental arch)
4. The financial exhaustion syndrome (expenses for the hospital, pediatrician, orthodontist, prosthodontist, plastic surgeon, ENT surgeon, psychologist, and speech therapist)

Blocksma formulated the following laws of good palate surgery:

*Do Not:*
- 1. deprive the palate bone of any part of its blood supply
- 2. violate the vomer or deprive it of any part of its blood supply
- 3. amputate the premaxilla or prolabium
- 4. denude the entire hard palate to gain temporary length for the soft palate
- 5. simultaneously deprive the palate bone of both oral and nasal mucosa
- 6. sacrifice long-term growth for immediate surgical expedience

*Do:*
- 1. obey the laws of good wound healing
- 2. keep relaxing incisions small
- 3. delay surgery involving bone at least until after the fifth year

This conservative approach, started in 1964 and now used with all oral clefts, closes the lip at 3 to 4 months with minimal undermining. At 18 to 24 months, closure of the soft palate with a modified von Langenbeck technique involves a small S incision around the maxillary tuberosities with fracture of the hamulus, division of the posterior palatine aponeurosis from the margin of the hard palate and nasal and oral mucosa suturing.

Blocksma noted:

In most cases a virtually complete abutment of the cleft of the hard palate occurs spontaneously with growth. This is not always true. At the age of 4 to 5 years, a simple turnover vomer flap will suffice to close the narrow hard palate fistula, after most of the palatal growth has been achieved. We then determine whether a pharyngeal flap is indicated, whether speech therapy is needed, or whether a Teflon implantation into the posterior pharynx may be required.
In 1977 Jean Psaumé and René Malek of Paris advocated soft palate closure before closure of the lip and hard palate because tongue retroposition occurs on account of lack of normal soft palate and abnormal width between pterygoid processes. They predict that early soft palate closure will correct preoperative tongue retroposition by improving muscle balance.

**OPPOSITION**

In 1966 Friedrich Schröder of Würzburg favored the von Langenbeck-Ernst-Veau palate bridge flap method over the Schweckendiek method because

1. Deformation of the maxillae after Schweckendiek’s operation can be avoided only in narrow clefts.

2. Good function of the soft palate can be achieved only in favourable cases. Since correction of an insufficient soft palate after Schweckendiek’s veloplasty by pharyngoplasty is recommended not earlier than the second decennium, the most favourable period for speech development is thus missed.

In 1977 Ken Bzoch of the University of Florida warned:

The rationale for two-stage surgical closure (i.e., soft palate first followed later by hard palate closure with obturation of the hard palate before final closure) appears logical but presents many hazards to achieving normal speech. Its application is usually devastating to speech development whenever prolonged postponement of hard palate surgical closure is followed. Obturators generally result in an inadequate seal of the hard palate as the soft palate moves toward closure. My longest experience with this method of approach involved primary soft palate closure postponed to 18 months followed by hard palate closure between three and four years of age. An excellent prosthodontist prepared and modified hard palate obturators in the interim. The population receiving this approach presented with a large number of abnormal habits of articulation, particularly glottal stop substitutions. Although early direct speech therapy was able to modify this in many cases, they were not as successful as early complete closure patients with similar clefts today. I might add, I can see no reason from experience or research why soft palate closure could not be instituted as early as the timing of lip closure for the advantage of this on facial growth, eustachian tube function and for muscle hypertrophy. Complete hard palate closure might then follow between one and three years of age.
At the 1978 American Cleft Palate Association meeting, Bard Cosman and Arlene Falk of Columbia Presbyterian Medical Center, New York, reported on the speech results of approximately 35 patients treated with early closure of the soft palate and delayed closure of the hard palate at 6 or 7 years (Schweckendiek). At age 6 years, 66 percent had poor speech and 32 percent had had secondary pharyngeal flaps. It was predicted that nearly 60 percent would eventually require a secondary pharyngeal flap.

**LIP ADHESION**

The lip adhesion principle developed by B. Johanson, R. Millard, P. Randall, J. Walker, R. Meijer and M. Collito has been described in detail in Volumes I and II. It is a simple surgical procedure available when presurgical orthodontics is unavailable to move maxillary segments into a more convenient, and possibly a better, alignment in preparation for definitive lip closure and eventual closure of the alveolar and hard palate cleft. By avoiding early elevation of mucoperiosteal flaps, it follows the same conservative principle of molding anteriorly what early soft palate closure achieves posteriorly. Often the two—lip adhesion and soft palate closure—can be carried out together, advantageously, at a very young age.

Since Volumes I and II of *Cleft Craft* have been published, a modification of the adhesion procedure has been developed. Cleft edge mucosal flap 1 is still used, but it is seldom inserted along the intercartilaginous line. Rather, the release of short, lateral vestibular mucosa is made by an incision running straight backward along the pyriform aperture. By letting 1 flap into this anteroposterior cut, the vestibular mucosal shortness is relieved without evertting the alar base and rim. Through this vestibular incision the nasal skin can be dissected from the alar cartilage. Then through-and-through lifting stitches can help slide the alar cartilage and its attached mucosa up into a better position. The lip is joined as a temporary adhesion using medial mucosa turned over to make up for any lateral defect left by 1 flap.
Richard F. Greminger of the Albany Medical College has extended the design of 1 flap to include a periosteal base (p), which, when approximated to a mucoperiosteal flap elevated from the alveolus, creates the inside lining of an "alveolar" ridge.
Nasal and Labial Flaps for Alveolar and Hard Palate Closure

The cleft of the alveolus and hard palate has been closed with various mucoperiosteal flaps turned off the vomer. This being a one-layer closure with a raw surface, there is some contracture resulting in varying degrees of maxillary distortion. The distortion depends on the position of the elements prior to surgery and the age of the patient at the time of surgery.

In 1872 Lannelongue closed the hard palate in a wide cleft by utilizing a portion of the vomerine mucoperiosteum which was continuous with one border of the defect. He made an incision on the vomer parallel with the border of the cleft, extended the anterior and posterior extremities of the incision to the border of the defect and elevated the vomerine mucoperiosteum from the underlying bone. The flap created was then held with sutures to the denuded palatal mucoperiosteum of the opposite side.

Other flaps from tissues of the nasal chambers have been used to close hard palate clefts. As early as 1851 Gay used a full-thickness flap of septum to fill the cleft, and in 1890 Sabatier moved the septum nasi to the horizontal plane of the palatal vault. Anton Freiherrn von Eiselsberg, in 1901, when he became director of the First Surgical Clinic of Vienna, reported using the vomer and its mucoperiosteum to close unilateral alveolar and hard palate clefts. Anyone tempted to repeat these maneuvers in a child should heed the words of Gillies:
The initial mistake was the opportune but ill-considered manoeuvre of bringing down into the palate defect in a wide unilateral cleft of the alveolus and palate a whole-thickness flap from the septum. The primary object of filling up rather than pulling together the gap in the palate was singularly successful to the extent of perfect speech. But his nose remained juvenile and flat, for the possible effect on the growing centres of the nose had been overlooked.

In 1895 Kraske used the inferior turbinates to close palatal clefts. He resected the inferior turbinate from before backward, leaving it attached behind but fracturing the bone in the pedicle as it was swung forward and sutured to one side of the denuded cleft in the palate. Fourteen days later the pedicle was divided and the remainder of the turbinate attached into the cleft. Kraske advised removing the bone when using this flap for cleft velum.

**PICHLER**

Hans Pichler, an Austrian who worked with Esser, was important in the development of maxillofacial surgery before World War I. He was an instructor of Richard Trauner of Graz, who recalled:

Pichler was a very true and upright man. We were united because of our great love of nature. Pichler fabricated ice sailing sledges on the large but narrow Lake Neusiedlersee near Vienna living there very spartanic but it was great fun for all when one of the pampered elder assistants slipped and fell into the ice water!

In 1926 Pichler first developed dissection of the cranially based vomer flap, which in unilateral clefts he tucked under the mucoperiosteum of the opposite edge of the palate cleft and fixed with mattress sutures to close the anterior hard palate in one layer.
In bilateral clefts he combined von Bardeleben's retropositioning maneuver of the premaxilla with hard palate closure using two mucoperiosteal flaps from the vomer tucked under the cleft edges.

**VEAU**

Victor Veau was the world leader in clefts in Europe from about 1925 to 1945. In the late 20's he had his own hospital with 75 beds where he treated his cleft lips and palates. Gerald O'Connor of San Francisco, who was training with Gillies in England, often crossed the Channel to observe Veau at work. He recalled:

Veau was a slow, meticulous innovator and rather stubborn—his way was the only way. He was a character, too, sitting in a "high baby chair" with a back, arm rests and feet support. He wore a baseball hat with magnifying glasses and had a large tube constantly passing oxygen under his shirt to keep the ether or chloroform fumes from putting him to sleep. His technique, surgery and judgement were quite good and basically he was a very good teacher and I would have learned and understood more had I spoken French.

Another version comes from Rudolf Meyer of Lausanne, who of course speaks French fluently. He recalled Veau sitting on a chair in the middle of the room waiting for the operating table bearing a cleft child to be rolled before him. As Meyer noted, he was not unlike the famous clown Grock who used to be sitting on a small piano chair under a spotlight, waiting for the grand piano to be brought to him.
The sound surgical principle of closing raw areas was the basis for Veau's greatest contribution. In 1931 he was turning vomerine flaps into the cleft to supply closure for the nasal side and partially reinforcing this with an oral mucoperiosteal flap. Previously, the nasal side had been left raw and subject to contracture and fistulae.

His method varied from that of Pichler in that the vomer flap did not tuck under the mucoperiosteum but was sutured to the freed nasal mucosa.

In 1937 Wardill republished Veau's diagrams to describe his own approach to the anterior cleft. Kilner's approach was also similar to Veau's, employing a one-layer mucoperiosteal flap closure of the anterior palate alveolar cleft and usually accomplishing it at the time of lip closure because of the ease of exposure. When postponed until after the lip has been united and has pulled the alveolar segments into apposition, this procedure becomes an awkward maneuver. The width of some clefts in the alveolar area and the fear lest a one-layer closure distort the alveolar arch by contracture have been the factors causing some surgeons to procrastinate on alveolar treatment at lip closure time.

**PREMAXILLARY FLAPS**

In 1927 Franz Ernst of Berlin advocated eversion of the mucoperiosteum of the premaxilla in bilateral clefts from before backward. It could, he noted, be divided in the midline and
turned leaf-of-the-book-wise to fill the cleft on each side between the premaxilla and the maxillary bone.

**COE**

Dissatisfaction with the anterior nasal closure of bilateral clefts by the standard Veau method led Herbert E. Coe of the University of Washington School of Medicine, Seattle, to describe a turn-under flap of premaxillary mucoperiosteum. In 1953, in *Plastic and Reconstructive Surgery*, he diagramed the usual von Langenbeck procedure with closure of the palatal cleft up to the premaxilla. Then a turnback flap of mucoperiosteum from the premaxilla based on its posterior edge would be turned and tucked under the mucoperiosteal flaps at their anterior cleft closure and fixed with sutures.

**DUNN**

In 1952 Fred Dunn of New York City advocated the use of vomer flaps to close the hard palate cleft. In two later sessions, first the soft palate was closed as far forward as possible, and finally the remaining defect, by two narrow, bipedicle mucoperiosteal flaps. The entire process was usually complete by 4 years of age, and Dunn reported good results with no interference with bone growth, tooth eruptions in correct position, normal dental and palatal arches and flexible soft palate.

**STENSTRÖM**

About 10 years later, Stenström, intrigued by Dunn’s report, carried out 10 such operations but added his modification. In 1973 he began to make assessment of this approach.

Sten Stenström of Umeå University Hospital, Sweden, is a little man with a short temper, a big heart and the soul of a missionary. He is usually inaccessible, working in his retreat near Lapland, several hundred kilometers south of the north polar circle where reindeer roam in the midnight sun. Yet he has been known to venture forth in missionary expeditions to Abyssinia.
and I remember him at the Swedish Red Cross Hospital in Korea. In Copenhagen in 1973, at the Cleft Palate Congress, he presented his interesting use of skin grafts to cover the raw surface of vomer flaps.

The vomer flap was incised and elevated in the usual fashion, and a full-thickness skin graft from the hairless groin was buried in the pocket with the raw areas facing each other. Twelve days later the lined vomer flap was again released, turned over and tucked under the opposite edge of the palate cleft. Stenström reported that in four weeks the depression on the side of the vomer was mostly filled out. In 1974 with Thilander, in the *Scandinavian Journal of Plastic and Reconstructive Surgery*, he presented diagrams of his method used in unilateral and bilateral clefts.

His follow-up of these 10 cases showed occlusion to be perfect except in three, and, although the soft palate appeared short, only three required posterior pharyngeal flaps. Late in 1974 Stenström sent me this note and the accompanying, more modern diagrams:

The report I gave in Copenhagen has been borne out in every detail by our subsequent experience:

The skin-grafted area of the hard palate completely resembles the untouched palatal mucosa; the shapes of the palatal and dental arches are strikingly good and there is almost no constriction of the maxilla in a transverse direction. I have also found that the soft palate can be completely closed at the same time without bilateral relaxing incisions. The usual uneventful healing is in my opinion due to the exclusive use of figure-of-eight sutures. Only in the case of very wide clefts is it necessary to leave a small residual opening at the front of the soft palate for closure at a later stage.

In some cases split-skin grafts were tried for covering the “vomer-pocket” instead of full-thickness skin grafts. Although I have not yet seen any bad effects from this, I have nevertheless reverted to full-thickness skin grafts in
order to eliminate as much as possible any tendency to shrink. A. Unilateral cleft. B. Vomer flap being tucked under opposite edge. C. Soft palate closure obtained without relaxing incisions but with figure-of-eight mattress sutures of 4-0 polyethylene. D. Full-thickness skin graft sutured along medial and lateral cleft edges. E. The vomer-pocket has been filled out with Visco-gel (De Trey). F. An acrylic palate plate has been placed on top of the Visco-gel and fixed with transalveolar sutures.

In 1978 Gunnar Jonsson and Sten Stenström of the University of Umeå, Sweden, presented further confirmation of this approach. They studied 6 to 8 week old beagle puppies in which the hard palate bone and the covering oral mucoperiosteum had been removed, except for a 4 mm. wide strip of bone in the midline. On one side the nasal mucoperiosteum was covered with an autogenous full-thickness skin graft (SGS) while the other side was left raw (RS). At 47 to 52 weeks of age the dogs were sacrificed.

The palatine suture was displaced towards side RS on all dogs, and the height of the nose was in all dogs greater on side SGS. There was a small consistent tendency that the overall growth was more pronounced on the side with the full-thickness skin graft. It is concluded that reducing the amount of scar tissue by covering raw surfaces with an autogenous full-thickness skin graft is one way to reduce maxillary growth impairment after palatal surgery.

In what could possibly be interpreted as an indirect, partial endorsement of his Swedish colleague’s effort to cover the raw surface of the vomerine flap, Johanson, with Hans Friede of Göteborg, wrote in 1977:

The development of the face and jaws in cleft patients, treated with a three-stage surgical procedure including a single layer vomer flap, was studied by analysing cephalometric radiographs and dental casts. The
material consisted of 13 patients with complete bilateral cleft lip and palate and 50 cases with complete unilateral cleft lip and palate, operated on 1964-1970. At the follow-up the average patient in both cleft categories demonstrated a maxillary retrognathia and in the unilateral cleft sample also a facial skeletal profile straighter than normal, though not as pronounced as we had found in cases where the vomer flap procedure was accompanied by bone grafting. However, the mean profile for the bilateral as well as the unilateral cleft group was straighter than reported for patients subjected to neither vomer flap nor bone grafting. The occlusal findings confirmed the maxillary growth retardation. . . . In an effort to reduce the restricted mid-facial growth found in the present patients, we have changed our surgical technique and since 1975 exclude the use of vomer flaps.

**NEED FOR TWO-LAYER CLOSURE**

The classic lip closure is done at about 3 months of age. When the clefts of the alveolus and anterior palate are closed at the same time with one-layer closure, faulty molding of the maxillary segment not infrequently results, with the premaxilla impinging on the collapsed lateral segments. Thus, surgeons have devised methods of accomplishing a two-layer closure of the anterior palate cleft.

**CAMPBELL**

Andrew Campbell of Johannesburg, South Africa, in 1926 tried closure of the alveolar and hard palate cleft with a septal flap, but the cartilage became detached and he then modified his plan and designed a two-stage closure. One flap took mucoperiosteum from the septum with the base on the palate; the other took mucoperiosteum from the cleft side of the palate based toward the nose. These flaps were overlapped across the cleft, bringing raw surface to raw surface with a broad plane of union and leaving no raw area in the mouth or nasal floor and no reason for contracture.
As Campbell said:

So far we have found that the raw surface on the septum is of little consequence. . . . There is no tendency to sloughing of the septal cartilage, and this is not surprising because of the excellent blood-supply from the opposite side. . . . If one deals with a bilateral cleft, the same operation is done on the other side but it is wise to wait until the raw surface on the septum is entirely healed—from four to six weeks.

This principle is the basis of several modern German and American anterior cleft closures.

BURIAN

In 1955 at the International Congress in Stockholm, Professor Francis Burian of Charles University, Prague, Czechoslovakia, described an upper buccal sulcus flap to aid in the two-layer closure of the alveolar cleft. He stated:

Severe cases of cleft-lip ought to be operated on later than lesser ones, the more so if greater deficiencies are present. The earliest date ought to be the fourth month of life.

His ideas after 30 years and 3,000 cases are of interest:

With severe cases of complete cleft it is not advisable to bring the poles of the cleft together. On the contrary, prevention of contact seems to be indicated. In 1933 I started to put a flap of lip mucosa between the poles of the cleft as a covering for the oral aspect of the reconstructed floor of the nostril. It was designed at that time as a method of preventing perforations in the anterior part of the palate which were of frequent occurrence in the Veau operation. I dropped this interposition-operation after discussion with Veau, who considered the gap in the alveolar process as an imperfection much worse than a naso-buccal communication. Later on when observing the operated patients I was impressed that on those operated by the interposition method. . . . there was much less deformation. . . . except for the premolar segment of the jaw. . . . [Thus] I resumed a modified interposition method with severe total clefts . . . omitting the formation of the palatinal flap and inserting the vomerian flap as advised by Campbell.
In 1976, M. Hotz of Zurich noted:

However, alveolar closure with Burian flaps (consisting of a small mucoperiosteal flap and a larger vestibular mucosal flap) at the time of lip closure seems to affect canine position. Burian flaps were utilized in about half of the present cases of unilateral as well as bilateral clefts. Each one of these patients shows a canine cross-bite. Therefore, this particular variation of procedure was abandoned a few years ago.

STEILMACH

In 1959 the astute Rudolf Stellmach of Berlin, considering mucosa from the upper lip inadequate for closure of the oral layer of the alveolar defect, developed a vomerine flap based anteriorly. This flap was turned 180 degrees to achieve oral closure for the usual nasal flap and an intervening bone graft.

In 1977 Stellmach reminisced:

Around the mid-fifties when we began to bonegraft the alveolar gap primarily in total clefts, we used a flap of lip mucosa for covering the oral aspect of the implanted bone. Flaps of this type, aimed at safe double layer closure of the postalveolar region, were described before by Burian (flap pedicle medial) and by Trauner (flap pedicle lateral). In using this with bone grafting I often found the vestibulum lining diminished, causing some inward traction of the lip. As we had discontinued closure of the hard palate, this brought me to the idea of covering the bone graft with vomer lining from behind. The vomer flap has an ideal quality for this purpose as it is thick and contains periosteum. When incised high at its cranial base
from back to front it can be turned forward. A pouch is created within the alveolars which can be filled up by bone chips. Shortcomings from lack of lip mucosa could be prevented.

STEINHARDT

Gerhardt Steinhardt of the University of Erlangen-Nürnberg, Germany, in his 1973 book with Schuchardt and Schwenzel showed again his method of two-layer closure of the alveolar defect. He employed a Pichler-type vomer flap for nasal closure and then cut a rather radical alveolar mucoperiosteal flap based above which he used to overlap his nasal closure as a second layer.

MUIR’S MUCOSAL FLAP

Ian F. K. Muir, a discerning Scotsman, is consultant in Aberdeen. While at Mount Vernon Centre for Plastic Surgery, England, he made several interesting observations and proposed an ingenious solution to the problem of the raw area in the alveolar closure. In the January 1966 British Journal of Plastic Surgery, Muir noted that in some babies with unilateral complete clefts the maxillary segments are in good alignment, and, after standard lip and anterior palate closure, end-to-end abutment of the alveolar segments occurs with good arch shape and dental occlusion.

In other newborn babies the premaxillary portion of the non-cleft segment is rotated away from the cleft, and subsequent medial movement of the lesser segment brings it in behind the premaxilla so that the arch is more triangular than the normal
horseshoe shape. The cause of this collapse has been attributed to the tension of lip closure. Muir analyzed the circumstances and laid the blame elsewhere:

The cleft in the alveolar gap . . . is usually closed by a single nasal layer leaving, on the buccal aspect, a raw surface . . . up to 1 cm. wide . . . [which] is . . . left to granulate, and finally to heal by secondary epithelialisation. This process takes place rapidly (although sometimes a breakdown occurs and a fistula is left), but must inevitably be accompanied by the formation of scar tissue . . . [and] results in the rapid in-drawing of the lesser alveolar segment.

In a complete cleft of the lip and palate there is a raw area left during a standard closure, as the Veau flap will not reach forward between the alveolar ends. Muir concluded that if the raw area could be eliminated its harmful effects would be minimized. He then proposed a flap for this purpose that could be better spared than the Burian buccal flap. True to the frugal Scots character, he noted:

There is, however, a source of tissue which appears not to have been tapped, namely the mucosa of the free edge of the lip which is usually discarded at operation. This tissue can be retained and used as a soft tissue flap to provide a buccal layer for the repair of the alveolar cleft. In practice the tissue from the lateral edge of the clef lip has proved most suitable. This tissue can be dissected up to a narrow base on the buccal aspect of the lip, and turned back into the cleft where it can be held by two “A” stitches.

Muir reported no fistulae and no alveolar collapse following this technique. Yet the presence of a lined gap in the alveolar area
presented two problems. There was some difficulty in hard palate closure across a persistently wider cleft, and some patients showed a substantial deficit of alveolar bone. With both cover and lining available, Muir proposed combining closure of the lip with rib bone grafting to the alveolar area.

Since the use of his flap was originally incorporated in a Tennison lip design, it was hoped that by 1974 he would have changed to the rotation-advancement approach and indeed he had! He kindly sent me more modern diagrams showing his flap during a rotation-advancement lip operation achieving a two-layer alveolar closure.

D. H. Walker of Johannesburg, reveling in freedom because, as he said, "consistency is a virtue of small minds," devised another variation of the two-layer closure of the "gap in the gum."
OVERLAPPING THE ANTERIOR FLAP CLOSURE

Nobuhiko Isshiki and Masanori Morimoto of the Otorhinolaryngology Department of Kyoto University designed a reinforcement of the anterior nasal closure of unilateral clefts, reported in 1968 in *Plastic and Reconstructive Surgery*. The V-Y mucoperiosteal flaps were cut narrower than those designed by Ganzer, Ernst, Veau, Wardill or Kilner. Then a wider mucosal flap was freed from the vomer on one side and the standard flap from the hard palate on the other, presenting enough excess for an overlap anteriorly. The mucosa of the flap on the vomer side was shaved raw for adhesion in the overlapping, which was fixed with sutures. The V-Y mucoperiosteal flaps covered the posterior area, and a labial mucosal flap covered the anterior extent of the cleft.

The development of various two-layer closures of the alveolar defect was destined to be of inestimable value during the alveolar bone grafting era.

It is interesting that two relatively new principles in the early treatment of alveolar clefts, *presurgical orthodontics* and *free bone grafting*, were evolved in different centers at about the same time and eventually were adopted for use in conjunction with each other in many more centers. As orthodontic manipulation was originally designed to aid the surgery by positioning the maxillary segments for bone graft stabilization, this aspect will be presented first.
As explained by Clodius in 1964:

Maxillary orthopedics, ... in contrast to orthodontics, are essentially the movement of basal bone, its alveolar process and the dental units contained within. If the teeth have erupted, they serve merely to enhance anchorage for orthopedic movement.

In 1772 Levret of Paris was the first to appreciate the orthodontic significance of additional extraoral force. He employed a linen band, not only to protect the suture line but also to align the maxillary arch.

In 1790 Desault, likewise of Paris and often considered the father of presurgical maxillary orthopedics, using a linen band tied tightly over the projecting premaxilla and around the neck in a “dental arcade,” preoperatively reduced a 12 mm. protruding premaxilla in a 5-year-old girl, bringing the prolabium on a level with the lateral lip elements.

Eight years after the publication of Desault’s collected works, Lefoulon in Paris expanded the maxillary arch of a young English professional singer with an anterior lingual spring. He introduced the term dental orthopedics—this part of the dental art being necessary to cure congenital and acquired deformities of the teeth and their arches.

In 1892 Friedrich von Esmarch designed an elastic band attached to a headcap. Its purpose was to keep the premaxillary segment in place after it was retropositioned by vomerine section. As Clodius points out, the von Esmarch design is widely used by many modern surgeons throughout the world, including himself.
but as a presurgical orthopedic maneuver to avoid vomer sectioning.

McNeil

The concept of early orthodontic treatment in alveolar clefts was introduced by C. Kerr McNeil of the University of Glasgow in 1950. There were two facets to his original concept:

1. The diminution in width of the palatal cleft brought about by the stimulation to growth of the palatal shelves under the influence of an oral appliance designed to promote such growth.
2. The control and correction of the displaced maxillary segments seen in clefts of the lip, alveolus and palate prior to surgery, thus assisting the surgeon by presenting him with a more normal bony facial skeleton over which he could perform his repair of the soft tissues.

McNeil advised cutting the model of the upper arch in an antero-posterior direction and shifting the two sections to partially correct the deformity. He then made an appliance to fit the corrected model, which the baby wore until need for a new appliance developed every few weeks. Outriggers on the appliance were attached to a cloth headcap. The plate was retained until after the palate repair. Elastic pressure was used against the projecting premaxilla.

Thus McNeil, the Scotsman, had started a movement of early orthodontic manipulation which was destined to be adopted in units around the world. The concept caused thought, trial and frustration, leading eventually to modifications to fit the facilities available in the specific areas.

Burston

In 1955, in response to a request by the plastic surgeons of Liverpool, William R. Burston of the School of Dentistry, University of Liverpool, undertook a pilot study of the McNeil approach. By 1958 the method had been adopted as a routine. In 1965, after 10 years of experience, Burston wrote:

Whenever and whatever orthodontic treatment be given to a case of cleft lip and palate, it is the surgeon who will mainly determine the eventual

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result. . . . Early orthodontic treatment of the infant makes its contribution by helping the surgeon to achieve a good primary repair of the lip over a symmetrical and well balanced facial skeleton. If this can be achieved, later orthodontic treatment becomes much more practicable.

In the same year, Burston outlined the method originally advocated by McNeil and being used by himself:

A feeding plate is inserted as soon as possible after birth, preferably before the infant has its first feed; this is a simple plate without bite blocks and can be provided within a few hours of taking the first impression. . . . When early orthodontic correction is judged necessary, a correction plate is fitted which incorporates bite blocks. The bite registration is a very important step in the technique because much of the action of the plate is derived from the child chewing into the plate. The blocks must be high enough to gag the bite and produce reflex chewing. The height is correct when there is a forward pressure on the plate (as shown by the blanching of the mucosa seen through the clear acrylic) during the biting and yet the plate is not dislodged. The time to change or alter the plate is reached when a uniform blanching occurs on chewing. Extra-oral strapping is employed to assist the action of the plate. . . .

The usual pattern in a thriving infant is that most of the improvement occurs within four months and that only in exceptional circumstances is further delay in lip repair justified.

In unilateral cases, provided good arch alignment has been obtained, the anterior palate is closed at lip operation. If, however, there is a significant gap between the alveolar segments, lip repair only is undertaken and an attempt made to improve the defect before the palate operation. Should this attempt fail, the soft palate and posterior half of the hard palate only is repaired and the residual defect closed by a bone graft inserted at age 3–4 years.

In bilateral cases, experience suggests that it is wise to close the anterior palate in most instances, even where orthodontic treatment has been only partially successful.
Burston warns that, following lip closure, most children should continue to wear a plate until the time of palate closure, with benefit to arch alignment, to feeding and to possible reduction in the width of the cleft. In a bilateral condition, if the anterior clefts are open without a plate, there is a real risk that the premaxilla will grow forward out of alignment, as shown here after an 18-month period. Explained Burston:

Early bone grafting has not been practiced in Liverpool because of the dangers of fixing the segments in an arbitrary and possibly unfavourable position.

By 1971 Bill Burston, a tireless, dedicated worker, consultant orthodontist and honorary lecturer in child health, had set up two baby cleft units, one at Alder Hey Children's Hospital and the other at Heswall Children's Hospital, the whole setup consisting of cots for 23 babies, plus accommodations for four mothers who may wish to be in with the babies. In 1977 he reviewed the principles of presurgical orthodontic correction of the maxillary bones in total clefts.

1. The deformation of the maxillary and premaxillary bones is brought about by separation of one or both sides of the maxilla from the nasal septum. In the unilateral case, there will be deviation of the midline to the non-affected side; in the bilateral condition the premaxilla remains on the vertical tip of the septum; i.e., the patient has a snout like any other animal. The nose of man is unique.

2. The facial sutures are open and active in the neonate and are thus capable of responding to the force applied to the bones. Growth of the face is very rapid in the first few months of post-natal life.

3. Force may be applied by fitting a plate which has been deliberately "corrected" and which also gags the bite slightly to promote chewing activity. Models are presented to chart the progress in a unilateral and a bilateral case. A. Plaster cast of the maxillary arch at birth. B. Corrected cast. C. Corrected cast with plaster added to relieve pressure on
growing margin of bones. D. Wax preform of plate to determine vertical height of bite blocks so as to gag the bite. E. Finished plate. F. Cast of corrected arch. This action may be reinforced by extra-oral pressure via an elastic strap with a pressure pad, the strapping being applied to a base of micropore tape stuck on the face.

4. The plate obturates the palate defect and this assists feeding. By denying the tongue access to the cleft, the latter closes down markedly, thus helping palate repair. The treatment involves fitting a succession of plates, taking about four plates for full correction of the segments.

This aid to surgery has a natural appeal to surgeons. In 1962 G. Crikelair, A. Bom, J. Luban and M. Moss of Columbia University, New York, reported six patients with complete unilateral cleft of the lip and palate treated by a modification of the McNeil principle, an acrylic intraoral appliance being used prior to surgery. They noted:

The opening in the hard palate decreases to a great degree spontaneously and in one patient disappeared completely.
THE STAND OF THE SURGEON ON HAND

David O. Maisels, consultant in plastic surgery in Liverpool, with Burston as his adroit orthodontic arm, can afford to be slightly prejudiced. When evaluating a temporary lip adhesion as a method of molding the arch, he commented:

It would seem preferable to achieve the same objective by non-surgical means. . . . Indeed, one might say the sheet anchor of this pre-surgical orthodontic treatment is that by starting it within forty-eight hours of birth, full advantage is taken of the postnatal growth spurt.

His answer to the fact that 30 percent of cases may never need orthodontia was:

It will not be obvious at first sight which do not need it, but it will do no harm and as soon as relationships are seen to be satisfactory, lip surgery is indicated.

As pointed out by Maisels, some cases respond to orthodontics better than others and by 3 to 4 months are ready for surgery. Some do not respond favorably and at 6 months are still not correct. In these patients the lip is closed, the anterior palate left open. Reexpansion of the arch at 5 years is stabilized with a bone graft.

In bilateral clefts, sufficient alignment has been achieved at 3 to 4 months to allow lip and anterior palate closure (A). Maisels warns that closing the lip but failing to close the anterior palate may not restrain the central stem (B).

In a small group, presurgical orthodontics fails to control protrusion of the premaxilla, and surgical retropositioning becomes necessary. In Liverpool, this group constitutes 6 out of 76 bilateral cases.
In 1974, in the *British Journal of Orthodontics*, Maisels, from his enviable position of having had excellent presurgical orthodontics available for years, verbalized with clarity what most surgeons feel:

It is axiomatic that for any one surgeon, the easier the operation, the better will be the final result.

Here are two of Maisels' cases, a unilateral and a bilateral cleft lip and palate, presented to emphasize the value to the surgeon and the patient of presurgical orthodontics.

Maisels stated:

Few would disagree that the technical difficulties of repairing this cleft have been greatly simplified in two ways. In the first place, the actual cleft is considerably narrower and the nasal deformity reduced following treatment, but what is perhaps just as important is the reduction in the degree of distortion. . . . In order to achieve closure of a very wide cleft lip, considerable dissection is required to free the soft tissue from the maxilla. Opinions differ as to whether this is best done superficial or deep to the periosteum lest the subsequent growth of the maxilla be jeopardized. This
difference of opinion is perhaps an indication that neither technique, if performed with care and precision, will have an adverse effect. However . . . there is no doubt that the pre-treated cleft will require less freeing of the tissue to close the lip without tension.

Whenever possible, the lip repair is combined with repair of the anterior palate although there have been instances when the orthodontist has requested the omission of this stage. . . . This practice is becoming less common as we move to the view that any post-operative correction is probably better carried out later by rapid expansion and bone grafting (Matthews and Grossman, 1964).

Here is another example of a unilateral case treated by Burston with presurgical orthopedics, which eased the strain on Maisels when he carried out the rotation-advancement lip and nose correction.

Maisels cautions that it is necessary to give the orthodontist time to prepare the patient:

In practice, we have found in Liverpool that the average case is repaired at 6 months although [this] shows a baby with a fairly severe bilateral deformity who was ready for operation at 3 months. In bilateral cases both sides are repaired at the one operation.
Such orthodontia is like manna from heaven to a surgeon sitting down to close a severe bilateral cleft lip. Yet heaven does not rain "manna" equally upon all surgeons. Presurgical orthodontics certainly facilitated the first-stage lip closure of this bilateral cleft. Maisels elaborated:

Probably the greatest influence of presurgical treatment has been the elimination of the need for excision or recession of the protruding premaxilla in severe bilateral clefts (Browne, 1949; Cronin, 1957; Monroe, 1965). Not only is it possible to correct the forward protrusion and upward rotation of the premaxilla . . . but also any lateral rotational deformity can be adjusted . . .

I now carry out a simple repair of both lip clefts and anterior palates at the primary operation, preserving virtually all the soft tissue in the lip. Then when the baby is 2 to 3 years of age, the columella is lengthened by a forked flap, as described by Millard (1958).

Here are two examples of the Burston presurgical orthopedics followed by one-stage lip closure and later forked flap by Maisels, sent to me in 1976. At this time Maisels wrote me that Burston had suffered a most frightful burn but was back at work with his nose and forehead reconstructed by flaps and his left eye blanked out by a deltopectoral flap. Despite this handicap he gets along well, not only with the children, but with the parents, because, of course, "it is still the same old Bill underneath."
JOHANSON'S ADVANTAGE

It is likely that most cleft surgeons would welcome presurgical orthopedics if it were available. As early as 1956 in Stockholm, Bengt Johanson was receiving this benefit. K.-E. Nordin was achieving arch alignment with a plate provided with a coffin spring and a little screen resting on a premaxilla and exerting pressure in a backward direction when expansion was in progress. This work was used in preparation for Bengt Johanson's early primary bone grafting. Later, in 1964, orthodontists Åke Ohlsson and Anna Kling reported the orthopedic method used in Göteborg, Sweden, in cooperation with surgery by B. Johanson. At age 1 to 2 months the nasal floor was closed, and 10 days later a plate was inserted. The plate was provided with facial arms for fixation with tape. In unilateral cases with contraction, a screw plate was used and the position of the screw varied according to the deformity and the effect desired.

In bilateral cases, expansion treatment again began 10 days after closure of the nasal floors. The divided screw plate with facial arms and anterior cup for the premaxilla was used from age 2 months until 7 to 8 months, when alignment should be completed. Then Johanson carried out his primary bone grafting. A retention appliance was maintained until after closure of the posterior palate at age 1½ years since a certain degree of collapse followed this procedure.
At the 1964 Hamburg Cleft Palate Congress, Nicholas Georgiade of Duke University, both dentist and surgeon, noted that since the middle of 1962 he had been using a modification of the expansion screw plate described by Ohlsson and Kling. He explained:

Horizontal expansion can be obtained utilizing parallel expansion devices also incorporated in the acrylic denture, as described, utilizing a split firm acrylic plate with a soft spongy acrylic over the prosthesis as in the solid prosthetic appliance. . . . Following bone grafting of the alveolar cleft area the prosthesis is maintained in position with removal and refitting every few weeks for approximately 2 months.

GRUBER

Colonel Haskell Gruber of the U.S. Air Force is in favor of maxillary orthodontics in cleft palate therapy. In 1966, while at Lackland Air Force Base, Texas, he noted:

At present, over 100 children with cleft lip and palate, ranging in age from 2 weeks to 13 years, are undergoing active orthopedic or orthodontic treatment. Another group of 68 patients has had primary or secondary bone grafting procedures . . . A record is kept for long-term and longitudinal growth studies. . . . Complacency, as well as the acceptance and use of older techniques only, no matter how true and tried, should not be tolerated without their continuous re-evaluation.

In 1975, at the American Cleft Palate Association meeting in New Orleans, Gruber reported:

With the preponderance of craniofacial growth taking place in the early post-natal months and years . . . it became all the more imperative to achieve normal orofacial growth environment very early in the infant’s life. This is accomplished by either repositioning the collapsed maxillary arch segments, or maintaining their normal position and permitting the tension of the repaired perioral musculature to mold them.

The employment of maxillary orthopedics both passive and active accomplishes the following:

1. restoration of a normal maxillary arch contour and maxillomandibular spatial relationships;
2. increase in volume of the oral cavity with better tongue position, improved respiration and speech;
3. more normal skeletal base for cheiloplasty with concomitant ease of surgical repair with less tissue undermining and subsequent tissue tension;
4. decrease in incidence of later arch collapse and cross-bite malocclusion;
5. apparent reduction in posterior cleft width;
6. better infant feeding habits and early parental involvement with habilitation of their child.

In the early restoration of normal form, function and physiology in the orofacial region, a more nearly normal growth environment is achieved for the tongue, the buccinator mechanism and the orbicularis oris.

MANCHESTER AND PEAT

Another surgeon who has the benefit of presurgical orthopedics is William M. Manchester of Middlemore Hospital, Auckland, New Zealand. In fact, because of this manipulation of segments prior to surgery, he dares more radical cleft closure than most. As early as 1965, and in the 1971 Melbourne International Congress, he reported having achieved a rather extensive closure of the alveolar and hard palate cleft at the time of his lip closure with the aid of orthodontist J. H. Peat, who presents him with premaxillary and maxillary segments in reasonable alignment. A plate divided in two half shelves overlapped and connected by a wire spring maintains an effective roof to the mouth during lateral expansion, preventing the tongue from pushing on the back of the premaxilla. The projecting premaxilla is restrained by simple elastic traction. At 5 months, alveolar, hard palate and lip clefts are closed, and at 9 months a V-Y palate pushback using Cronin’s nasal slide is accomplished. His 1970 comment on follow-up and final treatment is self-explanatory:

Regular attendance at the follow-up clinic continues until about the age of 16 years. Should it be needed, when the appropriate time comes orthopedic over-expansion of the arch is undertaken and secondary bone grafting is carried out. The missing teeth are supplied by means of the chrome-cobalt skeleton denture which also acts as a retention device. At about the age of 15, a complete rhinoplasty, including elongation of the columella, is done.
Yet another surgeon enjoying an orthopedic adjunct is Fred M. Woolhouse of Montreal. He wrote me in 1972:

We exploit the McNeil-Burston type of neonatal orthodontia by having our orthodontist insert the appliance usually before the baby's first feeding, i.e., within 12 hours of birth (we have a very compulsive orthodontist and very cooperative paediatricians). Consequently we usually (but not always) repair the lip over a symmetrical arch. The cases from outside the metropolitan area form a good control series since they do not get the benefit of this therapy.

In 1972 Motomasa Sasaki of the Sapporo Medical College, in the Japanese Journal of Oral Surgery, presented his use of the McNeil-Burston dental appliance with extending phalanges and attached head and cheek bandages to fix the apparatus in position. He also showed diagrams of what this appliance was designed to do in the various cleft deformities.

In 1974 J. O'Donnell, J. Krischer and F. Shiere of Tufts University, Boston, following McNeil's principle of presurgical orthopedics in unilateral cleft lip and palate, concluded:

1. Unilateral cleft lip and palate patients who have been treated with presurgical orthopedics demonstrate lower incidences of arch collapse and crossbite malocclusion than those treated by surgery alone.

2. A program of presurgical orthopedics results in a reduction of posterior cleft width throughout the course of treatment.

3. The greatest amount of reduction (28.5%) occurs during the period prior to lip repair and the total amount of reduction (45.4%) exceeds that of previous reports of patients who received purely surgical treatment.

In 1977 N. Robertson, W. Shaw and C. Volp of the Orthodontic Department of the Welsh National School of Medicine, Cardiff, used serial cephalometric analysis (with the aid of metallic implants) and an analysis of the models of 10 children with
complete bilateral clefts to study the effects of presurgical orthopedic treatment. They noted:

Successful orthopedic treatment reduced the premaxillary protrusion and the width of the alveolar cleft prior to the surgical repair. . . . The changes were brought about by two complementary effects:

(1) Further forward growth of the already forward premaxilla was restrained by the extraoral strapping which we applied with tension across the prolabium.

(2) Forward growth of the remainder of the midface (including the lateral segments) continued, thus "catching up" with the premaxillary element.

If the premaxilla is effectively restrained, the time required for alignment to occur will depend on the rate at which the lateral segments "catch up" as the face grows forward. In our cases this would appear (on the average) to be just under 5 mm. during the first 3 months of life.

. . . Because successful treatment partly depends on normal forward growth of the face, we believe therapy should be commenced within the first days of life when the growth rate is maximal—and it should be completed by 3 months, to comply with the traditional surgical program. . . .

Our other observations include the accentuation of the columella during treatment, but an absence of growth at the cleft margins.

Orthopedic treatment which fails to achieve the desired aims in 12 weeks of active therapy should be discontinued then in favor of such surgical setback as may be necessary to allow a satisfactory lip repair.

PINNING THE PALATE

It is not practical in most areas of the world to hospitalize cleft infants for orthodontic care over long periods as in Burston's unit in Liverpool. Robert Hagerty therefore called upon Willis K. Mylin, orthodontist and anatomist of the Medical College of South Carolina, to help him ensure the maintenance of a maxillary prosthesis with an expansion screw which would require minimal home care. Mylin, who understands construction, having just completed building his large and beautiful house with only the aid of a few subcontractors, turned his attention to this problem and with Hagerty developed the method of pinning the screw plate to the maxilla and sealing off the pins. If fitted and pinned in the early days of life, the expansion plate can be
maintained with relative ease and can have a great influence in positioning the maxillary elements. Mylin is content to leave the apparatus at work for two to six years if indicated.

Robert Hagerty, W. Mylin and D. Hess, in the 1965 *Journal of the South Carolina Medical Association*, described their pin-retained expandable acrylic prosthesis. They defended the need for the appliance in cleft palate when the normal “buttresses” are deficient and presented their case with graphic diagrams of (A) the normal, with equilibrium between the intraoral and extraoral forces, (B) unoperated unilateral complete cleft, with greater intraoral forces displacing the maxillary segment, (C) operated complete unilateral cleft, with greater extraoral force at work, (D) unoperated bilateral complete cleft, with intraoral forces greater, and finally (E) operated complete bilateral cleft, with superior extraoral forces displacing the maxillary segments.

They concluded that their

pin-retained expandable prosthesis is most versatile. . . . The advantages of this prosthesis may be listed as follows:

1. Rapid positioning of the maxillary segments.
2. Mechanical closure of the cleft, permitting more facility in taking nourishment and decreasing the amount of food entering the nasal cavity and nasopharynx.
3. Mechanical closure of the cleft, permitting anterior tongue thrust which balances the compressive forces of the lip musculature and also stimulates growth.
4. Mechanical closure of the cleft, permitting anterior tongue tip exploration to stimulate the early development of articulated speech.
5. The pushing compression effect of the tongue on the appliance, stimulating growth at the cleft margins and therefore reducing the size of the cleft.
6. A more normal facial contour resulting from more anatomical positioning of the maxillary segments and vomer.
7. A reduction in responsibility on the part of both patient and parents for the insertion and use of the device.
8. Constant maintenance of the prosthesis in the desired position, eliminating displacement into a non-functional position.
9. Reduction of the nasal quality of the speech.
10. Elimination of parental anxiety associated with external retention and fixation devices, insertions and maintenance of bite plates, feeding difficulties and general appearance of the child.
In 1976 Hagerty informed me that since 1965 he has been closing the velum at 6 months with transverse incisions along the posterior edge of the hard palate, dividing the muscle attachments but preserving the vessels and advancing the soft palate elements medially and posteriorly for union. The screw plate is then inserted, pinned into its position and maintained for six years, at which time the hard palate cleft is closed with the aid of mucoperiosteal flaps when necessary.

In the cleft palate clinic held every other Saturday morning in Charleston's St. Francis Hospital annex, Hagerty and Mylin, with a speech pathologist, an audiologist, a geneticist and invited orthodontists, meet to see 25 to 30 patients. The children with pinned screw plates are seen every six months for minor maintenance, since the prosthesis can become dislodged during an intensive bout with chewing gum.

In 1977 R. J. Jorgenson, S. D. Shapiro and C. F. Salinas of the Medical College of South Carolina, Charleston, reported on delayed closure in 75 of 180 patients treated with a pin-retained prosthesis prior to surgery:

The results of this study indicate that delayed surgery is related to less interference with palatal growth than early surgery and that the pin-retained prosthesis is a useful adjunct in the delayed surgery.

PRUZANSKY'S DISSENT

There has not, however, been universal acceptance of presurgical orthodontics. Orthodontist Samuel Pruzansky of the Illinois Research and Educational Hospitals, Chicago, in 1964 wrote a strong dissent against presurgical orthodontics. He noted that, just as

fads of fickle fashion fade and flow,

maxillary constricting wires are out, but with no more justification, in his opinion, jackscrews and spring plates are in! He pointed to the role of musculature in the growth of the maxilla and remarked that maxillary collapse was fully, quickly and economically correctable in the deciduous, mixed or permanent dentition.
STELLMACH

Stellmach of Düsseldorf stated in 1964:

We have used early orthodontic treatment of complete clefts since 1954 according to the McNeil technique, but only in a few cases have we used this before lip repair. The procedure is time consuming if not begun within the first weeks of life. . . . Orthodontic treatment, when commenced after lip repair, is aimed at preventing unfavorable approximation of the segments. The plate acts to direct and guide the segments moved by the lip muscle forces into a butt-joint contact. This is obtained within 2–3 months, usually with one correction of the plate. Even outward shifting of the segments can be achieved postoperatively by using several adjustments of the plate or a screw on it.

HUDDART

Huddart, North and Davis of Wolverhampton, England, studied treated and untreated cases in 1966 and found no apparent difference in the two groups of children in later years. Huddart added an extra thought in 1969:

If I have a severe protrusive premaxilla, I honestly think pre-surgical treatment is a waste of time if it is started when the child is more than 14 days old. I refer it to the plastic surgeon as quickly as possible. . . . The child benefits more by an early lip closure.

GLASS

Sussex orthodontist Denis Glass of the Plastic Reconstruction Centre, East Grinstead, made similar findings. In fact, he reported his opinion about presurgical orthopedics in 1970:

1. It does not stimulate maxillary growth;
2. It does not produce "clinical or bony union" of the segments;
3. It delays the time of lip closure until the child is 9 to 12 months old;
4. It draws attention to the child's deformity at home;
5. It provides added burdens of travel and absence from home to the neglect of the rest of the family;
6. It involves the orthodontist and technicians in work of doubtful value. . . .
As orthodontist, I am responsible for the final alignment of the bony segments of the maxilla and to join these segments by bone before uniting the soft tissues of the face and before restoring the muscle function of cheeks and lips is, in my opinion, of doubtful value.

Glass concluded:

The successful management of bilateral cleft depends on:
1. A careful study of the soft tissue behavior associated with the cleft.
2. Early lip and palatal surgery by a competent plastic surgeon.
3. Rapid dental orthopaedic correction of the three maxillary segments at 4 to 6 years.
4. A course of treatment as short and intense as possible followed by long periods of rest.

Glass had a rather violent youth. While at the University of London, he earned his colors for rugby and athletics, winning the hammer-throwing championship for the Combined Universities of the British Isles. During the war he was in three assault landings in a field ambulance with the infantry fighting from Sicily to Rome. He has indeed earned the good life and now enjoys gardening, hunting, fishing and painting when he is not working on the facially deformed.

SKOOG

In reference to maxillary orthopedics, Skoog stated in 1974:

This tedious process involves using cumbersome headgear and various other apparatus in attempts to bend the premaxilla towards the separated lateral segment. The unnatural pressure placed on the premaxilla is both harmful and unnecessary. The best way of producing alignment is to repair the lip. . . . An exception to this practice is made when the original malformation presents with collapse of the lateral segment. Expansion of the maxillary arch to a suitable position is then recommended.

His orthodontist, Hellquist (1971) used a pair of acrylic plates which act through a fan expansion screw. Lateral rotation of the lateral segments widens the cleft anteriorly.
HARDING AND MAZAHERI

Harding and Mazaheri of Lancaster warned in 1972:

Because the spatial relationships of the maxillary segments spontaneously tend to improve, we have become more selective about using expansion or holding prostheses for their management. These prostheses are possibly essential in those in whom there are plans for alveolar operations. . . . Many of the prostheses being used are designed to correct deficiencies in width and this is not a major problem in early infancy—particularly in patients with bilateral cleft lips and palates.

In 1975 M. Mazaheri, at the H. K. Cooper Institute for Oral-Facial Anomalies and Lancaster Cleft Palate Clinic, continued to endorse the standard lip closure at 10 pounds and two-stage palatal closure at 1 to 1½ years, usually without surgery to the area of the alveolar cleft. This was followed by orthodontic treatment during deciduous and permanent dentition if needed, the expansion of the collapsed arch being simple and without irritation. On the basis of a study of 125 complete unilateral cleft lip and palate patients from birth to 9 years under their standard treatment, he and his colleagues reported:

To date, there has not been data of a similar nature published to reveal a more satisfactory oral-facial growth, arch, dental and occlusal developments. Our investigations have shown that it is not necessary to treat the arch in early infancy with a holding or an expansion appliance, since it appears that the arch and the segmental relationship will undergo favorable change with growth and with eruption of the deciduous dentition, provided that growth is not retarded by surgical intervention and scar tissue. . . . The orthodontic cost for correcting a unilateral cross-bite during deciduous dentition is approximately $400 to $500. Primary bone grafting and orthopedic therapy might run into the thousands.

Orthodontist William H. Olin of the University of Iowa, who collects antique music boxes, in the early 1960’s became interested in the reports on presurgical orthopedics from Germany, Scandinavia and England. In 1978 he recalled:

I spent 6 weeks travelling in Europe observing the different techniques being used and returned to this country quite excited about experimenting.

After several years of using these techniques and comparing the results of patients that had not had presurgical orthopaedics, my conclusions were that
this procedure was not indicated in most cases of cleft lip and palate.

I feel that facial growth is best influenced by simple lip repair at approximately 3 months of age, or a two stage procedure if the cleft is bilateral, one side at 3 months and the other side at 6 months with little or no undermining. I also seem to favor palate surgery after the primary dentition is fully erupted, which would be 2.5 to 3.5 years of age.

Occasionally we do have some severe clefts which are very difficult to close surgically and our surgeon sometimes requests that we help him in reducing the size of the cleft. In these cases we cooperate and attempt to reduce the protrusion of the premaxilla or to close the cleft in the alveolar ridge so the surgeon will be able to complete a satisfactory lip repair. This is the only reason why I feel presurgical orthopaedics is necessary.

H O T Z

In 1976, in the American Journal of Orthodontics, Margaret Hotz and W. Gnoinski of Zurich University Dental Institute took a provocative stand. M. Perko was their plastic surgeon.

The controversy for or against early orthopedic treatment of cleft lip and palate patients still continues. American authors especially [Aduss and Pruzansky] “vigorously” deny its usefulness and are trying to prove that their cases, results of “conservative surgery only,” provide a yardstick against early orthopedics.

Unfortunately, they generally refer to it in connection with primary bone grafting, the effects of which procedure must be considered separately. Some recent publications advocating early orthopedics [Huddart; Maisels; O’Donnell and Robertson] state that it has definite advantages as concerns both growth and development and primary surgery.

Hotz and Gnoinski outlined their comprehensive care developed since 1957, with changes to 1965:

In order to normalize feeding, a plate of compound soft and hard acrylic resin is made as soon as possible, usually within 24 to 48 hours after birth. . . . The plate . . . carefully adjusted . . . is held by suction and adhesion only. . . . The hard acrylic layer provides stabilization of segments in both the transverse and anteroposterior dimensions. The soft parts adapt themselves to the underlying structures, gradually giving way to the increase of the transverse maxillary dimensions. . . . Handling of the plate decisively influences the effects of early orthopedics. . . . Arch alignment is induced by grinding away material in definite areas: in unilateral cases, on the butt ends of both segments. . . . The margins of the palatal shelves are relieved
medially and vertically. . . . In bilateral cases the butt ends of both lateral segments are relieved by grinding in an anterolateral direction. The margins of the palatal shelves are relieved medially and vertically. The premaxilla is supported posteriorly. . . . No active retrusion of the premaxilla is carried out. . . . Expansion is often necessary in bilateral cases lacking space either for alignment of a large premaxilla, and/or proper accommodation of the fast-developing mandible. . . . For surgical closure of the lip in unilateral clefts, we consider 5 to 6 months as being the optimal time. . . . The alveolar cleft has considerably narrowed by this time as a consequence of guided and undisturbed maxillary growth. The alar base is carried forward and supported by the lesser segment. . . . Current z-plastics are used for closure, mainly Millard and Tennison techniques. . . . The plate is reinserted immediately after the intervention. It lessens the pressure of the united orbicularis oris muscle on the butt ends of the maxillary segments . . . For lip closure in bilateral clefts, the Celesnik approach in two stages has proved most adequate. . . . Stage I: Symmetrical closure of the nostrils and nasal floor produces approximation of the three segments which are supported and guided by the orthopedic plate; arch alignment ensues. Stage II: Closure of the lip proper is preferably done by Veau or Manchester cut . . . Palatal tilting of the premaxilla is prevented by the supporting plate, fitted if necessary with a fan screw in order to allow further adjustments of the segments as well as to exert some counterpressure against scar contracture. . . . A new plate has to be made again at 10 to 12 months of age. Serving now mainly as an obturator, it is worn until a few weeks before soft palate closure. . . . Palatal closure in two stages is used for all complete clefts. . . . Velar closure is performed at about 18 months of age for the sake of speech development; hard palate closure is delayed until the sixth to eighth year. . . . After soft palate closure, no retention appliance is worn. . . . If demanded by the speech pathologist for better speech proficiency (plosives), an inactive plate may be used to cover the remaining gap. . . . Only about 50 per cent of the patients actually need it, usually not before four years of age.
Hotz’s logic parallels that of Cronin with regard to the considerable rate of growth during the first six months of life, total body weight being normally doubled, and advocates that one “take advantage of this quite dramatic rate of maxillary growth” within that time and not interfere with it. Hotz and Gnoinski conclude:

The main objectives of our efforts are: (1) to normalize form and function in early infancy; (2) to permit growth to develop to its full potential with regard to functional and esthetic requirements; (3) to render regular orthodontic treatment in the permanent dentition easier and successful in order to avoid large prosthetic reconstruction and/or major secondary surgery.

**MECHANICAL PRESSURE**

The ultimate in the principle of compression was developed in the 1970’s by Georgiade and Latham in North Carolina. In the bilateral cleft with a projecting premaxilla, they attach a coaxial arch alignment appliance with two concentric knobs, one for arch expansion by a pinned maxillary prosthesis and the other for premaxillary retraction. Every turn of the second thumbscrew achieves a 1 mm. posterior displacement of the premaxilla so that with one turn twice daily the premaxilla is positioned within the arch well enough in 9 to 10 days for surgical closure of the alveolar clefts. More detail on this principle is presented in Volume II, Chapter 3.

Maisels’ abstracted conclusion in his 1974 article in the *British Journal of Orthodontics* hits the bull’s-eye of the surgeon’s dilemma:

One wonders whether there is significance in the fact that most of the criticism of presurgical orthodontics has come not from surgeons, but from orthodontists who are either unable or unwilling to provide this service for their surgical colleagues and through them, for their patients.

During the 1977 International Cleft Palate Congress in Toronto, as I listened to experts in various disciplines argue among themselves, my suspicions were crystallized that rubber bands and surgical adhesions are medieval means of accomplishing what skilled *presurgical orthopedics* can do far better. To ask soft tissue
and the young scars to mold bony elements into alignment is an incorrect order of priorities. It is far better to have the bony base adjusted prior to closure of the lip and retained thereafter, if indicated. This maneuver will reduce the amount of surgery necessary, relieve the degree of tension against fresh scars, prevent the bearing and twisting suffered by the constructed lip against the jutting asymmetrical platform and limit alveolar collapse in response to closure of the lip muscle band across the cleft. Frankly, I particularly resent having my lip scars shoulder any unnecessary stress or strain!

So when Latham made his offer he was welcomed!!

Ralph A. Latham of the University of Western Ontario, London, Canada, who trained with Burston in Liverpool and worked with Georgiade at Duke University, is a research orthodontist with a hobby of migrant beekeeping. He has moved from flower to flower, setting his hives for the bees to feast in the heather of Wales, the blackberries of North Carolina and the clover and goldenrod of Canada. Using Italian queens fed, not on bee bread, but on royal jelly, he hopes to get 100 pounds of honey per hive per year eventually. This is his philosophy on treating the alveolar and hard palate cleft in unilateral cases:

**UNILATERAL CLEFT**

Present management of the complete unilateral cleft lip and palate condition is prone to a poor nasal appearance, malocclusion of the teeth and maxillary growth deficiency in the form of a depressed facial profile. These features do reflect a persistence of the birth deformity and collapse of the maxillary palatal segments in the first months of postnatal life. The present purpose is to focus attention on the main cause for all of these maladies, namely the cleft in the palato-alveolar portion of the primary palate, which in general practice is never surgically closed. There is good reason to regard the continuing cleft in the dento-alveolar ridge as detrimental to the form and growth of the middle third of the face.

Three factors have been conducive to the decision to leave the anterior palatal cleft. First, there is usually malalignment of the palatal segments at the time of lip surgery. Second, closure later is difficult due to the inaccessibility of the cleft borders behind the intact lip. Third, there is a popular attitude based on consideration of maxillary growth and orthodontic treatment that nonclosure of the anterior palatal cleft may be beneficial.
It is well established that the early associated cleft deformities are amenable to corrective manipulation. It is now possible to arrange the palatal segments favourably for surgical closure by orthopaedic treatment. If anterior palatal closure is performed before proceeding to close the lip, accessibility is not a problem. The indications for giving anterior palatal closure first priority for surgical treatment are now such as to commend this approach.

The main advantages include the following: Closure of well aligned segments using periosteal flaps offers the possibility of bone fill-in of the cleft maxilla. This confers stability to the jaw as a whole. It also provides more normal anatomical conditions for growth of the maxillae. The achievement of good maxillary arch form avoids the problem of malrelated maxillary dental bases which eventually require extensive orthodontic treatment.

**Surgical principles**

The procedure for gingivoperiosteoplasty described here requires a specific optimum alignment of the cleft alveolar segments. These should conform to an arch form with a cleft width of about two millimetres. The surgical procedure has three important principles:

1. Utilization of only palato-gingival mucosa for closure on the oral aspect, and use of nasal and septal mucosa only for nasal floor construction.
2. Turning out the mucosa within the cleft as flaps to effect the closure.
3. Periosteum to be included in flaps as much as possible.

**Requisite of mucosal type**

Palatal and gingival periosteum is associated with prolific osteogenesis on the oral surface of the palate and on the alveolar processes. Use of such periosteum on the palatal aspect of the repair provides an optimum environment for bone growth and the establishment in the cleft site of a normal maxillary growth process. Similarly, periosteum from the vomer and lateral nasal wall has bone resorption function of varying degree, and such periosteum should be kept on the nasal aspect of the cleft site where the continued manifestation of bone resorption would be in keeping with the normal growth pattern.

**Mucosa of cleft borders**

Most of the cleft border mucosa is of an oro-palatal or gingival type which is appropriate for the construction of the flaps on the oral side. This mucosa is of the same kind as adjacent gingival mucosa and tends to have a similar growth pattern. However, for the cleft mucosa to adequately reach across
the cleft site, the palatal segments must be within about 2 mm. of each other.

**Use of periosteal flaps**

It is important to expose bone on both sides of the cleft and to develop a tube-like lining of periosteum from one segment face to the other. A deep repair is of paramount importance. The most satisfactory part of the repair for its osteogenic potential is posteriorly between the palatal process and the posterior premaxillo-vomeral area. Properly performed, the surgery should be followed by the filling of the cleft site by osteogenic cells and fibroblasts which would initially support the periosteal flaps and as early as seven days post-operatively give way to their replacement by commencing bone formation.

In November 1976 Latham wrote me:

I believe I have just the perfect anterior palate surgical design to complement your Rotation-Advancement lip operation. Just thinking of all those beautiful lip operations that conceal behind them an unstable, malaligned, growth retarded, functionally denied and maloccluded dento-alveolar CLEFT that almost no one in North America is much interested in, makes me groan. . . . For ten years, I have known in principle what was needed. This is why this baby is special. With the help of her dentist father, I applied substantial tractional force in a correctional direction with a forward, rather than backward, force vector. The rubber bands and head gear were quite easily handled at home without hindering feeding. Will you do the surgery for this important baby? Gingivoperiosteoplasty should definitely be before teeth start erupting in the cleft area. About 2-3 months appears optimum. Going over 6 months is cutting it fine, although teeth tend to be delayed in eruption in relation to the clefts. This baby is now over 4 months old.

On the first day of December 1976, with Latham assisting, I operated on the baby in Miami to develop clinically a method of treatment employing the principle of sutural adjustment during facial growth (Latham 1974). Here is Latham’s report of the case:

The main anatomical problem is that both palatal segments are displaced to the same side, the noncleft side. The premaxillary segment is displaced anterolaterally with an upward tilt of the cleft premaxilla; the cleft segment is retroplaced and collapsed. The nasal septum is bent both anteriorly and posteriorly, which is a basic cause of facial asymmetry and nasal obstruction. The cleft maxilla frequently does not appear to be collapsed, but the collapse shows if the noncleft segment is restored to the midline.
These problems usually preclude surgical closure of the anterior palate and alveolar ridge at the time of lip surgery. Nevertheless, because of his background in basic research in facial growth and development, Dr. Latham thinks that the alveolar ridge should be united at the earliest possible time to optimize normal growth. But the dental arch must be expanded and retained with appliances until the cleft has filled in with new bone that can maintain the dimensions of the palate.

Orofacial Orthopaedic Treatment

The problem was how to pull the noncleft and the cleft segments downward, forward and into a normal arch relationship. Correction of the arch form requires that both segments be drawn by traction in the same direction. This problem was solved by the use of an acrylic intra-oral appliance which was pinned to the palatal processes and, in addition, tied anteriorly by passing a wire over the floor of the noncleft nostril and then around the appliance. The base from which to apply extra-oral traction was provided by a face bow anchored to a custom-fitted head cap. The traction was then placed with a rubber band from the appliance to the face bow. Both the amount and the direction of force were adjustable. Correction of the premaxillary segment towards the midline was obtained with three ounces of traction maintained over a period of three weeks. The traction plate on the cleft side dislodged early in the treatment, resulting in the corrected noncleft side overlapping the cleft side. A Georgiade-Latham expansion appliance was inserted to displace the cleft side laterally and to establish an operating space of about 2 mm. between the cleft alveolar ridge abutments.
While the alar base asymmetry in the case of the unilateral cleft is due primarily to the deformity of the underlying bony structure and its correction does a great deal to establish nasal symmetry, the infant's face may still look asymmetrical due to hypoplastic lip tissues. Final alar symmetry was simulated by pulling the lips together with adhesive tapes. Thus it was expected that some soft tissue growth would both facilitate the surgery and enhance the result.

The orofacial orthopaedic treatment worked well and the cleft palatal segments were well positioned for anterior palate and alveolar ridge construction by gingivoperiosteoplasty.

**Orthopaedics Facilitates Early Surgery**

**Gingivoperiosteoplasty: The Interdigitating Alveolar Flap Method.** A new modification of the periosteoplasty procedure was used. The distinctive features are closing the palatal aspect of the cleft using only palatal mucoperiosteum, and using interdigitating gingival flaps to construct continuity of the alveolar ridge. This modification involved no lateral relaxing incisions or denuded palatal areas. The basic incisions were at the cleft borders. Flaps from the lateral nasal wall and from the nasal septum were turned superiorly, and flaps from the palatal mucoperiosteum were turned inferiorly to effect a two-layer closure.

The two main incisions were commenced posteriorly. The first (1-2) on the medial border of the palatal process commenced near the posterior border of the hard palate and the second commenced over the vomer bone (3-4). The position of the vomer incision (3-4) was determined from an estimate of how far the cleft side palatal flap (a) would reach medially; the noncleft side vomeropalatal flap (b) was then cut long enough to meet it. Both of these incisions ended anteriorly at the markings for the lip at the alar base point laterally and at the base of the columella medially.
The curved premaxillary abutment was denuded by raising two triangular flaps, one anteriorly "g" and one posteriorly "e." The gingival ridge on the cleft side was raised as flap "f." This went between the two triangular flaps of the premaxillary abutment to give continuity of the ridge crest. The flaps "e" and "d" came together to close the oral aspect of the anterior palate. Most of the reach here across the cleft came from the palatal flap on the cleft side, which was thoroughly elevated from the palatal bone. The vomero-palatal flap on the noncleft side approximated a little, too, after it had been freed from the bone.

**Lip Surgery**

The anterior aspect of the palate was closed by the lip tissues. A lip adhesion procedure without 1 flap was preferred at this stage for two reasons: first, to avoid compression of a tight lip repair on the newly constructed dental arch; and second, to provide a later opportunity to perform the definitive lip closure after the maxillary arch had been expanded postsurgically, the palate repair had settled down, and new bone supported a stable maxillary base. Postsurgical arch expansion of more than 5 mm. would disrupt a good nasal repair.

**Postsurgical Arch Expansion and Retention**

At three weeks after surgery a new palate impression was taken and another expansion appliance prepared and inserted with pin retention. There then followed rapid expansion of the palate to correct the postsurgical collapse and further expand the alveolar arch. This was a provision to avoid later dental crossbite. In this case, the postsurgical expansion was about seven millimetres in the width of the molar gum pads. The appliance remained in place for the final lip closure by the rotation-advancement procedure, and was removed two weeks later.

Here is an interesting series of models of this case:
In October 1977 Latham wrote:

I am still very pleased with the result of our combined efforts. Three similar infants have subsequently been treated.

Then in January 1978:

You will see in the most recent cast I am sending you the arch form looks very acceptable indeed. On the radiograph there appears to be a bony bridge which is obscured by a supernumerary tooth which comes from the cleft maxillary side, so clear definition of the uniting bone is still difficult to assess. The deciduous first molars are just erupting and in another few months they will give a better perspective on the proportions of the arch in general.
Overall, it appears to me that the sequence and timing of treatment has been close to the very best possible and I feel that this represents an historically important milestone in the progress of the treatment of congenital cleft palate. Don’t you think it is essential to get a number of such patients going so that serial records in a long term follow-up study can be obtained to observe antero-posterior growth, the form of the maxillary arch and to see if early prevention of collapse by bone support holds up in the long term?

**BILATERAL CLEFT**

Then Latham and I turned our attention to a patient with a severely protruding premaxilla and "collapsed" maxillary segments. The case was shown to Berkowitz prior to our treatment, and he wrote me:

The evidence is in and one can predict the outcome if you should either surgically attach the premaxilla to the palatal segments and/or close the palate. The outcome will be a malformed maxilla.

It may be a good idea to retract the premaxilla half the distance to the palatal shelves just so you can unite the lip. The case will then react like all your other cases and perhaps turn out equally as well; you need not do more. There is no literature written within the last ten years which supports anything else!

Convinced that the status quo was not good enough and always searching for an improvement, confident that the litera-
ture in the next 10 years will not repeat all the platitudes of the last decade, we proceeded cautiously. Latham's report follows:

The bilateral cleft lip and palate infant usually shows a protruding premaxillary segment that is a main focus of attention in treatment. However, this problem becomes secondary in those rare instances when the maxillary segments have collapsed to the extent that their gum pads touch in the midline. This extreme malrelationship was the case in the infant Willie M., offering a challenge even for a pinned-screw expansion appliance.

The Miami Cleft Palate Team noted that a lip adhesion procedure by itself could not be expected to retract the premaxillary segment since this was locked out by the collapsed maxillary segments. When Willie was 4 months and 24 days old, Latham inserted a Georgiade-Latham coaxial cleft palate orthopaedic appliance and, by passing a stainless steel pin of 0.036" diameter transversely through the premaxillary basal bone behind the tooth buds, retraction was exerted on the premaxilla simultaneous with expansion of the maxillary segments.

A novel accessory used with the coaxial appliance was the retraction force monitoring system specially developed for this case by Olivier Monbureau at the Dental Research Center of the University of North Carolina at Chapel Hill. This employed a triple light indicator mounted on a black box that also housed small batteries, and its purpose was to show when adjustment of the appliance was required. For the next 4 days treatment progressed well as the appliance was regularly inspected and activated. On the 5th day Dr. Latham was notified that the appliance was not working properly. Subsequently this observation was confirmed and on the 9th day the coaxial
appliance was removed and treatment continued employing a facial strap (Liverpool type) for premaxillary retraction, and a standard Georgiade-Latham expansion appliance for continued expansion of the maxillary segments.

The expansion component used initially in Willie’s case was of a design that allowed maxillary rotation in the coronal plane simultaneously with lateral expansion. So much expansion was required that a spreading of the bridge of the nose was a matter of concern with use of the standard expansion appliance. Although previously used with success on an expansion problem, the rotating-expansion appliance developed a fault when used for the first time with the coaxial retraction component. Correction was quickly performed but in the course of a second attempt to obtain expansion, the maxillary segments collapsed to their original positions. Engaging palatal bones with the retention pins had been a delicate matter from the start, but now faced with renewed force for rapid expansion, insufficient pin insertion in bone combined with the rotation facility in the expansion appliance and permitted unimpeded collapse. At this point, 11 days into treatment, resort was made to the standard expansion appliance normally used. Premaxillary reposition was aided by a facial strap (Liverpool type). Effective expansion was resumed and in the three days immediately preceding the surgery date, or after 14 days of orthopaedic treatment, the 12 mm. of expansion was obtained. Ideally, the premaxillary segment should have been retracted further by a few millimetres still to allow for rebound.

Orthopaedics Facilitates Early Surgery

**Bilateral Gingivoperiosteoplasty.** The Interdigitating Alveolar Flap modification was used to reconstruct in two layers the anterior palate and alveolar ridge bilaterally, as shown in these diagrams:
The lip was then closed bilaterally using a lip adhesion procedure. An expansion appliance was made to be inserted post-surgically. The tendency for maxillary relapse was strong since there was no retention for the aligned arch prior to surgery. With this surgical procedure bone tends to form within 60 days, so there is a risk of bone forming across the repair before expansion is achieved. Thus, an expansion appliance to splint the expanded maxillae was inserted several days postoperatively by resident Robert Zaworski and the father instructed to turn the expansion screw ½ turn every other day. When he had expanded to the limit of the appliance (less than one mo.), it was maintained as a retainer for an additional 2 months postoperatively.

On March 2, 1978, a forked flap was marked over the adhesion union, taking portions of the prolabium, adjoining scars and lateral lip elements. A Millard mouth gag was inserted and the cleft in the soft palate closed by splitting the cleft edges and dissecting out and dividing the abnormal anterior levator muscle attachments to the posterior edge of the hard palate. The nasal mucosa was closed with catgut. The levator muscle bundles were retropositioned about 1 cm. and sutured with two 4-0 Vicryl sutures. Then the oral mucosa was closed with 4-0 chromic catgut mattress sutures with one through-and-through suture just anterior to the mended levator sling to prevent anterior drift. The gag was removed and the forked flap banked in whisker position after the lateral lip mucosa and muscles had been joined to each other in the midline behind the prolabium.
Thus, by 1 year of age the forks have been banked for columella lengthening, the lip is closed with muscle union and a mucosal sulcus, the alveolus, hard palate and soft palate are closed and the levator muscle is retropositioned. A retention plate will be used as circumstances require.

Here is a series of cast models made by Latham and Berkowitz to demonstrate the progress of the treatment.

Berkowitz's comment after following this case was:

The geometric effect on a neonatal palate of a fixed intraoral premaxillary retractive device designed by Latham was reviewed by analyzing serial casts, lateral cephalographs and computerized axial tomography. This study demonstrated that the nasal septum buckles at the vomer-nasal septum junction, and that excessive premaxillary ventroflexion occurs as well. Anterior palatal growth was mainly responsible for the closure of the anterior cleft space. Straightening of the facial profile was mainly due to mandibular growth. Forceful retraction of the premaxilla accounted for a net retrusion of 3 mm. over a ten (10) month period of time. In this case it is too early to determine the effect of early palatal surgery on palatal growth and development.
The buckling of the septum is not serious and is shown by Berkowitz's computerized axial tomographic view of the nasal septum, taken through a plane through the superior orbital fissure and the premaxilla. In my opinion the ventroflexion is minimal compared to that in cases in which the lip has been closed like a bowstring over the protruding premaxilla. Although the total premaxillary retrusion might have been only 3 mm., it was about 9 mm. at the time of gingivoperiosteoplasty, rendering the operation feasible. It is heartening that Berkowitz does admit some excitement at studying this approach only for these severely protruding premaxillas and has encouraged Mazaheri and Olin to join him in experimenting with it and recording results. He noted:

There are certain cases that will ultimately need surgical premaxillary repositioning. If these cases were identifiable at the newborn stage, then forceful repositioning might be of use. Unfortunately, there are still no all-conclusive predictive parameters. Friede and Pruzansky (1973) have reported that in those cases in which the distance between the premaxilla and the anterior portion of the lateral palatal segments is greater than
25 mm., the growth prognosis is poor. Possibly these cases might be good subjects for this approach, always remember that selectivity of cases is of prime importance. Forceful retrusion should not be performed for all complete bilateral cleft lip and palate patients. The effects of this procedure on midfacial and septal growth have still not been documented. Other investigators have to monitor these results since the originators of this procedure have failed to do so. In this case the early closure of the palatal cleft will mask the effects of forceful premaxillary retropositioning; therefore, better controls need to be established to more accurately evaluate its utility.

In 1979 Berkowitz added:

I do not see any reason for the lateral expansion of the maxillary palatal segments at the newborn period. This case does demonstrate that after Latham expanded the palatal arch it returned to its original dimension when the appliance was removed. Any further palatal arch width change that occurred was due to growth and not to palatal manipulation. This increase in palatal width is predictive in almost all instances, provided there has not been any inhibiting scar tissue.

Berkowitz has since voluntarily used the Georgiade-Latham apparatus on two bilateral clefts with severely protruding premaxillae. I see a hope for progress here!!
Early Maxillary Bone Grafting

The first bone graft to a cleft palate was carried out in 1901 by von Eiselsberg when he grafted an entire little finger—bones and all—into the cleft. The first attempts at bone grafting in growing cleft patients were made by Lexer in 1908, and the first successful bone graft to an alveolar cleft is attributed to Drachter in 1914. Veau’s effort in 1931 to fill a cleft palate defect with tibial chips failed. Then there was an interval of indifference to this approach.

In 1952 a subtle preface to the osteoplastic era was provided by Axhausen, who wrote:

All attempts to induce bony healing through excision of mucosa in the area of narrow clefts and freshening of underlying bone surface have proved futile. . . . If there were a means of inducing subsequent bony healing between the premaxilla and the lateral fragments, this approach would be preferred; it would then be possible to preserve well-formed incisors. To find such means appears to me to be the final problem in the repair of complete clefts at present.

Suddenly almost everyone began bone grafting or apologizing for not doing so. In fact, the world literature on alveolar bone grafting read like a roster of the elite in a German Panzer Division as compared with the sparse but strong guerrilla bands from Sweden, U.S.A., Yugoslavia and Britain.

SCHMID

In the modern era, Eduard Schmid of Stuttgart was the first to implant bone in infants with clefts. On the occasion of the
Austrian Meeting of Dentists in 1951 to 1952 at Bad Aussee, Schmid reported several cases of cleft lip and palate in which he implanted small iliac bone grafts between the maxillary stumps after surgical closure of the cleft in order to prevent contracture in the cleft area. With multiple publications on this subject beginning in 1954, he struck the sparks that ignited an intense interest in bone grafts in the cleft maxilla throughout the world.

His follow-up report 23 years later is of great importance. Eduard Schmid, Werner Widmaier, Heinz Reichert and Klaus Stein in 1974 stated their present stand. Since 1962, 87 children with clefts of the lip, alveolus and palate (80 percent unilateral and 20 percent bilateral) have been treated by a modification of primary osteoplasty not only of the alveolus but also of the hard palate at the time of closure of the lip, usually at 8 months of age. Using compact and spongy layers of hip bone for grafting, Schmid and his colleagues noted:

We lay great emphasis to atraumatic handling of the involved tissue, mobilizing two flaps at the vomer and the lateral edge of the gap, which are rotated horizontally, thus obtaining two layers of mucous membrane to line the oral and nasal cavity. The space is filled with bone. Since only the actual margins of the cleft are involved, the blood supply of the alveolus and hard palate remain unimportant. At age 7 years the remaining cleft of the velum is closed, either by the method of Veau (1931) or, if feasible, again leaving the palatine arteries intact by the method of Widmaier (1961).

They concluded:

We now utilise primary osteoplasty in wide clefts, and achieve satisfactory results. However, we do not use this method in cases of primary compression, where the maxillary arch is first aligned by the orthodontist, before we stabilise it later by bone implant as Nordin and Johanson (1955) recommended.

At about the same time Bengt Johanson of Sweden became interested in bone grafting the alveolar cleft. In 1955 Nordin and Johanson used a block of cancellous bone in the alveolar defect and chips of cancellous bone along the hard palate. Their bone
was obtained from the tibia in primary cases and from the iliac crest in secondary cases. In 1961 Johanson and Åke Ohlsson described their three-stage treatment of clefts:

The *initial operation* is performed at the age of three to four weeks without special prior treatment. The nasal floor of the hard palate, in one layer, is closed with a vomerine mucosal flap and anterior to the alveolar process by direct adaptation of the labial soft tissues in two layers. The vomerine flap, which on the oral side is first covered with granulation tissue, has after some few weeks a stable covering of secondary epithelium. At this junction, the orthopaedic correction of the jaw is started and continued up to the age of six months. Special expansion plates are used, fixed to a head cap by means of extra-oral shafts. At the *second operation*, the components of the upper jaw should be ideally positioned in relation to each other and in correct occlusion. Careful repair of the lip is now combined with transplantation of autografts, chips and marrow, in the cleft in the hard palate and alveolar process. The donor site is tibia. . . . A continuous orthodontic control is subsequently kept until the permanent bite is fully developed. At the *third operation* which is usually performed at one year, the posterior palate is closed. . . . The treatment has been completed in 27 primary and 31 secondary cases. The graft united and a stable homogenized upper jaw was secured in every instance.

**SCHRUDDE**

In 1957 J. Schrudde, while with Rehrmann in Düsseldorf, first published his plan of primary bone grafting to cleft cases using autogenous rib to bridge the defect anterior to the alveolar processes. In 1959 he readvocated this principle with R. Stellmach.
In 1965 Schrudde, now at the University Clinic, Cologne, Germany, reaffirmed his advocacy of primary bone grafting in the *British Journal of Plastic Surgery*, stating:

The procedure, however, had a favourable effect on the development of the upper jaw and the cutting of teeth. The graft also improved considerably the position of the base of the nose immediately above the lip.

He described his more recent approach:

I have of late been closing the palate after primary osteoplasty during the 14th, 15th or 16th month but I have also been performing plastic surgery on the palate at the same time by grafting a rib chip in the hard palate region from one edge of the cleft to the other. This rib chip across the cleft is there to stand up to scar contraction and it therefore guarantees that the upper jaw will develop in a normal way. . . . I apply the bridge flap method as does Axhausen, but I retain both vascular and nerve tissues at the major palatine foramen [which] serves as a more nourishing bed. . . . The important point is that this type of osteoplasty permits a very early cleft palate operation to be performed.

In 1971, after 12 years, Schrudde was still enthusiastic:

Encouraged by our experience of primary bone grafting, we have now altered that operative procedure and advanced the time of operation. The palate is closed by means of primary osteoplasty when the child is approximately 1½ years old and beginning to talk. . . . Under these conditions, the maxilla is able to put up more resistance to postoperative scar tension and is more stable owing to the fact that the alveolar graft has become consolidated, supplemented by the primary bone graft of the hard palate.

In 1972 Schrudde reported follow-up of his primary bone grafts, revealing good and bad results. This stimulated him to
continue the evaluation, which he reported at the Spanish Plastic Surgeons meeting in Las Palmas, 1976. Thirty-six patients from his group of 50 were reexamined while 14 did not return, probably because of satisfactory results. In order to demonstrate the influence of primary osteoplasty on the formation of the maxillary arch, occlusion in three planes (sagittal, transverse and vertical) was presented. The sagittal plane gives information on the degree of pseudoprogenia; the transverse plane reveals the palatine dislocation of the maxillary arch on the cleft side; the vertical plane measures the open bite. From 1972 to 1976 there was improvement in the positioning of the jaws in all planes.

The improvement can be attributed to intensive orthopedic treatment, and, as followed by x-ray studies, the transplants have become fully adapted functionally and firmly integrated in the maxillary arch.

To facilitate the evaluation of the x-ray films, a grade grouping of the transplants was outlined by Schrudde in accordance with their structure and size:

Group 0: Functionally fully inserted chip, clearly structured. The axes of the teeth near the cleft are almost parallel.

Group I: Functional adaption unsatisfactorily advanced; clear convergence of the teeth near the cleft.

Group II: Pseudoarthrosis or considerable loss of transplant substance with pronounced convergence of the teeth near the cleft.

Group III: Loss of the transplant or incomplete bone bridging of the cleft.

In 1972 the transplants were graded by groups and four years later regrouped. The improvement was impressive, as shown in the table.

A bite imprint of the upper jaw and the Panorex shot increased the reliable assessment of the transplants. Schrudde noted:

X-ray evaluation of the transplants is in many cases made more difficult by dentition and by superimposed parts of the bony facial structure, as seen in this case published in 1973 and re-evaluated in 1976.

Schrudde explained that the positive development on the part of the transplants was the reason for the improvement of the jaw positioning. He also clarified factors in the apparent improvement:
All those cases in which x-ray pictures were taken during the cutting of teeth reveal a distinct reaction on the part of the transplant to functional stimuli. In many cases we found that the tooth piercing its way almost rarified the osteoplasty, till then well stabilized, down to narrow marginal areas. After the tooth had come through, we found in all cases we observed that there was a complete regeneration on the part of the transplant as seen in this 12 year old female.

Further evidence of adaptation of the transplant is seen in the processes of accumulation and breakdown as well as increase in thickness in certain areas of the transplant. The extreme degree to which an implanted piece of rib-bone can take its place in a stress system is demonstrated in these two x-rays.

Schrudde noted:

The 1963 figure shows a freshly implanted rib-bone, which has been positioned very far forward in the maxillary arch, a place that we do our very best to avoid these days. The 1964 figure shows the same transplant one year later. Processes of accumulation and breakdown have moved the transplant into a position through which the stress plane of the maxillary arch clearly runs. This process of adaptation promises that during further development the original bone transplant will be able to react to local stress in the required manner.
Schrudde summarized:

Assessment of primary osteoplasty in respect to its efficiency is completely satisfactory.

1. With increasing age on the part of the patient, there is significant improvement in occlusion.

2. Individual observations during dentition clearly show that the transplanted bone is not a passive bridging element.

3. The analysis of the process of accumulation and breakdown and especially of the spread of thickness shows that the transplanted bone is functionally adaptable.

A cleft which has not been closed using bone will never be in a condition in which the jaw can react in a physiological manner to the demands made. Only primary osteoplasties promise to create conditions under which stress involved meets a system which, by virtue of its bony completeness, can react in a physiological manner to this stress.

In conclusion, this occurs only if the surgery is correct. First the bed of the transplant must show no gaps, either in the oral or in the nasal direction. Suture dehiscence and infection in recent years has become a rare
occurrence. A complete rib segment is used as the transplant and this is cut in the shape of a V at both ends to ensure better positioning. It is desirable for the rib segment to be inserted under light tension. We have not experienced complications in taking out the rib and have operated on far in excess of a thousand children.

BÄCKDAHL

In 1961 in *Acta Chirurgica Scandinavica*, musical M. Bäckdahl and dedicated K.-E. Nordin of Stockholm advocated bone grafting both the alveolar cleft and the remaining maxillary defect. This was facilitated by partial resection of the inferior turbinate in preparation for a modified Campbell two-layer cleft closure. They turned the septal flap down to cover the oral side and the lateral flap up to close the nasal side and packed “tib chips” of bone between the two. An x-ray follow-up (a) before bone graft, (b) three weeks after bone graft and (c) 12 months after shows adaptation of the bone structure.

NYLÉN

Bengt Olof Sixtus Nylén of Karolinska Hospital, Stockholm, an international traveler, was trained in plastic surgery by G. Webster and W. Pierce in California and T. Skoog in Sweden. In 1973 Nylén wrote me:

Bengt Johanson left Stockholm for Göteborg around 1957 but interest in primary bone grafting was maintained by Karl-Erik Nordin and Magnus
Bäckdahl, who in 1959 designed a four-flap method. Mucoperiosteal flaps with their bases along the cleft are brought together in pairs, to form a cavity in which the bone is inserted. In some cases, the anterior part of the inferior turbinate may be partially transected or used if needed. The rib grafts are placed with a large piece on the inside of the oral lining, another on the undersurface of the nasal lining and many small pieces packed between the two main struts. The anterior defect is lined by a mucosal flap from the sulcus.

In 1966 Nylén reported 254 cases, 66 with early bone grafting and 188 with late bone grafting, by this same method. In 1973 he wrote:

We have a special jaw orthopedic unit of 15 beds where the infants are brought at 2-3 weeks of age. The preoperative jaw orthopedics is started immediately by Nordin who is the full-time orthodontist. . . . After good alignment of the upper jaw, the early bone grafting operation is performed. . . . We have followed these cases and believe that so far the results are quite promising. We have not seen any deformities as have been reported in different bone grafted series with other methods. The crossbites found in these cases are about the expected frequency of other series. Cephalometric examinations show development similar to the normal facial skeleton. . . . With this treatment the patient is rehabilitated at a young age with a minimum of operations and with promising results.

At the 1973 Cleft Palate Congress in Copenhagen one of the original authors, Karl-Erik Nordin, with Arlander, Barr, Leanderson, Körlof and Nylén of Stockholm, reaffirmed the original 1963 Washington, D.C., Congress approval of early maxillary bone grafting. They gave a 7- to 12-year follow-up on the cases operated on between 1960 and 1966, 70 percent of which had been grafted before 6 months of age and another 22 percent before 12 months. The studies included casts, x-ray films and photos, hearing and speech tests, evaluation of appearance and function of the nose and lip. According to their evaluation of the 73 early primary bone grafts in the bilateral clefts, there were 20 with no crossbite and 36 with only canine crossbite. Appearance, speech, facial skeleton and ear function all compared favorably with those in the non-bone-grafted cases. Nordin went one step farther to describe his approach to transplantation of teeth to the bone grafted alveolar cleft when migration had not occurred. He presented a number of cases.
The endodontically treated and filled root is placed in the split and excavated alveolar crest and surrounded by small chips from the excavation. The root is covered with the mucoperiosteal flap elevated before the procedure. The development of the periodontal structure is followed by X-ray until it is time for applying a crown.

Finally, in 1974, Nylen, Körlof, Arnander, Leanderson, Barr and Nordin reported primary bone grafting in complete clefts and concluded:

From the point of view of appearance, the results were excellent or good in 80% of patients with unilateral complete clefts. The corresponding figure for bilateral cleft group was only 50% and 50% of these patients needed secondary operations. . . . In speech assessment, reduction in open nasality and improved articulation (particularly consonant production) were noted in the bone-grafted group. . . . The results presented . . . appear to us promising and indicative of a need to pursue further this form of treatment.

WIDMAIER

Werner Widmaier, a war-wounded patient of Schmid's, modified the method in 1959. In 1964, at Schuchardt's Second Hamburg Symposium, he and Schmid gave their reasons for bone grafting:

Check-ups of the complete cleft-palate cases showed . . . in a good percentage of the unilateral clefts the dental arch developed normally.

However, mostly in bilateral clefts, contracture of the dental arch could not be avoided. These experiences led us to the primary simultaneous osteoplasty into the cleft of the bony structures.

They presented their method of dissecting the mucoperiosteal flap from the lateral cleft edge. The lateral flap was used for nasal closure and the vomer flap for oral cover, and bone from the ilium or rib was inserted between the two. This maneuver achieved a two-layer closure with bone between both in the alveolar area and all the way back to the posterior edge of the hard palate. They then used Widmaier's method for the soft palate.
REICHERT

Heinz Reichert, a former student of Schmid, gave an interesting comprehensive review in 1969, putting events in perspective:

The development and method of bone grafting used in 450 unilateral and bilateral clefts at the Stuttgart Clinic will be described. From 1951 to 1955, bone was grafted 3-4 weeks after the primary lip repair . . . . By 1956 both procedures could be done in one operation, as published by Stellmach and Schrudde at that time. The children are 7-8 months old at the end of surgery.

The x-ray controls from 1951-6 and the findings with the 2-stage cases demonstrated that the bone graft, when it "took" on both stumps had suffered a deformation after 2-3 years . . . so that only a small step was left. At the same time the alar bases and nasal floor sunk slightly and at the alveolar process and hard palate the mucoperiosteum contracted upwards. In severe clefts, in spite of bone grafting, we discovered a slight collapse in the premolar and molar region which gave to the alveolar arch the hint of a lyre shape.

The practical result to come out of these observations was to enlarge the bone grafts in both vertical and horizontal dimensions. In the vertical dimension we now fill the cleft with a "bone span" extending from the nasal floor, alar base and pyriform opening down to the alveolar edge. Horizontally, the bone graft extends from the anterior edge of the maxillary arch to the posterior edge of the hard palate. In areas where resorption is expected since there is little or no functional burden in the first years after surgery, particularly in the nasal floor and alveolar ridge, we have grafted cartilage from the "pelvic edge" (Beckenkamm)—this is usually not resorbed and is not replaced by bone until 14-16 years.
The determining factor for bone graft success is soft tissue coverage of the bone graft. Based on Wassmund’s (1939) two-layered closure of the nasal floor, combined with Campbell’s and Pichler’s techniques for closure of the hard palate, Widmaier (1956) developed his own method which allows bone grafting of the complete cleft area.

The primary operation works positively not only on the width of the maxilla but also on the nasal symmetry, contour of the upper lip, alveolar edge and palatal vault. We no longer see depressions of the alar base on the cleft side because the pyriform “ring” is closed by a cartilage-bone graft which forms a lasting foundation.

**Bone Grafting Clefts of the Velum**

In 1967 Reichert began to apply osteoplasty to wide clefts of the velum alone, since here too he had observed partial contraction of the molar region in the maxillary arch following cleft closure. In 1970, in the *British Journal of Plastic Surgery*, he explained this occurrence and gave his solution:

This is quite understandable when the difference between healthy and cleft palates is borne in mind; the roof of the normal is arched like a bridge from one tuberosity to the other, while in the cleft palate, the frontal part of the maxillary arch is like the middle of a bow, the free ends of which can be bent towards one another by the tension of a cord, in this case represented by the scar.

In wide palatal clefts therefore we now implant a triangular piece of iliac bone, completing the roof of the hard palate, giving the closed soft tissue layers support, reducing scar formation, preventing maxillary compression and shaping the palate to normal roundness.
This indirectly improves speech results since the movable soft palate does not become shortened by contracting scars and has a solid base for the new attachment of the muscle fibres mobilised from the edges of the clefts. If in some extremely short palates a pushback procedure has to be performed later, the result is stabilized far better by the incorporated bone. Furthermore, as cleft patients grow older, the function and retention of a dental prosthesis will certainly be better on a solid hard palate.

Reichert concluded:

It is considered that at least 10 years after operation is necessary before final assessment. This period has already elapsed in some 150 cases of complete clefts (lip, alveolus, and palate) treated with primary bone grafting and we have observed a significant improvement; most cases show no compression at all.

SCHUCHARDT

Professor Karl Schuchardt of Hamburg, head of a 450-bed maxillofacial surgery unit in a Berlin military hospital during the entire Second World War, has been a leading force in Germany ever since then. We had the pleasure of visiting his charming home (as shown) during the Second Hamburg Cleft Palate Symposium. Schuchardt has employed primary osteoplasty and bone grafting to the alveolar cleft at the time of lip closure at the Nordwestdeutsche Kieferklinik since 1958. By the time of his report with Pfeifer and Kriens at the Rome Congress in 1967 he had 419 cases.

The combined procedure was performed at 6 months of age. He created the alveolar pocket for his bone grafts from local nasal mucosa for lining, like Veau-Axhausen, and from buccal mucosa with his improved modification of the Burian-Trauner flap to get more tissue for oral cover. For wide clefts he admitted using Stellmach's vomerine mucosal flap.

With a typical North German show of strength, Schuchardt advocated the use of two full-thickness rib grafts. These were dovetailed at both ends to straddle the alveolar gap at the edge of the pyriform aperture so as to fill the bony defect and support the alar base.
In some cases he extended the bone grafting into the hard palate area, laying cross-strips of split rib.

According to Schuchardt:

A most important characteristic of the solid rib graft is that it is able to withstand the pressure of the united muscles, predominantly the orbicularis oris. Thus the rib graft not only prevents collapse of the lateral maxillary segment but also transmits the pressure from the premaxilla to the lateral segment and forces it outward.

This action improves the development of the alveolar arch. It should be stressed that the implanted rib acts by orthopaedic means, thus eliminating any preoperative orthodontic treatment and reducing the later postoperative treatment to minor orthodontic measures.

Another advantage of solid rib transplants, which keep the alveolar segments at their proper distance apart, is that crowding of teeth close to the cleft will be improved as adjacent teeth migrate into the incorporated grafts. Thus primary osteoplasty is an important physiological means of improving dental alignment. Since the transplanted bone has no inherent growth potential, teeth which have moved into the incorporated grafts favour regional bone growth.

In his enthusiasm for his own regimen, Schuchardt attacked Herfert’s opinion:

My experiences are incompatible with Herfert’s opinion [based on findings in the dog] that the detachment of the palatal muco-periosteum is the cause for the underdevelopment of the hard palate later on.

He expressed his suspicion that the postoperative deformity was caused not by the detachment of palatal flaps but by contracture in the area of the cleft closed with nasal mucosa only. He reemphasized that his satisfying functional and aesthetic results had been achieved by surgery alone.
One of the outstanding German leaders in cleft palate surgery is Rudolf Stellmach of the University of Berlin. His acute sagacity and unusual generosity have made it possible to include several rare portraits in these volumes. One of Stellmach’s important contributions has been his modification of the vomerine flap used for oral closure of the alveolar cleft. He first presented this method in 1959, and it has been adopted by many surgeons throughout the world. As he stated in 1964:

In our experience anterior lip mucosal flaps are limited to smaller clefts since branching off a wide lip flap may cause too much loss of inner lining of the lip and a narrow vermilion border.

Therefore, in the large type cleft we prefer to cover the bone graft from behind. The vomer flap is raised in its full length, but the posterior part is cut in at the cranial base from behind to the front, forming a tongue-like flap. It is turned forward to serve as the back and oral layer of the bone bed.

In 1976 Stellmach wrote:

We still do bone grafts to the alveolar gap and we use the tilted vomer flap [Stellmach] for covering the autogenous rib implant exclusively. Nevertheless the indication for primary bone grafting has been minimized to extreme total clefts. That means clefts with a severe hypoplasia of the alveolar arch bone in the cleft area. Determination can be made on either intraoral x-rays or on the basis of simple clinical judgement or orthodontic measurement of the alveolar arch length in comparison to the opposite side. In these rare cases, the central incisor tooth buds will be absent, along with or without the lateral incisors. Early bone grafting helps to prevent a severe collapse of the arch.
In 1977 he added:

Formerly when we closed the hard palate at the time of lip repair, we often got overriding of the arches and secondary arch malformation. If narrowing is produced strictly between the alveolus of both cleft sides, the alveolar arch will abut end-to-end within a few months’ time. It is my feeling the surgeon should assist arch alignment as far as possible by careful selection of his procedures.

**BRAUER AND CRONIN**

In 1962 Brauer, Cronin and Reaves reported their first 10 cases of early maxillary orthopedics and alveolar bone grafting. Then at the American Cleft Palate Convention in Washington, D.C., in 1963, Brauer and Cronin were the delegates from Texas promoting the combination of maxillary orthopedics and anterior palate bone grafting. They reported two and one-half years of experience with the McNeil principle: using the motor force of the baby’s gumming and sucking from within, working against an acrylic plate, to guide the maxillary elements into alignment.

At 1 to 2 weeks of age the infant was brought to the office, and Brauer or Cronin took an impression of the arch in warm Kalginate. That same evening a dental student poured the impression into stone and later prepared a plate with an expansion screw. The plate was inserted and the mother instructed to turn the screw once a day or once a week, depending on the need for expansion. For a protruding premaxilla in a unilateral cleft, a bypass plate was employed, and an elastic band attached to a cloth headcap was used to bend the premaxilla around. This action took about two months and was followed by lip closure.

In bilateral clefts, the lateral maxillary segments were expanded by the screw plate while elastic traction was applied to the protruding premaxilla.

Once the relationship of the upper arch to the mandible was as close to correct as possible, the bone graft was inserted. The insertion had been made as early as 4 months of age, with an average of 8 to 12 months, and had been done before, during and after anterior palate repair.

As Scott of Ireland demonstrated that forward growth of the maxilla occurs primarily along the septal-maxillary junction,
Brauer and Cronin reasoned that fixation of the retarded cleft segment to the normal, growing maxillary segment should provide orderly advance of both elements. They gave their threefold purpose in bone grafting:

1. To fix the cleft maxillary segment to the normal side.
2. To provide support for the teeth in the region of the bony cleft.
3. To build out the flat contour often seen on the cleft side of the maxilla.

They turned a vomer mucosal flap over and sutured it to a mucoperiosteal flap from the cleft side for the nasal closure. Rib grafts were used as onlay strips, wedges into the alveolar gap, and chips. The oral cover was supplied by advancement of the labial mucosa over the bone grafts and suturing to the vomer flap.

HORTON AND OTHERS

At the same Washington Cleft Palate Convention in 1963 a Virginia contingent of Horton, Crawford, Adamson, Buxton, Cooper and Kanter reported similar interest in prosthetic prevention of maxillary collapse and fixation with bone grafting. They claimed 63 bone grafts since 1957 and noted that they appear to help prevent maxillary collapse . . . aid in the development of teeth adjacent to the graft and help fill out the alveolar ridge contour.

Georgiade, Pickrell and Quinn reviewed 2,200 of their cleft lip and palate patients at the Duke University School of Medicine and concluded:
It became clear to us that many of our results, particularly in the bilateral cleft and complete alveolar cleft group, were short of our desired goals from both functional as well as esthetic standpoints.

Over a two-year period they visited various European maxillofacial centers in Prague, Göteborg, Uppsala, Düsseldorf and Hamburg and were impressed that, in spite of the enthusiasm of the individual surgeon for a particular procedure,

No one surgical procedure could be used for closure of all various sizes of alveolar clefts . . . but . . . the replacement of the missing segment of the alveolar arch with a bone graft appears to have considerable merit . . . stabilization of the arch . . . prevention of collapse.

Although they expressed preference for cancellous bone taken from the ilium inferior to the crest, they suggested three ways of using a rib graft: (1) H-shaped strut wedged between the alveolar ends, (2) linear separation of the rib ends and insertion into the cleft and packing with chips, or (3) rib chips used to fill the mucoperiosteal pocket.

It was their feeling in 1964, with 42 cases in various stages of orthodontic treatment and bone grafting, that

These procedures singly or in combination will become a part of the overall management of patients both as primary and secondary procedures.

**Čupar**

Professor Ivo Čupar of Zagreb, Yugoslavia, in 1964 noted that secondary maxillary deformities occur only in total clefts, while in subtotal ones with an intact alveolar arch there is no clinical evidence of such changes. Thus he reasoned:

Primary osteoplasty converts total clefts into subtotal ones and this considerably diminishes the likelihood of developing deformities.

Yet the transplanted bone must be protected from the stress and strain until fully consolidated. Having this precaution in mind, Čupar explains his approach:

In small children 1 or 2 years old following osteoplasty and complete cheiloplasty, I usually introduce an orthodontic plate to maintain the
existing shape of the alveolar arch: to resist for a few months an undesirably strong pressure of the lip.

**P R E V O M E R I N E G R A F T**

For special bilateral bone grafting of the clefts, several surgeons turned to thrifty use of the excess bone. In 1960 Oberniedermayr of Munich advocated surgical repositioning of the premaxilla between the lateral segments, using the resected prevomerine bone for grafting. He created a small bone bed with little local flaps and stabilized the premaxilla by Kirschner wire transfixion. In one of his double cleft lip and palate operations the transplanted bone was lost by infection after two weeks, but bone consolidation occurred similar to that described by T. Skoog.

**P F E I F E R**

Pfeifer of Hamburg, assistant to Professor Schuchardt in 1962 and later in 1964 reported a method of triple osteosynthesis he developed for exceptional cases of bilateral clefts with extreme protrusion of the premaxilla. Mucosa was turned to form a bed for the transplants. A cylindrical piece of prevomerine bone was taken, split into two pieces and inserted into both alveolar clefts to fix the alignment of the retroposed mobile premaxilla. Pfeifer claimed a stable union with symmetry.

**S C H R Ö D E R**

Friedrich Schröder of Würzburg is another who favors early bone grafting. In a 1973 book edited by Schuchardt, Steinhardt and Schwenzer he reported early rib grafts in the form of full-thickness struts across the gaps in both unilateral and bilateral clefts at the primary operation. To the question about subsequent maxillary deformity, he stated:

With orthodontic treatment growth disturbance can be avoided.
Clarence Monroe of the Chicago Children's Memorial Hospital reported in 1969 a four-year follow-up. He had closed the lip under local anesthesia between 2 weeks and 3 months of age, or at a weight between 7 and 10 pounds. A day or two before, Bailey Jacobson and Sheldon Rosenstein had fabricated a prosthesis to cover the hard palate from the canine teeth back to the tuberosity with enough extension of soft acrylic into the cleft on the superior aspect to achieve retention of the plate. After lip closure the plate was inserted. Muscle pull rotated the premaxilla, but the plate prevented narrowing of the cleft until the premaxilla was back in good arch form by 1 to 2 months, or even 4 to 10 months. When the premaxillary ridge was touching the lateral alveolar ridge, the position was stabilized with a rib bone graft. A prosthesis protected the bone graft two months for stabilization of the graft. At 1 to 1½ years, a von Langenbeck closure of the palate was achieved.

In 40 cases treated over four years, no instances of severe contracture of the upper dental arch have been seen. In two cases, when the alveolar ridge lined up excellently, palate closure was done at the same time as the bone graft. This procedure promptly pulled the alveolar ridge off alignment into crossbite. Monroe and Rosenstein feel that

Position of the arch should be stabilized with well-healed bone graft before palate is repaired.

Mellifluous Sheldon Rosenstein, holding dual professorships in orthodontics at Northwestern University in Chicago and St. Louis University in Missouri, is also the orthodontist working with Clarence Monroe. In 1967 he described management of the maxillary segments in complete unilateral cleft patients. He reconfirmed his stand at the Duke University Cleft Palate Symposium in 1973, stating:

We claim no panaceas, and we do not think it is the only approach. It is an approach and carries with it a definitive sequence of procedures. In essence,
it consists of (1) the placement of an intraoral prosthesis prior to lip closure, (2) molding of the arch segments, (3) stabilization of the segments by means of autogenous bone graft, and (4) retention of the prosthesis until palate closure. We are generally finished with the early infant procedures when the children are 15 to 18 months of age.

Two major avenues of legitimate investigation and concern should now be mentioned. First . . . does early maxillary orthopedics and osteoplasty do any harm, and second, do these procedures do any good?

Rosenstein admitted that his oldest patient in this series was only 7½ years and therefore he did not know the answer to either question. He did note that at 5 years of age some good and no harm was evident. He concluded:

Despite disenchantment in some quarters, we are not yet prepared to abandon these procedures. On the contrary, we are still very much excited about them.

Since then Rosenstein has co-edited the comprehensive book *Cleft Lip and Palate*. In 1975 in the *Angle Orthodontist* he concluded:

Thus far, we are able to state that in our sample, using our treatment procedures in the sequence advocated, we have seen no growth attenuation in the posterior/anterior dimension. The maxilla, at least to the ages observed, does not appear to have been attenuated by our procedures.

Further, it would seem that after a limited first phase of orthodontic treatment to align dental units, the degree of crossbite is considerably smaller than . . . those using more conventional approaches; thus it is possible that we are doing some good.

We are still using these procedures on our newborn and continue to feel that we have a real opportunity to be able to do more orthodontically for these children when they possess a full permanent dentition and are ready for comprehensive treatment.

**GRIFFITH**

In 1977 B. Herold Griffith of Northwestern University, following Clarence Monroe and joining Sheldon Rosenstein, noted the encouraging results he had seen and was getting with maxillary bone grafting. He is following 118 cases, 36 of them more than 10 years postoperative. Evaluation of the cases includes Broad-
bent-Bolton measurements, cephalometric studies, occlusal films and team evaluation. No retardation in maxillary growth and fewer problems with the dental arch are reported. This is the design of treatment: Preoperatively the patient is fitted with a prosthesis by Rosenstein, which is inserted at 2 to 3 months when the lip cleft is closed and the muscle begins to align the segments. At 5 years of age, with minimal undermining and inturning of mucoperiosteal flaps at the alveolar cleft edges, a split rib strut is placed as an onlay subperiosteally across the cleft, a rib block is inserted into the cleft and buccal mucosa is used for cover. In the bilateral cleft, a jackscrew expander spreads the maxillary segments to give the premaxilla a chance to take part in the arch, and then the same method of bone grafting is used. After a wait of six months for bone graft solidification the palatal cleft is closed. Under this regimen, Griffith claims that there is no evidence of attenuation in maxillary growth and there is less evidence of dental deformities previously considered unavoidable.

ROBINSON

In 1969 Frank Robinson and Barrie Wood of Manchester, England, admitted that many surgeons of the United Kingdom considered bone grafting of cleft palate unjustified, the main criticism being that the combined soft tissue and bone grafting procedures took more than the classic hour allowed for such surgery. They noted that with good teamwork the total procedure could be completed in an hour and a half and then reported:

In unilateral cases the results have been impressive in that only three examples of alveolar collapse occurred in 21 cases. . . . Bilateral clefts have presented greater difficulty; orthodontic correction has been more prolonged and less satisfactory and only six cases of the nine in the series were grafted. Three of these collapsed. . . . It will take several years before definite conclusions can be made but our interim conclusions on primary bone grafting are:

1. That collapse of the lesser maxillary segment is prevented.
2. That the lesser segment is brought under the growth stimulus of the nasal septal cartilage and the middle third of the face grows as one unit.
3. That teeth which have formed at the margins of the cleft tend to migrate into the grafted zone.
When this paper was given in Newcastle, George Joss suggested that the good results here might be explained by their accurate two-layer soft tissue closure of the alveolar space as described by Muir.

MATTHEWS

The articulate David Matthews, with Ivor Broomhead, orthodontist William Grossman and Henry Goldin of the Hospital for Sick Children, Great Ormond Street, London, reported in 1970 on early bone grafting in clefts over a seven-year period from 1962 to 1968. The patients were operated on at 3 months of age with the left seventh rib as donor area. The split rib grafts were notched to fit snugly into the alveolar gap and covered with a Stellmach flap. Then small spare pieces of bone were inserted below the alar base. In bilateral cases, which are operated on in two stages at an interval of three weeks, sufficient bone is taken for both sides, and half is stored subcutaneously in the chest wound for subsequent use. When the severity of the projecting premaxilla demands surgical retropositioning, Matthews encourages use of Denis Browne's "set-back" without concern if bolstered by bone grafts. These authors noted:

Preoperative orthodontics is of great value . . . . But it is not, of course, a passport to certain surgical success.

In 1976 Matthews forwarded this case (A. Position before orthodontics. B. After orthodontics. C. Eruption of teeth. D. Clinical appearance) and included the x-ray films to show the eruption of teeth along the line of the bone graft (E. Rib strut. F. Teeth erupting along the line of the graft). He explained his present stand:
I have used bone grafts in the neonatal period to bridge alveolar gaps for 16 years. A rib is used and it is inset as two struts after separating it longitudinally to increase the amount of cancellous bone exposed. Clearly, an alveolar strut cannot be the answer to the problem of maxillary collapse, but it has a value. It assists greatly the maintenance of the alveolar arch, preventing anterior overlap, and it provides a matrix into which tooth buds bordering the defect can migrate. In my series, this has occurred in 31% of cases. . . .

In order to achieve maximum advantage for the alveolar arch, it is necessary to position segments with preoperative orthodontics, so that the lesser segment cannot swing medially on the graft as a pendulum. It is probable that this preoperative manoeuvre has given me much better long-term maintenance of the alveolar arch than other workers have reported. The graft provides maintenance of the alveolar gap as well as the arch, but it cannot, of course, prevent medial displacement of the posterior part of the lesser segment. I have never thought it logical to fill the full length of the bony defect with bone for fear of reducing subsequent growth and expansion through childhood. In every other circumstance, a bone graft is used to cause a solid union and I am fearful of the long-term consequences of rigid union promoted in so young a child.
DELAIRE

The university town of Nantes, at the mouth of the Loire River in Brittany, is the site of Tessier’s medical school and the home of Jacques Delaire, a fine cleft surgeon. I had heard he was probably the foremost surgeon in France doing primary bone grafting in clefts and wrote to ask his present stand. This is his 1977 response, along with several of his cases showing results three and one-half years after cheilorhinoplasty and primary bone grafting (two stages in bilateral cleft):

1. I have not done any bone grafts since October 1975 (even though I continue to think that in certain cases they improve the quality of results of my operations), for the following reasons:
   — From 1969 to 1975, I adopted your technique of cheiloplasty associating it with a vertical bone graft (in front of the ascending surface of the maxilla), a more extensive subperiosteal dissection, and a primary rhinoplasty.
   — Since that time, I have used a similar technique without a bone graft, with a more extensive reconstitution of the transverse muscles, elevators of the nose and upper lip. The results thus obtained, without grafts, are about the same as those I was obtaining two years ago.

2. My oldest cases of bone grafts in cleft lip are sixteen (16) years old.
3. Altogether, the results that I have obtained with these grafts seem to be better than those where a graft had not been used. The preparation of the bed of the graft accompanied from the beginning by a greater periosteal liberation creating a vertical periosteal sac in front of the ascending maxilla, along with careful reconstitution of the floor of the nostril, may be responsible for some of the improvement.
4. There have been no systematic cephalometric studies, but these patients have been studied by the orthodontists on my service and have been
treated the moment any problem of occlusion manifested itself. In addition, I have developed a method of posterior-anterior extraoral traction using an orthodontic mask (1972) which prevents certain types of maxillary retrognathia.

5. The primary graft has seemed to me to diminish the vertical and transverse problems of occlusion: cross bite, open bite, and deep bite.

ALL THAT GLITTERS IS NOT GOLD

It would seem that to follow the principle of “replace missing tissue with similar tissue in kind—bone for bone, etc.”, early bone grafting of alveolar and hard palate clefts would be indicated. As it has turned out, the answer may not be so simple, and, after a discussion of donor bone, the arguments against early bone grafting will be presented.
18. Choice of Bone and Its Fate

As already noted, first choice of the bone graft donor area is not unanimous. Autogenous is preferred by most over homologous grafts, as stated by Stellmach in 1964:

Experiences with preserved bone were not successful since the bone graft did not survive.

Rib, iliac crest, tibia and vomer all have their champions. Yet there is argument even as to the type of graft and its placement.

**Rib**

Some surgeons prefer full-thickness while others split the rib and some insist on the addition of chips. David Matthews described a special tailoring of split ribs struts to fit into the alveolar defect. In the young, rib is thin and lean with very little cancellous bone; hence, probably, its reported partial absorption in early primary grafting. In general, costal bone can be spared without undue sacrifice since the rib will regenerate in its periosteal sleeve. With proper instruments, up to 60 cm. of rib, or 120 cm. of split rib, can be removed through a 5 cm. incision. Opening the pleura is a hazard that should occur rarely and can be handled with positive pressure anesthesia. Split rib is a good choice in bone grafting and has stood the test of time. Because there have been problems, including resorption, the work of Joseph Reichman, L. Kerr and L. A. Whitaker of the University of Pennsylvania, studying the fate of autogenous rib grafts in rabbits, is of interest.
The various types of rib graft were inserted into a subperiosteal pocket and the animals injected with vital dyes and then killed and examined. It was found that split rib with the marrow facing bone healed the best. Bone chips (1 mm. in length) were almost completely resorbed. Split ribs with the marrow in contact with soft tissue and full-thickness rib demonstrated poor healing and a high rate of resorption.

ILIUM

The crest of the ilium in the young offers poor material, and surgery here is considered by some surgeons a threat to growing centers. Georgiade, Pickrell and Quinn prefer cancellous bone from an area inferior to the iliac crest. They feel:

There is probably more rapid calcification with new bone formation when this type of graft is used.

The ilium offers an excellent source after the age of 10 to 12 years and especially in the adult, but the discomfort and general morbidity have been greater than with the rib.

Hogeman, Jacobsson and Sarnäs of the University Hospital, Malmö, Sweden, noted in 1972 that in bone grafts to the maxilla

The use of grafts from the iliac crest instead of from the ribs raised the frequency of successful operations from 34% to 58% and with subsequent addition of a buccal bar ["a spongy bone graft on the buccal side of the alveolar ridge to cover the defect"], to 98%.

In 1974 Schmid, Widmaier, Reichert and Stein expressed preference for compact and spongy layers of hip bone, stating:

Rib implants are considered less useful because of the small amount of bone and especially spongiosa obtainable in a small child.

Tessier’s method of harvesting iliac bone is described by S. A. Wolfe of Miami, who has used the method more than 100 times without complications of bleeding, infection or contour deformity, and with less discomfort.

The skin incision, about 5–6 cm. long, is made several cm. below the longer incision through iliac crest periosteum. Two oblique cuts reflect the lips of the iliac crest, behind the anterior superior spine, and periosteum is reflected
from inner and outer surfaces of the ilium. Tessier’s retractors fit perfectly to expose the central bone which will be harvested, and both cortical plates can be taken if needed. Extra cancellous bone is taken with a curette.

The site is generally drained with a hemovac, and the lips of the crest are wired firmly together. I have begun using a final wire to figure-of-eight these coapted lips to the intact anterior superior spine. A hole is made in the spine with an ice pick-like instrument (Walter Lorenz). The beauty of this method is that the hip is solid, there is no post-op movement of broken bone or torn muscle, and the patient can generally walk the first or second post-op day.

**TIBIA**

In young infants of pre-weight-bearing age, a medial, slightly curved incision, as designed by Johanson and Ohlsson, *Acta Chirurgica Scandinavica* 1961, gives excellent exposure of the tibial shaft, offering a large supply (50 cc. or more) of cancellous bone. A cortical segment is removed, and the desired quantity of cancellous bone and marrow can be taken and packed into the cleft. The line of incision, the tibial cortical segment chiseled free to be removed and the bone graft with extra bone marrow are shown. Radiographs of the tibia present the defect two weeks after removal of the graft with periosteal bone formation beginning and healing only three months later. Visible scars and the possibility of a short leg have reduced this donor area’s popularity.

**VOMER**

Vomer in the projecting premaxilla has an economic advantage but offers a limited supply. The chance of the surgeon’s being overzealous in this quest for bone might result in retropositioning of the premaxilla too far.

**SKULL**

In infants and children skull also is a source of bone for grafting. Under the age of 3, complete regeneration occurs even when large quantities of full-thickness skull are taken.
DESTINY OF THE BONE GRAFTS

Of course, the vascularity and functional position of the bed, the type of graft and its size all influence the destiny of the bone grafts.

Manchester of Auckland, New Zealand, stated in Melbourne in 1971:

I claimed many years ago and repeat today, that a bone graft takes and remains just as a skin graft does.

Ivy, paralleling the long life of his bone grafts and in just as good shape, stated in Montreal:

I saw one of my bone grafts the other day at Mount Dora and that is 48 years since it was transplanted! I maintain that once you get the bone graft into good position with a successful take, it will remain there in good shape and without change.

Joss and Broadway of Norwich, England, in 1966 made a three-month tour of European bone grafting centers under the auspices of the Council of Europe and reported:

In many of these centres the grafts, after a while, resorbed in the alveolar region, leaving only a small strut of bone joining the segments at the level of the nasal floor.

They therefore considered that the question of having teeth erupt into the graft had, perhaps, been overstressed.

This was like turning a pair of foxes loose in the chicken coop, and feathers and fur have been flying ever since. Johanson, a fighting cock of the coop, bared his spurs and attacked the intruders several years later:

I want to come back to this report of Joss, which I really thought was a very irritating one, where it was stated that in most of the countries he visited (among others, my own clinic, late at night) the primary bone graft, the onlay graft, just disappeared. I have never used, in my whole series, an onlay graft.

And still later:

It was said by Joss . . . that he never saw a case where the bone graft had survived or remained as a bone graft. All of them were absorbed, he said. We thought this was very funny, because in our series we had never seen a case
like this. We have never demonstrated a case to him, so we wondered where he got this knowledge.

Kriens of Hamburg accepted the challenge but noted that the process of bone grafting was still being improved. He described the evolution of the Schuchardt primary osteoplasty. First, a strong strut was used to hold the alveolar segments apart, but later partial resorption of the graft was seen. As Schuchardt and Kriens noted that small struts had a rare tooth bud making its way into the graft with subsequent alveolar collapse, they were stimulated to increase the amount of bone. As many layers as possible were inserted between the alveolar stumps, and the pocket was filled further with chips. Since transplanted costal bone has no inherent growth potential, intrusion of tooth germs was considered important. In fact, where a tooth bud entered the graft in about three months, resorption of the bone was no longer a problem. Kriens ended with a provocative teaser:

The effort to stimulate regional bone growth by the transplantation of epiphyseal cartilage may add another chapter to the story of primary osteoplasty.

At the 1969 Chicago Cleft Symposium, Colonel Haskell Gruber of the U.S. Air Force referred to his young series of 125 bone grafts:

We find that in a period of 6–8 weeks, the bone graft as such disappears, and then within a period of 12–20 weeks, you suddenly begin to see bone laid down. We feel that the organic salts are removed and the inorganic matrix remains and upon this base new bone is laid down. We have done a great many x-ray studies of these. We find we don’t have alveolar bone . . . we have maxillary bone . . . . Our oldest case is now 4½ years of age, and in the primary dentition, and the bone has remained.

Matthews responded:

I agree entirely with Colonel Gruber that this bone is not the bone that was originally put there. I think the orthopaedic surgeons settled years ago that this is a re-occurrence of bone on a matrix which was provided by the original graft.

In 1964 Stellmach had made a similar statement:

Autogenous bone becomes transformed with the first two years after grafting. The new structure is similar to the neighboring bone.
In fact, as early as 1961 Johanson and Rockert, using microradiography to study autogenous tibial and iliac bone grafts to the palate, contradicted Holmstrand’s 1957 findings that all evidence from study of bone grafts pointed to the replacing bone assuming the same ultrastructure as the original transplant.

Johanson and Rockert found that the excessive tissue of the graft was absorbed and not remineralized. The rest of the graft lost its original structure and was transformed to the same structures as adjacent palatal bone, showing good adaptation of the graft to functional demands.

As his concluding statement during the 1969 Chicago Cleft Symposium, Johanson reported having opened a six-year-old bone graft:

The area where the bone graft was looked exactly as if it was a non-clefted case.

Colonel Gruber then asked Johanson why he advised bone grafting after orthodontics and whether it had been successful with the permanent dentition resulting in good occlusion and arch alignment. Johanson answered:

We feel that when the orthodontist has finished his work and we add bone to the alveolus that you do not have to look at these cases any more from a prosthodontic point of view.

Tom Cronin of Houston, having given some of his bone grafting statistics, suggested that the method of grafting must be important:

When we just put in the onlay graft, we often seemed to have very little bone left later, but by putting in more bone in wedge grafts, the grafts seemed to remain fairly well as shown by repeated x-rays over several years.

David Matthews of London backed Cronin:

My bone graft is only put into the alveolar gap. It is indeed a strut or a wedge. . . . I found in 31.5% of cases teeth growing into the gap. . . . I would think it impossible for a dental follicle to grow into a static, well-established bone plate, but it can and does grow into this new bone, and I can show you pictures of the teeth growing into the bone.
BIOLOGY OF BONE GRAFTS AND FACTORS INFLUENCING THE SURVIVAL

S. A. Wolfe, craniofacial surgeon at the University of Miami, discussed the biology of bone grafts.

Transplanted bone survives. There is no doubt of this to anyone who has had the opportunity to reoperate in an area in which he has previously put a bone graft. Whether or not this is the same bone that was put in is still a matter of debate. It is likely that some of the individual cancellous cells with osteogenic potential do survive (Boyce), but it is also evident that one can put in only the mineral matrix, as in freeze-dried or boiled bone, and eventually have invasion and inhabitation by osteocytic cells. And just as there is constant turnover of cells and collagen in a skin graft, a bone graft is metabolically active and has constant cellular and matrix turnover. A good bit of work remains to be done with radioisotope-labelled cancellous bone to clarify exactly what is happening.

Factors important to maximal survival of the bone graft:

1. First, the type of bone used. There is a higher percentage of take (persistence of the volume of the transplant) with grafts which are largely cancellous, as opposed to cortical. Thus, a higher portion of an iliac graft can be expected to survive in comparison with a rib graft, since a larger portion of it is cancellous.

2. The bone graft must be solidly affixed to the recipient bony area. Grafts that are subject to motion at their point of contact with recipient area bone seem to fare worse than ones which are solidly wired in place. Split ribs in the infraorbital area do better if wired to the infraorbital rim, compared to those which are just laid in place; nasal bone grafts which allow some wiggle are often the ones which will have to be redone. There is some experimental evidence that split ribs do better if a layer of periosteum is left on the outer surface (but then the donor area will not do so well), and the cancellous surface placed against abraded donor bone, than if any other combination is used.

3. There should be coverage of bone grafts by periosteum if possible, and then cover by adequate amounts of soft tissue, not under great tension. If bone grafts are placed free in soft tissue, almost complete resorption can be anticipated. Considerable resorption also occurs if bone grafts are subject to pressure from tight, inadequate soft tissue cover.

4. The size and number of foreign bodies present should be minimized. It may take more skill in carpentry and ingenuity to obtain solid fixation without the use of screws, mesh trays, and cumbersome orthopedic plates, but these types of hardware interfere with vascular contact with the graft,
provide a nidus for infection, and are against basic principles. Solid fixation can generally be obtained with a few properly placed wires, interlocking "autoretentive" bone fixation, and occasionally a small Kirschner wire. If extrinsic support and fixation is required, it is better to use a few percutaneous screws in normal bone on either side of the bone graft, and then bridge across externally with acrylic.

5. Finally, in human beings there seems to be a "critical mass" of bone graft, even fresh, autogenous, cancellous, that can be expected to survive under the best of circumstances. A bone graft can exceed one cm. on two dimensions, but not three. If larger amounts of bone than this are required, surgery must be staged.

The difficulty obtaining adequate amounts of donor bone, and the pain and deformity often associated with taking bone in the past, have led to many efforts over the years to find an acceptable bone substitute: the evolution has been from ivory to Kiel bone to bank bone among biological materials, and from acrylic to silastic to proplast among synthetic materials. Certainly, there have been reported successes using all of these substances, but the failure rate is still high compared to fresh, autogenous bone, and the patient continues to be at risk from infection and rejection long after the procedure, at a time when the autogenous bone would have been incorporated into the skeleton and have the same defense mechanisms as normal bone.

Until the basic transplantation barriers are eliminated, as they eventually will be, efforts should certainly continue in developing and perfecting ways of taking autogenous bone, with as little difficulty, pain and deformity as possible.
19. Increasing Uneasiness among the Bone Grafting Troops but Increasing Interest in Late Grafting

This impressive Germanic gathering in front of the Royal College of Surgeons, London, in 1959 during the Second International Congress, is composed of various palate experts. From left to right are Steinhardt, Rosenthal and Trauner, and on the other side are Schmid, Schuchardt and Rehrmann. All are obviously still quite happy about early bone grafting. Yet against the almost arrogant avalanche of surgeons grafting bone primarily into alveolar clefts, there began to appear a scattering of skeptics even among the surgeons themselves.

Pruzansky’s Dissent

In 1963 at the convention of the American Cleft Palate Association in Washington, D.C., orthodontist Samuel Pruzansky leveled a provocative dissent from presurgical orthopedics and bone grafting implants in cleft lip and palate. He launched his attack by accusing an army of surgeons buttressed by orthodontists and prosthodontists:

Their battle cry is a cabalistic mumbo-jumbo invoking the mystique of embryology and growth and development.

Instead of research with documented results, he claimed,
We have been fed opinion, anecdotal pap, wishful thinking, and empirical trivia.

He gave as the basis of his dissent a longitudinal growth study of children with cleft lip and palate begun in 1949 involving casts, roentgenccephalometric, laminagraphic and other measures on more than 1,000 children from the time of their birth and explained he had no motive to support or fault any philosophy or method of therapy:

The only objective is to report the facts as they are!

and

Not all clefts are alike!

In a large series of complete unilateral clefts of the lip and palate, Pruzansky found 37 percent without crossbite and 40 percent with complete buccal crossbite on the affected side. The rest showed varying degrees of incomplete crossbite.

Since a significant number of patients do not develop cross-bite at all, is there justification for treating all patients by presurgical maxillary orthopedics and bone grafting?

He answered his own question:

In our judgment, there is none. Moreover, the malocclusion present in the preschool child can be readily, quickly and less expensively treated by simple expansion procedures.

He summed up the arguments for and against bone grafting:

For. Mesodermal deficiency.

Against. A static concept that does not allow for change as a function of growth and development.

For. Prevents malocclusion.

Against. Many cases do not need orthodontic treatment. The majority can be treated by conventional procedures.

For. Closes off anterior fistulae. Binds the segments and prohibits their orthodontic manipulation at a later age.

Against. Produces and maintains excessive width of the cleft posteriorly, a disadvantage to velopharyngeal reconstruction. Potentially hazardous operation (pleural puncture, pathological fractures of the tibia, scarred leg) not warranted for an elective procedure of dubious merit.
Pruzansky noted with irony that

nearly the same reasons invoked by Brophy for jaw-compression now seem perfectly suited to justify jaw-expansion.

In 1923 Brophy had been convinced

that an adult, growing up with a cleft palate, has not the full complement of tissue . . . as it has not been subjected to the uses for which it was intended. Besides, the tuberosities spread which contributes to the shortening of the palate.

But the error of Brophy's reasoning stemmed from his erroneous interpretation of the consequences of cheiloplasty in complete unilateral clefts:

Following closure of the cleft lip, the alveolar borders of the anterior extremity of the cleft, by reason of traction of m. orbicularis oris, gradually approach each other. . . . The malar bones act as pivots and the posterior processes, the tuberosities, move farther apart, and the cleft is widened.

Thus, on the basis of the "abnormal separation of the tuberosities" fallacy, Brophy formulated a method of approximating the separated bones prior to the closure of the lip.

Pruzansky argued that collapse of the arch can be treated easily with rapid, complete and inexpensive correction. To the claim that

Excessive medial movement of the maxillary segments . . . is an undesirable side effect of cheiloplasty and therefore should be prevented.

Pruzansky countered with

Collapse of the arches may be regarded as desirable in that it facilitates velopharyngeal reconstruction. Pre-surgical orthopedics inhibits such collapse and thereby may retard velopharyngeal correction at an early age.

Finally, the provocative Pruzansky took a sword swipe at the German orthodontists, devoted to promoting growth by profoundly stimulating development, for providing

soil in which pre-surgical orthopedics and bone grafting can take root and flourish.

In a dare worthy of a duel, he challenged them:
Instead of expending their energies in understanding more about the natural post-natal development of cleft lip and palate, they continue in search of the prosthetic or surgical touchstone that will transform cleft palates into normal palates overnight.

A Pruzansky conclusion:

When the adult dentition has erupted, and orthodontic treatment is completed at about age 13, then it becomes possible to determine whether that individual is indeed deficient in tissue mass at the alveolar process. In such instances, [1] endorse bone grafting. However, such cases seem to be in the minority.

At a social gathering in Pruzansky's suite during the 1963 international meetings, Owsley recalled that the "new" early bone grafting of the maxilla came into the conversation. Husky Bengt Johanson, a stalwart advocate of primary bone grafting, who often looms even larger than he is, got into a confrontation with feisty little Sam Pruzansky. They lined up eyeball to eyeball (Sam was standing on his bed) and Sam snarled to Bengt:

It won't work!

This was a prophecy.

SKEPTICISM OF THE ORIGINATOR

It is important to realize that E. Schmid, the surgeon who initiated maxillary bone grafting in the early 1950's, voiced skepticism when he wrote:

Besides, no experience is yet available to determine whether this procedure will be able to improve the results of cleft surgery. The procedure has merely been presented for discussion.

In his 1964 Gillies Memorial Lecture, Francis Burian of Prague questioned the value of the popular early bone grafting:

There is no doubt that this operation has a logical basis, for the graft supplies the bone tissue to fill in the defect, which is more or less extensive in total clefts. However, I have some doubts about this operation. A bone-graft must be applied to denuded bone. To lift off the periosteum of such young bone is a very delicate operation, especially on the poles of the
cleft, which are most important for the further growth of the maxilla. We must bear in mind that the growing potency of the parts of the maxilla is already weakened in clefts and additional harm may be caused, the consequences of which would appear only after many years. Besides, a bone-graft requires a safe and reliable bed in which it would be perfectly covered. In my opinion, there may be difficulties in achieving this. The taking of the graft itself undeniably imposes a further strain on the infant. . . . Results will become open to criticism only after at least ten years. Of course, in the case of an older child with a reconstructed lip, where all conditions are favourable, there is no objection to secondary bone grafting.

AN EARLY BONE GRAFTING LEADER BALKS

Johanson concluded in 1964 at the Hamburg Symposium that

The primary bone grafting in our hands has not prevented the bite to develop similar to what you will find in carefully treated series without bone grafting. The orthodontic correction of the deciduous bite has, however, been easy to perform, and the stabilization of the premaxilla in the double cleft cases has been of unquestionable value. As a result of our findings, we have now started a new series with every second case treated primarily and in the rest the bone grafting will be postponed until the time of the second dentition.

In 1964 S. Pruzansky and in 1964 and 1967 S. Pruzansky and H. Aduss compared the results achieved at Illinois without presurgical orthodontics and early bone grafting with those from Göteborg reported by Kling with presurgical orthodontics and bone grafting. The comparisons suggested, they felt, that Kling's findings were indeed much worse than those achieved by "less modern" methods, and Kling seemed to concur:

From the point of view of the bite, the results do not seem, at a glance, to differ much from those achieved earlier with less advanced methods of treatment.

In 1965 Johanson, in the Northcroft Memorial Lecture, reviewed over 100 cases treated with his early bone grafting during a 10-year period. The results were so disappointing, he concluded, that he had discontinued this method of treatment. Since 1968 his order of treatment has been changed to: first, a lip adhesion;
at 1 month, closure of hard palate with vomer flap; at 6 months, closure of soft palate; and at 18 months, closure of lip. Only at 12 to 18 years does he bone-graft the alveolus and hard palate. This is his regimen today.

Johanson is a vigorous Viking from Sweden who is intolerant of nonsense and smashes through mincing opposition. His favorite relaxation involves five to six hours of rowing in a small boat to Roslagen in the Baltic Sea. Carrying a 9 mm. rifle in a watertight tube, he slides out of the boat, wades through icy water and climbs onto rocks from which he can shoot 200 pound seals and lift them up onto land for skinning. He considers 10 to 15 a good day’s haul and reports that the meat is delicious, particularly the liver. I have seen him handle opposition in a congress as if he were shooting a seal—and in English, no less!

At the Second International Symposium on "The Early Treatment of Cleft Lip and Palate" held at Northwestern University Dental School in April 1969, Sheldon Rosenstein of Chicago’s Children’s Memorial Hospital, in response to the banter of those for bone grafting and those against it, asked for proof of good results at age 14 to 15 years by conventional methods. Chairman Richard Cole of the Lancaster Cleft Palate Clinic repeated a valuable refrain:

It strikes me again, however, that our concern is and should be making sure that we are now accurately and adequately documenting our treatment results through accurate measures.

This brought Bengt Johanson to his feet!

Yes. . . . I would say that that which started us with primary bone grafting and the new thinking of combining bone grafting with early orthodontic treatment was that results in the early soft tissue repair were not good. . . . We found when we had had about 10 years’ experience with primary bone grafting, that our results were much better and so we were very pleased. . . . Then these cases changed from the primary dentition, and we found that we really hadn’t gained that much. . . . Everyone here has shown different series of cases, some with orthodontics combined with bone graft, some with orthodontics without bone graft, and some with soft tissue repair only. We have seen that all of us can show very nice results depending on the given case. . . . I can show you beautiful cases with a bone graft, with teeth coming down into position and how with orthodontic treatment
the permanent dentition looked good. But I know in documenting the series which now parallels the bone grafted series that our results are much better today, without the primary bone graft, than they were when we started.

I still say that the bone graft will have a place, in the end, in the final handling of the total cleft. But everyone here is saying, "I just started; I want to find out, in my own group, whether primary bone grafting is good or not." For God's sake, go back and look through everything that already has been done. We don't have to go back and do these things all over again in every little unit in the world. We can use the publications and the information we have; we can rely upon each other.

In his latest follow-up study of children treated with primary bone grafting, Johanson, with Hans Friede in 1974, concluded:

In spite of the inherent fault of small numbers of patients and no actual controls these intermediate data on the effect of primary bone grafting point to the conclusion that this method did not result in the expected normalisation in the growth of the middle face and the jaws. On the contrary our results seem to be inferior to those reported for cleft patients subjected to neither early jaw orthopaedics nor primary bone grafting.

The bone graft of the anterior maxilla healed in every instance but it resulted in an abnormal maxillary development with increased frequency of both lateral and anterior crossbites.

The local and general maxillary growth retardation gave our cleft patients a pronounced maxillary retrognathia which increased with age. When full grown, the facial profile of our patients will frequently be concave; in many cases to such an extent that we cannot recommend primary bone grafting. In our Center this treatment method has not been carried out on cleft infants since 1964.

Also in 1974, Bengt Johanson gave a follow-up on his secondary bone grafting. He had 125 cleft patients (21 bilateral and 104 unilateral) with the mean age of 20 years at the time of bone grafting. The follow-up interval after bone grafting varied from 3 to 14 years (mean interval 7.5). Ninety-three patients were available for final evaluation; with the exception of six of these, all had postoperative orthodontic treatment.

At surgery, particular attention was paid to the filling of the cleft in the alveolar process and hard palate. For at least one year after surgery, a removable retainer was used until permanent prosthetic construction had been completed.
The bone grafts healed in 96 percent of the cases. In 12 patients pinhole-sized fistulae remained. A slight degree of relapse after orthodontic treatment was noted. The cephalometric values indicated maxillary as well as mandibular retrognathia. Even if many of the patients showed straight or slightly concave facial profiles, normalization of the anterior occlusion had occurred by means of the moderate retroclination of the lower incisors without overexpansion of the maxilla.

It was concluded that bone grafting of the alveolar process, and the palate in the adult, normalized and stabilized the maxilla in practically all instances.

**DERICHSWEILER AND OTHERS**

In 1958 Hans Derichsweiler of Munich reported early orthopedic treatment before bone grafting. At the Hamburg Symposium in 1964, it was reported that Derichsweiler found 90 percent severe malocclusion after bone grafting in 30 bilateral clefts at age 6 months. His cases without grafting revealed a similar percentage of malocclusions, which led him to conclude that bone grafting may have other merits but the prevention of severe malocclusion is not one of them.

In 1965 J. Chalmers of the University of Liège reported work on growth of grafted bone, showing that bone grafts reveal virtually no capacity for growth unless they are subjected to great stress. Only bone transplanted with a cartilaginous growth center will show growth.

In 1966 P. Baumgartner and B. Maeglin questioned the possibilities of detrimental late results following early osteoplasty of the cleft alveolus. They wrote:

> Since a graft does not ordinarily follow body growth after transplantation, it would be conceivable that ossification of the cleft could invite impairment of growth of those bony parts in the cleft area joined by the transplant.

In 1967 S. Stenström and B. Thilander of Umeå University, Sweden, reported experiments with bone grafting in guinea pigs. Half of their animals had excision of the maxillopremaxillary suture followed by insertion of an iliac bone graft. Growth was studied by radiographs and subsequent examination of the skulls.
The cleft but ungrafted jaws grew symmetrically and equally compared with normal controls. The skulls of the grafted animals were asymmetrical and showed limitation of growth.

The dynamic Kenneth L. Pickrell of Duke University, who trained with the pioneer John Staige Davis at Johns Hopkins University Hospital from 1937 to 1940, recalled that time as the era of ether and horsehair. In 1968, with G. Quinn and R. Massengill, he gave a typical no-nonsense evaluation of 25 infants followed for a minimum of four years. Although partially conflicting with the findings of others, they summarized their stand quite bluntly:

1. Primary rib grafts in the maxilla do not increase in size concomitant with facial growth and development.
2. Teeth do not migrate and erupt spontaneously through a rib bone graft.
3. Rib bone grafts do not form a true alveolar process; a permanent alveolar notch remains.
4. The orthopedic effect of the bone graft decreases as its incorporation increases.

The late J. J. Longacre of Ohio, long devoted to his favorite sport of splitting ribs, might have been expected to jump at the chance to insert a few of his grafts as early as possible. Such was not the case, for in 1970 he indicated reservations at least in the time of the bone grafting. His recommendation for patients with a bony deficit follows: An early retainer is to be used until deciduous teeth erupt, when an expansion appliance is in order. At 4½ to 5 years, a bone graft with split rib is inserted, and the maxillary segments are maintained in position until the bone graft is consolidated. Six months later, a V-Y palate closure is followed by further maintenance of expansion until molars erupt.

REHRMANN CALLS A HALT TO EARLY BONE GRAFTING

A most important result, because of its status as the study with the longest chronological interval between surgery and reexamination, was presented by Rehrmann, Koberg and Koch at the
International Cleft Palate Congress in Houston in 1969. The able and untiring Alfred Rehrmann, a classical musician and violin maker, was a student of Wassmund in Berlin for three years. He then became an assistant to Schuchardt in Berlin, served in several maxillofacial units during World War II and finally rejoined the dogmatic Schuchardt in Hamburg for seven years. Having been regimented in the ways of the Hamburg primary osteoplasty, Rehrmann carried on this work, but with comparative controls, when he became professor of the Westdeutsche Kieferklinik, University of Düsseldorf. With Koberg and Koch, he evaluated and analyzed statistically the long-term follow-ups of primary and secondary bone grafting in infants and small children over a 10-year period. Two groups consisting of 50 children each were compared. In the bone-grafted group, 40 children had a primary osteoplasty, 34 percent with a Stellmarch flap. The other 66 percent had a surgical procedure using Veau-Axhausen for the nasal lining and Burian-Trauner for the oral lining. The remaining 10 children were grafted secondarily at a mean age of 4.5 years. In the control group the alveolar cleft was closed according to Veau-Axhausen, but in 16 percent a simultaneous Pichler flap was used to close the hard palate, while in 84 percent the mean age at hard palate closure was 4.5 years. All the subjects had LeMesurier lip closure. Forty-seven percent of the bone-grafted group had orthodontia as compared to 48 percent of the controls.

Bite relations in all three dimensions of those cases in which the Stellmarch tilted vomer flap or the septal mucosal flap of Pichler was used were not worse than those using the Veau-Axhausen method. Rehrmann concluded:

The use of a very great part of the septal mucosa does not influence the forward directed development of the maxilla.

After comparing the bone-grafted cases with those without grafts, Rehrmann drew further conclusions:

Bone grafting in the area of the alveolar processes does not bring about permanent stabilization of the segments. Lengthening of the bony bridge was never observed. . . . Contrarily, the inserted bone becomes shorter over the years. . . . The frontal ends of alveolar processes conjugated by bone are
rather retarding in their development in all three dimensions. . . . The resulting bony bridge . . . keeps these ends of the alveolar segments together comparable to a claw. . . . Malocclusions of grades 2 and 3 in the sagittal and horizontal planes were prevalent in the grafted group in high significance in comparison with the ungrafted group. Therefore, it must be concluded that early bone grafting in nearly all of our cases provokes retardation in development of the maxillary arch and local growth arrest of the maxillary bone. For that reason, we have abandoned primary and early secondary bone grafting and limit osteoplasty to the time after secondary dentition.

After over 40 years’ experience, he wrote in 1971:

We must confess that the disfigurations mostly are the consequences of the surgeon’s work. To unite the segments in a very early age means to connect the segments—more or less—by a bar of scar tissue hindering the tiny baby’s maxilla to expand to an adult width and form. In addition: damaging of tooth germs, depriving the segments of their periosteum, especially of its anterior ends, brutal "realignment" for achieving an instant normal shape, and last, the bridging of the cleft by means of bone transplantation are highly responsible for the undesired results.

My compromise is as follows: . . . bridging of the alveolar and palatal part of the cleft should be made with the cranially pedicled mucosa of the septum by tilting it over the cleft and incorporating its edge into a pocket. The anterior ends of the segments should never be touched or denuded. The premaxilla should never be repositioned by surgical means. . . . The remaining velar part of the cleft is closed at 2 years utilizing bridge flaps and elongation of velar mucosa by Z-plasties.

At the 1969 Cleft Palate Symposium held in Chicago, foxy Mazaheri of Lancaster challenged Cronin of Houston, known to have championed early maxillary bone grafting:

Dr. Cronin, you mentioned that you had 11 bilateral cases and that out of the 11 you had 8 who had crossbites in terms of maxillo-mandibular bite. Are you saying to us that this is a good result, or a fair result? Does this show that you are achieving a better result in terms of maxillo-mandibular relationships as compared to those which most of us show without any early bone grafting or orthopedic therapy?

Cronin responded:

No, aside from stabilization of the free-floating premaxilla, I think that is the only part that is really good. As to the rest of it, I don't think it is any
better. In all our cases the orthodontist has been able to achieve a good occlusion, but whether we have helped him any by these early procedures is open to question.

Mazaheri countered:

I believe in our experience that the major difficulty with these patients has been the scar tissue which is created by denuding the bone.

This comment reopened the "old wound" about the consequences of maxillary wounds and the subject was met head-on by Johanson:

I think the healing process that you get when you resurface that denuded hard palate with secondary epithelium is not a type of scar tissue in the same respect as the scarring of raising a mucoperiosteal flap and replacing it, which is followed by scarring and shrinkage.

David Davies of South Africa concurred:

It is a great mistake to compare the scarring of skin and scarring of a denuded area inside the mouth which behaves in a different way . . . and 14 days later, the whole anterior palate is healed. . . . It is hard to imagine that a large amount of scar tissue has been laid down, since the healing period is too short.

Skoog, in his 1974 book, noted the animal research of Engdahl and Hellquist and pointed to the deformity developing after subperiosteal maxillary resection and bone grafting. He concluded:

This investigation clearly demonstrates, that within a standardized maxillary defect, the bone produced by bone grafting behaves quite differently during growth than the bone which regenerates from a periosteal lined cavity that has been filled with blood. These observations may well explain the unfortunate results of primary bone grafting in infant clefts.

He then summarized and condemned early bone grafting with three sentences:

To restore maxillary continuity bone grafting techniques were implemented at early ages (Nordin and Johanson 1955, and Schmid 1955). Bone positioned in this way, though providing immediate stability, did not develop with the child (Thilander and Stenström 1967, Friede and Johanson 1974, and others). When retardation of facial growth became apparent this method of treatment was widely abandoned.
Pediatric surgeon Ambrose Jolleys of Manchester recalled in 1977:

At the Royal Manchester Children's Hospital, I worked with a general surgeon who then did the cleft lip or palate work and I became involved deeply in this depressing subject. I was concerned about the possibility that the surgeon aggravated the problem by his surgery and became interested in the possibility of pre-operative orthodontic procedures. After more training under Sir Denis Browne and David Matthews at Great Ormond Street, I returned to Manchester and with Professor Robertson have tried to evaluate the place of bone grafting and correct timing of palate surgery.

In 1972 Jolleys, with N. R. E. Robertson of Cardiff, reported a five-year study of early bone grafting in complete clefts of the lip and palate. At 3 months, after presurgical orthodontic treatment, closure was achieved for the lip, the anterior palate with a mucosal flap and the soft palate with a Wardill two-flap method. A retention plate was inserted until 11 months, when the hard palate cleft was closed and the plate returned until 21 months. In the experimental group, split rib grafts were fitted horizontally into the alveolar gap and surrounded by chips between the ages of 12 and 15 months.

No clear advantageous result could be detected in the grafted group. A notch remained in the cleft area and the grafted bone was insufficient to support a tooth in normal position.

On the other hand, limitation of growth occurred in the upper jaws in the graft patients and was manifested by reduced antero-posterior development, an increased incidence of crossbite, and a reduced area of upper jaw.

Evidence is presented that this deleterious effect became worse between the 4th and 5th years of age, and appears to be due to the presence of bone.

Bone grafting in young patients has been abandoned.

In 1972 Karl-Erik Hogeman with S. Jacobsson and K. V. Sarnäs of Malmö reported a follow-up of 145 cleft patients after secondary bone grafting. In some of the early bone grafting, they noted, the operation was successful, but clinical and radiographic review showed a deepening of the groove, indicating that the growth of the graft had not kept pace with the adjacent alveolar bone. They concluded:

Today we refrain from early operations . . . and now do not operate on patients below 12 years. In our experience, secondary repair with bone graft
has proved a safe and effective method for securing stable occlusion with improved lip appearance.

Charlie Horton of Norfolk, who had shown an interest in primary bone grafting, wrote in 1971:

Even if bone grafts do not prevent collapse, they help improve the nasal contour, the tooth environment and provide a symmetrically growing base for the child. I never was a proponent for a primary bone graft, and I still feel that bone grafts in later ages are worthwhile.

In 1973 Franz Härle and Jürgen Düker of the University of Freiburg, West Germany, following comparative clinical investigation of children with unilateral clefts, found worse occlusion in the group with osteoplasty. Animal model tests in young inbred rats showed that the growth of the maxilla was significantly hindered if a bone defect similar to a unilateral cleft was simulated. Maxillary growth was severely, and in a statistically significant manner, impeded if the defects were filled with autogenous bone grafts. From clinical follow-up and animal experiments they concluded:

The logical consequence of our investigations is to abandon primary and early secondary osteoplasty. . . . The only possible osteoplasty in cleft surgery is a late secondary osteoplasty. . . . The operation should be done after the second dentition and after development of the mid-face, i.e., after the age of 15 years.

In 1973, at the International Congress on Cleft Palate in Copenhagen, Wolfgang R. Koberg of the Rhinisch-Westphalian Technical College, Aachen, West Germany, renounced emotion and passion during discussion of early bone grafting and promised to discuss it purely factually, fairly and tolerantly. His last paragraph was pithy:

The first, and unfortunately to date the only exact report on late results following primary and early secondary osteoplasty in the cleft alveolus was made on the basis of a large group of patients and confirmed with statistical data and presented in Houston in 1969 (Rehrmann, Koberg and Koch 1970). In this oldest and (with 70 bone grafts) the largest group, it was possible, by comparing alternating rows, to show that after bone grafting in X²-test, moderate and most severe dysgnathia predominated highly significantly in
the sagittal and transverse directions on the side of osteoplasty in children. We have incriminated our osteoplasty for these alarming results of iatrogenic arrest of maxillary development, and have therefore abandoned primary and early secondary bone grafting. Similar decisions were also taken by Hollmann (1964), Hollmann and Tomasoni (1965), Perko (1966, 1969), Manchester (1969), Mazaheri (1969), and Hogeman and Jacobson (1972). The cited disappointing late results were consequent upon osteoplasties which were achieved according to the principle of the Dusseldorf group (Rehrmann 1964, 1967, 1971; Schruder and Stellmach 1958, 1959, Stellmach 1958, 1959, 1960, 1963, 1964, 1965, 1966, Schmid 1967). We have been waiting for the past 5 years for the late results of other large cleft centres (Hamburg and Stuttgart) (Koberg and Veneziani 1969), in order to make a definite statement as to whether it is only a question of difference in operative technique (Pfeifer 1972) or whether the grafted bone does actually hold the anterior ends of the segments together like a claw and thus stifle their intrinsic growth potential (Koberg 1970). Our long-term results were recently fully confirmed by Härle (1971) on the basis of extensive clinical investigation and additional animal experiments. Consequently, most severe maxillary deformities are to be expected as late results of primary bone grafting, so that late secondary osteoplasty remains as the only justifiable form of bone transplantation in cleft surgery.

**BONE GRAFTING AT 5 YEARS**

Impressed by his observations in India, that

the maxilla of adult cleft patients who had not been operated upon showed normal growth and form,

Wilfried Schilli of the University of Freiburg, West Germany, began a research study. At the 1973 International Congress on Cleft Palate in Copenhagen, Schilli, with G. Komposch and G. Munker, reported a study of 34 complete cleft palate cases in which rotation-advancement of the lip and Veau closure of the nasal floor were done at 3 months, Campbell closure of hard palate and Schilli modification of Widmaier method for the soft palate at 3 years. At age 5 with the aid of orthodontia when necessary, the arches were symmetrical. At this time half of the patients had their alveolar arches stabilized with autogenous pelvic bone grafts. First comparative study at 7 years of age revealed a slight tendency to underdevelopment of the entire
maxilla in all three dimensions, and deviation of the middle line to the grafted side was significant. At age 9 there was more evidence of disturbance:

90% need orthodontical treatment whereas the control-group after the Vomer-flap-operation only in 14% need orthodontical treatment.

Stellm ach of Berlin noted in 1976:

Primary bone grafting in the average case did not show permanent improvement of the late orthodontic results nor could the necessity for later orthodontic treatment be minimized as expected beforehand. With the exception of severe hypoplasia, we postpone bone grafting to the end of the second dentition and maxillary growth.

In 1965 J. B. Lynch, Steve Lewis and Truman Blocker of the University of Texas, Galveston, reported 92 cases of maxillary orthodontics and early bone grafting. They commented:

The value lies not only in stabilizing the maxillary arch and in orthodontic correction, but in providing a mass of bone into which permanent teeth may migrate spontaneously or may be moved orthodontically.

By 1977 J. B. Lynch, now at Vanderbilt University and occasionally enjoying flushing dove, duck and quail from the Tennessee bush was expressing second thoughts:

During the wave of enthusiasm for early maxillary bone grafting in the early sixties, I was involved in over 300 cases. Follow-up of these patients has indicated that presurgical orthodontia and bone grafting has not uniformly prevented maxillary arch collapse, nor has it eliminated conventional orthodontic treatment. The bone graft itself tends to become quite thin and attenuated in the majority of patients. With the exception of an occasional bilateral cleft with a very unstable premaxilla where stabilization with bone graft might be of some benefit, I do not believe that maxillary arch repositioning and bone grafting in infancy accomplishes anything that cannot be better done when the child is older. I do, however, feel that the earlier orthodontic involvement in the care of these patients has had a beneficial impact.

Howard Aduss, orthodontist at Abraham Lincoln School of Medicine, University of Illinois at the Medical Center, Chicago, threw a staggering block against primary bone grafting at the Cleft Palate Symposium at Duke University in 1973. He summarized:
It would be remiss to omit an assessment of the current status of presurgical maxillary orthopedics and bone grafting. On the basis of reports by Rehrmann and co-workers after a five-year follow-up and Jolley's and Robertson after ten years, it appears that presurgical maxillary orthopedics continues to be employed to align segments to facilitate repair of the lip, but bone grafts have not provided the stabilization that has been hoped for; bone grafts have not decreased the prevalence of crossbite; and the grafts have provoked retardation in the development of the maxillary arch and local growth arrest of the maxilla. As a result of their findings and those of others, both Rehrmann and his group and Jolley's and Robertson have abandoned the use of primary bone grafts for infants and children.

**EARLY BETTER BUT LATER BEST**

At the International Cleft Palate Congress in 1969 in Houston, Bill Manchester of Auckland, New Zealand, accused bone grafters of having all been led up a blind trail.

David Matthews of London, at the Second International Symposium on Early Treatment of Cleft Lip and Palate, held later that same year in Chicago, took Manchester's stand to task:

This seemed to me to be a most improper remark, however well-intentioned it might have been.

He continued to defend his own position:

The best craftsman that I have ever seen in this work was Tommy Kilner, and I spent a good deal of time as his junior. But as time went by I spent a good deal of time trying to correct some of the quite disastrous consequences of some of the most beautiful operations that he had done. Consequently, I am most reluctant to agree that if we went back to these early methods we would get better results than they did. At any rate, for these reasons, in 1960, I started doing early bone grafting.

Matthews spent several years experimenting and modifying. Always in the front line and with great technical skill himself, he probed the possibilities of early versus late bone grafting. In 1970, after seven years of experience, he reported, with Broomhead, Grossman and Goldin, his results.
Preoperative orthodontics was begun within the first two to three weeks of life. In severe premaxillary protrusion, a Denis Browne type of setback was used. Matthews feels that the end result was not prejudiced by this radical operation provided the setback was backed up by bilateral bone grafts. In his early grafts, notched split rib grafts were inserted at 3 months of age into the alveolar gap in front of a Stellmach flap, small spare pieces being placed below the alar base. The survey included 84 cases with radiographic evidence of bone graft survival in 88 percent and teeth moving into the area of the graft and erupting in 31.5 percent. Perfect occlusion was found in 13 percent, perfect occlusion after minor orthodontics in 47 percent, failure resulting in maxillary collapse in spite of evidence of the bone graft in 14 percent and small arch requiring further surgery in adolescence in 25 percent. Possibly seeing the handwriting on the wall, Matthews wrote:

If primary bone grafting is ultimately abandoned, it will be because the long-term results do not justify it; not because of technical hazard.

ENTHUSIASTIC ABOUT LATE GRAFTING

In the late grafts the technique of "rapid expansion followed by bone grafting" was used as first reported at the International Congress in Washington, D.C., in 1963 by Matthews and orthodontist William Grossman. Sectional cap splints were applied to the parts of the maxilla and connected by a Fischer expansion screw set in acrylic. In unilateral clefts, a single screw was set transversely to expand the two segments; in bilateral cases, a second screw was set at right angles to the first to move the premaxilla. As Matthews remarked:
The secret of orthodontic success is the rapidity of the expansion.

Expansion was completed in two to three weeks with a turn of the screw three times a day. The segments were slightly overexpanded in younger patients in whom growth was not complete. Following expansion, a thin graft of iliac bone carrying periosteum was wedged well down into the alveolar gap between nasal and buccal mucosa after closure of any preexisting fistula.

The bone graft extended back the full length of the hard palate and forward to support the alar base. The extension apparatus was maintained for seven weeks for consolidation of the graft, then a removable appliance was used for three months and finally a denture or fixed bridge was fitted. Although the first cases were undertaken at 10 to 12 years of age, Matthews in 1976 preferred to wait until 18 with the intention of setting the maxilla in occlusion with the fully developed mandible for permanent adult relationship.

Where rapid expansion and bone grafting failed to obtain normal occlusion because of retroposition of the maxilla, maxillary osteotomy was advocated six months after insertion of the graft. This action involved section of septal bone and cartilage close to the nostril floor and division of the pterygoid plates and lateral maxillary walls at the level of the antral floor.

Of the 55 cases, 74 percent have remained in perfect occlusion and 15 percent have shown only minor degrees of lingual occlusion. In 10.5 percent there has been relapse, and thus these were considered failures.

In 1976 Matthews reviewed his position on rapid expansion in the teenage patient and included this case example:

Bone grafts are still used in cleft cases to maintain the maxillary segments in correct occlusion in a teenager, after rapid expansion with segmental cap
splints and distraction screws. The object of this operation is to restore the collapsed maxilla, after growth has taken place, by producing solid bony union through the full length of the bony defect. In 1969, I reported 50 successful cases out of a series of 55. In 1974, I reexamined the successes and have found that the position has been maintained.

It seems, therefore, that it is reasonable to claim that this procedure does restore permanent normal occlusion. An important additional benefit is the restoration of a patent airway.

In 1972 Norman R. E. Robertson of Cardiff and J. Fish of Manchester reported their experience with 40 cleft patients, 8 of them bilateral, who had had the clefts closed in infancy. Forty-eight bone grafts following rapid expansion technique of Matthews had been carried out between the ages of 3 years 6 months and 11 years 6 months, by means of cap splints with expansion screws and rib bone grafts. Robertson and Fish concluded:

1. Later bone grafting after preliminary rapid arch expansion does not prevent collapse and the recurrence of crossbite in the buccal segments.

2. The degree of collapse occurring may be related to the tension in the soft tissue of lip and cheek.

3. Over expansion might prevent relapse occurring but it is suggested that the method described is of limited value when considered in relation to the production of a better occlusion.
The later bone grafts remain in situ and do not cause interference to the antero-posterior growth in the maxilla. This may be related to the fact that not a great deal of antero-posterior growth is occurring at the ages studied.

They acknowledged:

This is contrary to the claims made by Matthews and Grossman for their series.

**Bone Grafting at 12 Years**

In 1977 at a Cleft Symposium in Chicago, John Owsley of the University of California, recognizing the difficulty of early bone graft take and expansion, advocated maxillary bone grafting as a later stabilizing effect. At 12 to 13 years, when the patient is unwilling to wear a retention plate any longer and hence promises a propensity for crossbite, he advocates insertion of a bone graft. Using a split rib, a cortical wedge inserted into the cleft along with packing of cancellous chips, he constructs his stabilization of the maxillary arch. This is splinted with a lingual arch wire with spring expansion to throw stretch stress on the bone graft.

**Present Stand**

Early placement of bone into a bony defect seems sound, but evidently there are other factors involved: (1) Not all clefts require bone grafting; (2) traumatic surgery in the area of young growing bone may affect subsequent growth; (3) scar or bone graft rigidity may retard growth. Yet a number of surgeons still favor primary bone grafting into the cleft followed by orthodontics to maintain arch position. The majority, however, seem to feel that, as this surgery does not invariably prevent crossbite and may retard maxillary growth, it is best postponed until after complete facial growth and permanent dentition!?
20. Periosteal Flaps and Grafts

or "Boneless Bone Grafting"

It is interesting to note that Francis Mason of London, in his 1877 book *Harelip and Cleft Palate*, wrote:

The great advantage that Langenbeck claimed for the separation of the periosteum was that the new palate is composed of bony substance. "The osseous formation," he remarks, "takes place about the third week after operation. It is completed at the end of the fourth week and afterwards attains considerable solidity." He tested its strength by trying to pass a needle through it and believed that ossification had really been effected. Doubts, however, have been thrown on this point, for it was supposed that the toughness was due merely to cicatricial tissue.

M. Marmy experimented with this operation in dogs' palates and found that, although union was exceedingly tough and almost as hard as bone, no true osseous tissue was formed. M. Ollier clarified the issue:

If there may be doubt as to ossification, all must admit that it forms a very resisting surface which has the strength and takes the place of bone.

In 1909 in Cleveland, at a meeting of the American Society of Orthodontists, a presentation was made by Wayne Babcock on osteoplastic operations for the correction of deformities of the jaw. Robert Dunn then asked an interesting question:

Orthodontists are frequently required to correct cases of malocclusion where the operation for cleft palate has already been performed and there has been a failure in getting union in the anterior portion of the cleft. In the operation that follows there may be some opening of the cleft. Does Dr. Babcock consider that bridging the gap with a flap or periosteum would result in a restoration of bony union?
It was almost 60 years before attempts were made to answer this question.

SKOOG

In the shadow of picturesque twin cathedral spires, Tord Skoog of the University of Uppsala, Sweden, compact in stature, always demonstrated evidence of the quiet, controlled drive and strength that once made him a Swedish national 400-meter runner. It was his good fortune to produce lovely twin daughters, both of whom were 400-meter runners for their national track team.

Although still using rib bone grafts in alveolar clefts in 1965, Skoog noted at the Second Hamburg Cleft Palate Symposium in 1964:

One interesting observation may be mentioned from our series on maxillary bone grafting. In a case which had not been grafted, and in which collapse had occurred following soft tissue repair, a substantial bone bridge developed spontaneously between the premaxilla and the lateral maxillary segment during expansion. The explanation may be that in the first operation the periosteal membranes had united across the cleft. This may indicate that the function of the grafting procedure is mainly to provide a framework along which periosteal continuity between the maxillary segments is restored.

During the same symposium Professor Gerhardt Steinhardt of the University of Erlangen-Nürnberg responded to Skoog’s observation:

In the last month I visited the clinic of Professor Oberniedermayr in Munich. In conversation, Dr. Singer, his first assistant, told me of an interesting case of bone union similar to what Dr. Skoog told you about just before:

In a double cleft lip and palate operation the transplanted bone was lost by infection after 14 days. In any case bone consolidation occurred. My question: Is bone grafting a real transplantation or only a stimulation?

As chairman of the Symposium, Professor Schuchardt closed this discussion with

As far as I know, Dr. Singer, first assistant to Prof. Oberniedermayr, uses routinely in cases of double sided clefts vomerine bone for the osteoplasty which he places only in one side. To do this he has to dissect the periosteum
from the bone. Parts of the periosteum might act as a stimulation for the bony union.

Besides this we know that in a favourable osteoplastic milieu, every mesenchymal tissue, even organized haematoma, and scar tissue can lead to bony tissue.

Then in 1967 Skoog reported, in the *Scandinavian Journal of Plastic and Reconstructive Surgery*, the use of periosteum and Surgicel for bone formation in congenital clefts of the primary palate. This principle has become known as the "boneless bone graft."

In the same year and not far from the Coliseum in Rome, with the front stage of the main auditorium of the Hilton as the prize ring and the Fourth International Congress as cheering spectators, an impromptu world's heavyweight "cleft alveolar" title fight erupted. In one corner was Karl Schuchardt, a champion of bone grafters. In the other corner was Tord Skoog, defender of boneless grafters. Schuchardt, the puncher, got in a few heavy blows, while Skoog, the boxer, jabbed and danced for points. The match was stopped after the first round and declared a draw for lack of sufficient evidence.

Skoog continued his work and in 1969 stated:

This surgical procedure is based on three main premises:

1. The periosteum covering the maxillary segments possesses normal growth potential.
2. Denuded bone in this area will regenerate normal periosteum similar to other bones.
3. The re-established interaction between growth centers on the medial and lateral sides and the biomechanics of the soft tissue environment will determine the growth and development of the united maxilla.

Skoog's operation involved subperiosteal exposure of the bone bordering the cleft and the establishment of periosteal continuity
between the maxillary segments across the cleft, utilizing local flaps of the periosteal membranes.

The nasal closure is obtained with standard mucoperiosteal flaps elevated from the sides of the cleft, both superiorly based. The oral covering flap of periosteum is taken from the external surface of the maxilla, based superiorly and medially near the infraorbital foramen, and is transposed 90 degrees over the anterior alveolar portion for the two-layer closure.

To add to his ammunition, Skoog demonstrated experimentally, in rabbits, bone formation in a subperiosteal hematoma beneath the periosteum of the nasal bone. He elaborated on his plan to stimulate even more bone formation:

The average result utilizing periosteum alone for repair of the complete cleft is a fairly narrow and thin bridge of bone. . . . In order to secure more bone formation . . . Surgicel® (oxidized regenerated cellulose) was used as a matrix . . . as a scaffolding to keep the periosteum in the desired position and to maintain a hematoma in the area.

Since obtaining a watertight periosteal pocket is difficult, Skoog formed the periosteal pocket at the time of lip closure (3 months). The second stage was performed 3 to 15 months later with an incision through mucoperiosteum down to the newly formed bony bridge and dissection of a pocket into which Surgicel was packed. Careful closure completed the procedure. Skoog even advised combining periosteoplasty with implantation of Surgicel during primary closure of incomplete clefts of the lip but found local edge periosteum adequate for a pocket.

One reaction Skoog received from his periosteal flaps, besides the formation of bone spicules, came from Johanson. In reference to bone absorption in grafts, Johanson remarked:

Incidentally, Tord Skoog used this report of Joss to justify his implantation of synthetic material to replace bone. We thought that it would be interesting to open up the graft in one of our cases to see what had happened. . . . I did this in January of this year, about six years after the bone graft, and the area where the bone graft was looked exactly as if it was a nonclefted case. I hope that Dr. Hellquist communicates with Tord Skoog so that he gets this information, because I have not been very successful in this regard.
In his superb 1974 book, *Plastic Surgery: New Methods and Refinements*, colorfully illustrated and beautifully written, Skoog presented an extensive review and defense of his "boneless" bone grafting. He noted that Ollier, one of the pioneers of free skin grafts, in 1867 clearly demonstrated the osteogenic capacity of the periosteum. Yet two clinical observations started Skoog toward developing the technique of periosteoplasty. (1) A maxillectomy on a 4-month-old child with melanotic progonoma left the periosteum in place. Complete bone regeneration was confirmed by x-ray studies two years later, revealing normal maxilla except for missing teeth. (2) A complete bilateral cleft operated on in 1957 with soft tissue closure formed new bone spontaneously within one of the two clefts. This occurrence was interpreted by Skoog in 1966 as the result of periosteal membranes, unintentionally united across the cleft at the primary operation and subsequently forming solid bone.

Skoog acknowledged:

Criticism of this technique of maxillary reconstruction has reflected anxiety about operating on the juvenile maxilla. Fear of endangering future development has engendered this feeling.

He then hastened to point out:

In a study, using implant techniques, Björk (1966) confirmed that the anterior portion of the maxilla was never a growth site. There is thus little to suggest that maxillary development would be iatrogenically impaired when performing a periosteoplasty.

Swedish researchers were stimulated to study the possible effects of periosteoplasty on maxillary growth in animals. In 1972 E. Engdahl, using 300 rabbits aged 2 to 3 weeks, performed unilateral maxillary resection varying the position of the periosteal lining and the material used to fill the defect (blood clot, bone marrow aspiration). In 1974 Skoog interpreted the results:

This series of experiments shows that the maxillary periosteum possesses an osteogenic capacity capable of completely regenerating bone.

Also in 1972 R. Hellquist, using more than 100 growing rabbits and guinea pigs, studied the effect of removing the
periosteum from the facial bones. An example of an adult guinea pig demonstrated normal bone growth and cranial development after unilateral periosteal resection of the facial bones at 6 days of age. Another example of an adult rabbit revealed no impairment in growth despite extensive unilateral removal of periosteum at 10 days of age. There was one important notation, however:

In several animals in the rabbit series, damage to perforating maxillary vessels resulted in deviation of the snout towards the operated side.


• The periosteum covering the maxillary segments in cleft deformities possesses a remarkable growth potential, but this force remains inactive until the periosteum bordering the bony defect is surgically manipulated.
• When the periosteum is shifted across a cleft, its osteogenic capacity is harnessed to rebuild the bony defect. The cambium layer, separated from the bone and placed in contact with a hematoma, induces the characteristic tissue reactions of bone repair.
• Properly arranged, the periosteum will lay down more bone than conventional bone grafting procedures. In fact, the skeletal anatomy can be restored extensively, including the hypoplastic piriform border and the underdeveloped portion of the lateral segment. This segment is the best source of bone-forming periosteum, the thick membrane on the inner aspect being particularly potent. Also, extensive mobilization of the periosteum of the lateral maxillary segment can be carried out without interfering with bony sutures or other growth centers.
• Periosteoplasty is most effective at an early age and is preferably performed in conjunction with the primary lip repair. The operation has, however, proved to be quite effective up to the age of five and in a few cases up to eleven years of age.
• Following periosteoplasty the tendency for maxillary collapse is reduced by the rapid formation of new bone within the cleft.
• Periosteum induced new bone grows with the individual, unlike the static transplanted bone.
• In addition to growing with the individual, this bone responds to maxillary orthopedics. If maxillary collapse should occur in cases of major deficiency, up to 9 mm. extension of the bone bridge has been achieved by...
expansion treatment. Bony substitution of the original defect will thus be completed.

- Bone formed by the local periosteum is of a dentoalveolar character.
- The tooth buds, compressed within the reduced volume of the lateral segment, will regularly migrate into a more normal position when new bone has formed, and in the cleft area they will erupt through this bone.
- Periosteoplasty is useful to correct the extensive bony deficiency associated with even a minimal cleft lip. The technique is recommended as an integral part of repair in clefts of all degrees.
- Surgicel® can be used advantageously as a scaffold to support the raised periosteum at the desired level, thereby regulating the volume and shape of the newly formed bone.
- Bone surfaces deprived of periosteum in the flap transfer will regenerate a new periostal layer, which will be thickened and hyperactive at first, but will gradually acquire a normal appearance.
- The regenerated periosteum has good osteogenic qualities, which permit repeated periosteoplasties to be performed, resulting in additional bone formation.

In fact, bone formation is not consistent or predictable and thus may require repeated periosteal “flaps” to create enough bone to be functional.

In 1976 orthodontist Rune Hellquist and Tord Skoog gave a report of 66 complete unilateral clefts of the lip and palate, 36 with primary periosteoplasty and 30 without. They made several observations:

In all patients who had undergone periosteoplasty, new bone formed within the alveolar cleft. A good amount of new bone developed in about half the
number of cases. Bone formation increased after repeated periosteoplasty and new bone bridging the cleft was then a constant finding. . . . Infant periosteoplasty, involving transfer of local peristemeum across the alveolar cleft, is effective in restoring framework and . . . does not retard or impair growth of the maxilla during a follow-up period of 5 years. . . . In the deciduous dentition, no differences were found in intercanine and intermolar dimensions between the periosteoplasty cases and the controls. . . . The new bone formed in the cleft area after periosteoplasty does not seem to withstand the contracting forces introduced by palate surgery.

Tord Skoog had promised to send me some x-ray films of his periosteoplasty and because of his untimely and tragic death did not; Bengt Pontén kindly forwarded the two accompanying cases. In 1976 effervescent, forthright George Joss of Norwich, England, once a rugby player at Aberdeen University and now just as vigorous in cleft surgery, wrote what he considers to be “The Place of Boneless Bone Grafting—a gimmicky title which I have now dropped in favour of Periosteoplasty.” It all started on Joss’s World Health Organization Fellowship tour of the cleft palate primary bone grafting centers of Sweden and Germany. Here is an outline of his 1966 to 1976 transition:

1966—W.H.O. Fellowship to study bone grafting in cleft palate in Sweden and Germany. “Best Buy” considered to be the simple Widmaier flaps seen in Dr. Schmid’s Clinic, Stuttgart. Reading literature; found same flaps described by Andrew Campbell, F.R.C.S., Ed. (B.M.J., 1926).

1966—Commenced a study using Campbell-Widmaier flaps plus Skoog flap, with implantation of rib grafts or bone marrow injection in alternate cases as a comparative study. By accident (anesthetist stopped case before bone implanted), one case of bilateral cleft had flaps but no bone graft or marrow. 6 months later (1967), X-ray revealed bone had formed spontaneously; just as good.

Great excitement! Realized bone graft may be unnecessary; periosteal flaps appear to be sufficient.

1967—Clinical research carried out on large number of patients who had periosteal flap repair (Stellmach), but no bone graft. (Easily identified by their computer.) Kind permission of Professor Rehrmann.

Findings: Periosteal bone formation without bone graft confirmed in every case but one (breakdown due to infection). Spent whole of one night photographing X-ray evidence; (fear of Gestapo!).

Comment: Perhaps Professor Rehrmann did me a good turn in declining permission to publish. Although initial results were very gratifying and unquestionably periosteal bone formation developed in every case, the longer term follow-up introduced disappointment. All cases of unilateral cleft incorporating Millard repair with initially excellent lip and nose formation. Gradually, with dentition, evidence of lateral segment crossbite and even some anterior crossbite developed. Formation of nostril deteriorated by age 3 to 5. Significant percentage developed fistula at junction of hard and soft palates—presumed due to difficult compatibility of Campbell flaps with Kilner-Wardill cleft palate repair.

It had been believed that the ease of bridging even the widest cleft with Campbell flaps would eliminate the need for post-operative orthodontic correction. 10 year study of method intended but plans revised.

1971—Post-operative orthodontic correction by static retention appliance (similar to Georgiade plate). This introduced a previously unintended variable into the study but succeeded in preventing anterior and lateral crossbite due to alveolar collapse.

1973—Visit to Professor Skoog in Uppsala. Despite being on Sabbatical leave (due to coronary thrombosis), Skoog kindly demonstrated his method on two children with complete unilateral clefts. Decided to abandon my own method, and therefore, 10 year study of Boneless Bone Grafting with Campbell and Skoog flaps, because incidence of palatal fistula too high to accept.

1976—I now use Skoog’s periosteal flap technique alone, except that I do not personally think that re-operation each 3 months to raise a further periosteal flap is acceptable. My method now is to use a Millard lip repair in all cases, combined with Skoog alar rotation and his periosteal flap.

In 1977 Joss wrote from Norwich prior to leaving for a locum in Riyadh, Saudi Arabia.
I still remain firmly committed to periosteoplasty and perform it on every case of complete cleft.

Other surgeons began using the Skoog primary periosteoplasty.
Bernard O'Brien

The ingenious and extroverted Bernard O’Brien of Melbourne, Australia, is one of the world’s leaders in microvascular surgery and the transfer of “free flaps.” He started at an early age to attain great heights, which won him the Melbourne University pole vaulting title from 1946 to 1950 and the honor of representing the state of Victoria in the national pole vaulting championships, and also the Australian Universities’ championship. When he was not vaulting from a pole, he was tossing one as the University javelin throwing champion for several years.

O’Brien cited the observations of Joss, who, when touring the Scandinavian and West German units, noted absorption of bone grafts regardless of the method. He admitted similar experience with his own grafts and became interested in the boneless bone graft of Skoog, which had also been embraced by an Italian, Santoni-Rugiu, in 1966. O’Brien explained his approach:

A Millard cleft lip repair in the unilateral clefts was associated with a two-layer periosteal closure of the primary palate (Skoog) and one-layer closure of the hard palate. The secondary palate cleft was closed at the age of one year by incorporating the palatal island flap (Millard) to lengthen the nasal layer. Preoperative and postoperative photographs and models with serial x-ray studies have been carried out in all cases (12).

He confirmed Skoog’s findings of spontaneous bone formation within six months and summarized his follow-up of five months to four years:

(1) That bone forms spontaneously in the primary cleft is evident within six months and increases with time;
(2) that satisfactory alignment of the alveolar arch is achieved, and
(3) that bone deposition following “Surgicel” implantation at the time of the secondary palate operation may lessen alar base asymmetry.

There has been no evidence to date of interference with maxillary growth.

In late 1976 he wrote me his most recent stand:

My experience in this procedure extends over a ten-year period. I have reserved it for wide clefts, both unilateral and bilateral. No orthodontic treatment has been carried out prior to surgery unless the premaxilla has been very projected.
The largest possible periosteal flap has been elevated. The dissection can often be carried out more efficiently with the surgeon standing on the opposite side of the patient. There needs to be careful preservation of the base of the flap.

There has been good radiological evidence of bone formation in every case and good bony union has been obtained. A longer term follow-up is necessary though the results have been promising. Some orthodontic treatment has been required at a later age, but there has been no case yet that has needed a secondary bone graft. I am continuing to use this method.

RINTALA

In 1974 A. Rintala, A. Soivio, R. Ranta, T. Oikari and J. Haataja of the Finnish Red Cross Hospital, Helsinki, reported 63 patients (54 with cleft of the primary and secondary palate and 9 with cleft of the primary palate only) on whom the maxillary periosteal flap technique of Skoog had been used. The surgery was performed at age 3 months and the last x-ray films were taken at 3 years. These workers noted:

The periosteal flap formed a manifest bone bridge in 54% and a diffuse bridge in 22%, whereas no bone formation was seen in 24%. Whether implantation of Surgicel was performed in the same stage or omitted did not seem to affect bone formation, any more than it did the original width of the alveolar cleft.

OHMORI

Seiichi Ohmori, the doyen of Japanese plastic surgery and an oriental Marco Polo in reverse, has ventured throughout the world in search of ideas to bring home to develop. Two of them were free flap transfer and Silastic implants in auricular reconstruction, and he is now involved in primary periosteoplasty. In 1977 at the Toronto Congress, with Yuiro Hata of the Tokyo Metropolitan Police Hospital, Ohmori reported on 380 Skoog-type primary periosteoplasties using Surgicel in the pocket. These were carried out at 3 to 6 months, and as the bone formation at the maxillary cleft was proceeding (65 percent showed some bone
formation), an improvement of the alveolar arch and nasal floor was seen in most instances. Orthodontic treatment was necessary for the more severe cases. One of their cases is presented here.

Interestingly they noted:

Recently, if the patient has a wide cleft, a free periosteal graft from the tibia has been used as it is difficult to obtain sufficient tissue from the maxilla.

OTHER OPINIONS

There has been, however, a varied reaction to boneless bone grafting and the question of bone formation between two opposing layers of mucoperiosteum.

Reichert

In 1970 H. Reichert, a primary bone grafting proponent, noted:

In many operated palate clefts, bone is found years later when at the time of closure, only periosteum attached to nasal and oral layers was sewn together in the midline. Skoog (1967) called this phenomenon "boneless bone grafting." However, the development of this bony layer takes time, during which deformation of the dental arch may occur, and the wider the cleft the more likely this is.

Georgiade

While visiting Duke University in July 1971, I observed Nicholas Georgiade executing a Campbell-type, two-layer mucoperiosteal flap closure of an alveolar cleft. He was asked:
Do you get bone?

His answer was quite straightforward:

We've heard the big boys, but we still do not get bone.

**A Danish study**

In 1974 Uwe Prydso, Peter C. A. Holm, Erik Dahl and Poul Fogh-Andersen reported bone formation in palate clefts after palatovomerine plasty. Since the 40's Fogh-Andersen had closed the primary palate at 2 months of age with two mucoperiosteal flaps according to Veau. In 1970 Dahl showed that 91 percent of these patients developed crossbite, and later he convinced Fogh-Andersen to study the process by taking biopsies. Finally, the intelligent, droll Peter Holm, a rising new star in Danish plastic surgery, entered the study. Prydso also joined the group as histochemist to evaluate the microscopic specimens. Here is Holm's synopsis of the project:

Here in Denmark we have the best controlled material on boneless bone grafting and we have seen the effect of this bone formation on the adult patients. This is important work because the research has been carried out on human beings. At 22 months of age, a bone biopsy including both halves of the hard palate and nasal septum was taken from nine children with complete unilateral cleft who had had previous surgery at the age of 2 months. The newly formed bone had fused with the nasal septum and the palatal shelf. No suture had developed. The bone contributed normally to vertical growth of the nasal and oral cavities.

To evaluate appositional growth activity on the buccal aspect of the maxilla, periosteal biopsies from the region of the second deciduous molar on both sides were taken from the same children, revealing reduced appositional growth activity on the cleft side. Alkaline phosphatase reaction was twice as slow on the cleft side as on the non-cleft side. Biopsies of all nine children showed the same result. Biopsies from a control group of unoperated children of 2 months of age with unilateral complete clefts showed no difference in enzyme reaction on either side.

The conclusion of this investigation was that surgical procedures should be postponed as long as possible; surgical procedures which result in bone formation across the cleft should be abandoned.
FREE PERIOSTEAL GRAFTS

In 1969 at Jackson Memorial Hospital, Miami, Florida, during primary closure of a unilateral cleft lip, a student of Skoog's was available to create a "Skoog" maxillary periosteal flap which was thin and riddled with perforations, not unlike the finest Swedish lace. No bone formed in this cleft, and although one case is no test, it did occur to me at the time that such a flap probably does not have a generous blood supply and thus acts as a free graft rather than a pedicle one. In 1969 I designed a periosteal free graft experiment on rabbit skulls for M. H. Heycock, Maytag Fellow and now plastic surgery consultant in the shipping center of Hull, England, and medical student B. M. Barrett, Jr., now a plastic surgeon in Houston, Texas.

Nine rabbits 8 weeks old were used. The scalp was incised in the midline and an epicranial periosteal flap was elevated so that a quarter-inch-wide
A burr hole could be drilled in the skull. A free graft of periosteum taken from the opposite side of the skull was placed in the hole over the dura, osteal side up, and covered with Surgicel. Then the periosteal flap was replaced over the hole in the bone and the scalp closed to duplicate the principle of Skoog. The opposite side, with a skull bone hole devoid of any periosteum, was left as a control. The rabbits were sacrificed at various times from 10 days to 22 weeks. The microscopic findings were of interest. Although two control holes produced a thin layer of bone and four experimental holes with periosteal grafts produced no bone (as seen in the section of rabbit No. 2, sacrificed at 21 weeks), the experimental holes with periosteal grafts unquestionably produced more bone than the control holes. Five of the experimental free periosteal grafted holes produced bone (as seen in rabbit No. 3). The four that did not were complicated by infection, loss of the periosteal graft or early death of the rabbit.
From this experiment it was difficult to show that free periosteal grafts were responsible for new bone formation. When the new bone did form in the periosteal pocket between the graft and the epicranial periosteum, rather than in scar or on the dural side, it was thicker at the edge of the defect and thinner in the center, suggesting new bone was being laid down from the bone margins rather than the periosteum. Rabbit No. 6 demonstrates this.

The presence of Surgicel promoted giant cell formation with only a minimal amount of new bone.

In 1972 the Finnish team of V. Ritsilä, S. Alhopuro, and A. Rintala reported their study of free periosteal grafts. In this first publication on the subject in the literature, they acknowledged the effectiveness of periosteal grafts in forming bone.

In a subsequent article in 1972, in the *Scandinavian Journal of Plastic and Reconstructive Surgery*, Veijo Ritsilä, Sakari Alhopuro, Uno Gylling and Aarne Rintala of the Finnish Red Cross Hospital, Helsinki, after more than 80 Skoog periosteal flaps and their own successful bone formation following free periosteal grafts in animals, wrote:

> From our experience, at least in wide defects it can be very difficult to cut a flap with a wide enough base: the flap often becomes little more than a string whose contiguity with the maxilla is illusory.

The usual mucoperiosteal flaps are used to close the nasal side of the alveolar and anterior palatal cleft. A free graft of periosteum taken from the anterior tibia, 1 by 4 cm. in size, is used as a bridge. With the bone side inward, the periosteal graft is fixed with catgut to the maxilla on each side of the cleft, establishing a two-layer periosteal continuity between the maxillary segments, and the entire graft is covered with oral mucosa. The Finnish team followed these cases carefully with regular x-ray studies and reported:

> The bone forming capacity of free tibial periosteum where transplanted to the maxillary cleft is undoubted. After 2 weeks there is callus in the area of transplantation and after 6 weeks definite bone can be observed in the area.

Veijo A. Ritsilä started as an orthopedic surgeon and in fact is still the leader of the Research Laboratory at the Orthopaedic Hospital of the Invalid Foundation in Helsinki. He has recently visited bone research laboratories in New York, Los Angeles and
Toronto. In 1975 in Paris he noted, with Alhopuro, Ranta and Rintala, that

free periosteal grafts from the tibia have definitely stronger bone forming capacity than the local maxillary periosteal flaps.

In 1976 he answered my question as to how he got interested in free periosteal grafts by commenting on the difficulty of cutting healthy flaps of periosteum with a wide enough base. Then he added:

I have thought, too, that in maxillary cleft areas, there is often a growth disturbance per se, and it is unwise to use this "sick" maxillary periosteum from the area. The tibial periosteum has maybe a greater growth potentiality because it is planned to grow more rapidly than the maxillary periosteum. In this way, free tibial periosteal grafts could bring new healthy mesenchymal tissue possessing more growth and bone formation potentiality to the defect area of the maxillary cleft, which perhaps is condemned to the underdevelopment in the growth area.

At the Finnish Red Cross Hospital we have compared roentgenographically our material of 22 patients in the respect of bone formation with a series of 63 patients operated with the local maxillary periosteal flap techniques (Skoog) in our hospital. With maxillary periosteal flaps, a definite bone bridge was achieved in 54%, diffuse ossification in 22%, and no bone formation in 24% of the patients. The corresponding figures in the series of 25 free tibial periosteal grafts are 76%, 12%, and 12%. Our experience is that a free periosteal graft produces more bone in a shorter time and with less failures than the maxillary periosteal flap.

At the time of the occlusal X-ray controls, also alginate impressions of the alveolar bridge and palate were taken. The follow-up period has been on average 4 years. Using incidence of crossbite as a basis for comparison, results of this material with free periosteal transplants compared with our earlier material with and without local periosteal flaps. In respect to the dental occlusion, there was no marked difference, but definite growth of the alveolar complex in the antero-posterior direction could be seen. Growth stimulation in the lesser segment could also be detected. However, the observation period is still too short to assess conclusive results.

In two last years I have proposed and used free periosteal and also perichondrial grafts in clinical orthopaedics in the spinal fusion of scoliosis, in the treatment of congenital and post-traumatic long bone pseudoarthrosis and in reconstruction of articular cartilage destruction or defects. Also, my free periosteal transplantation method has now applied clinically to reconstruction of tracheomalacia and tracheal stricture in some European countries.
A series of x-ray films reveals the situation: (a) preoperative cleft, (b) two weeks after transplantation, and (c) one year after the free periosteal graft.

Bone formation can be seen, and a tooth is erupting through the newly formed bone.

Although realizing it is too early to evaluate this work, he made several pertinent points:

Periosteal grafts are easily available and cause the baby no trauma worth mentioning. . . . It is unnecessary to detach the maxillary periosteum, which can be difficult and may cause disturbances to the normal periosteal bone growth. . . . A periosteal graft does not produce the immediate orthopaedic effect which can be achieved with a bone graft. But if a good alignment of the alveolar arches is achieved preoperatively, or even postoperatively by the pressure of the reconstructed lip, the transplanted periosteum provides a rapid fixation of the arches. A periosteal graft, unlike the bone graft, does not undergo the resorptive stage before bone formation.

The advantages of periosteal free grafts over maxillary flaps cannot be denied. The only question that still bothers me is whether effective bone will be formed consistently.

Although periosteal pockets across the alveolar cleft have been created through the years, it is possible that more bone has been laid down in them than has been realized. The principle is an interesting one but seems to have some of the drawbacks that regular bone grafting suffers—trauma, dislodgment of periosteum and scarring. The bone formed appears to be variable and un dependable, often requiring several periosteal flaps for sufficient bone formation. Perhaps in time we will find that this new bone and the accompanying scar acts as a restraint to growth, or it may turn out to be just what the patient and the surgeon need.

Following a group of papers on primary periosteoplasties by flaps and free grafts came one of the highlights of the Toronto Congress on June 8, 1977.

Scene: Concert Hall, Royal York Hotel

Debate: Resolved, That Periosteoplasties Are an Excellent Method of Primary Maxillary Alveolus Repair.

Affirmative: I. T. Jackson, Scotland

Negative: E. S. Broadway, England
The argument for primary periosteoplasty was presented well, with fine cases showing good results. Both the Skoog flap and the pericranium free graft had been used. Jackson, in all honesty, admitted that his follow-up time was not long enough and, although early results were promising, harmful later effects might cancel the benefits.

The argument against was championed by the orthodontic representative of Joss’s unit, E. S. Broadway. I had been warned ahead of time that for the sake of debate, this would be a trumped-up argument for the negative, when actually they were still proponents of the primary periosteoplasty. Broadway presented cases in which primary periosteoplasty had been used and which revealed crossbite, with the implication that the method had been, and should be, abandoned.

Then a vote was requested from the audience on how many would do primary periosteoplasties on the basis of the data presented and not on whether they had been doing the procedure previously. The show of hands was estimated at one-quarter yes and three-quarters no.

I wrote Eddie Broadway for the facts and this was his response:

The truth is that George Joss has been carrying out primary periosteoplasty for about 10 years. The results are very variable, some excellent and some rather indifferent. Bone certainly forms in some, but by no means in all. I do not know why, and I do not think anyone else does.

I do not agree that bone across the cleft prevents or modifies bone growth of the upper jaw. I cannot agree with the concept that the bone is like a strut preventing collapse or stopping lateral development. The bone, no matter how it is formed, is a living material and will react to pressure or stimulation.

The problem of growth disturbance is much more likely to be due to the lifting of large flaps of periosteum off the growing bone and it is the donor site which is the important one, not the recipient area which everyone seems to concentrate on.

MICROVASCULAR ANASTOMOSIS OF PERIOSTEUM

The problem with the Skoog periosteal flap seemed to be its poor vascularity and inconsistent formation of small amounts of bone.
The same seemed to be true of free periosteal grafts. Then senior resident John M. Finley of Indiana University, Robert D. Acland, director of microsurgery and Michael B. Wood, both of the University of Louisville School of Medicine, in 1978 presented their important work on dogs.

Rib periosteum was transplanted to the groins of 9 dogs. In half of the periosteal grafts, no microvascular anastomoses were done (free grafts); at 6 weeks after grafting they had become resorbed. The other periosteal grafts were revascularized by microvascular anastomoses of the intercostal vessels to local muscular vessels; at 6 weeks those with confirmed vascular patency had all formed substantial amounts of new bone.

Five cm, full-thickness defects were created in the tibias of 10 dogs. The control animals (without grafting) did not heal in two months. However, the experimental dogs, with vascularized periosteal grafts in the defects, regenerated their tibias with healthy new bone by 6 weeks—and were walking on them then.

They also noted that non-weight-bearing bony defects such as in the cranium and ulna did not form bone, indicating that mechanical stress may be a necessary adjunct to new bone formation. It was suggested to Finley and Acland that revascularization of periosteal grafts by microsurgical anastomosis could be a more dependable bone-forming maneuver in the cleft maxilla as the stress on the maxilla would aid in this process. Finley responded:

This work does demonstrate without question that periosteum can be quite osteogenic under the right circumstances. . . . With such vascularized grafts perhaps palatal defects could be bridged by soft tissues and new bone without the need to perform radical local mucoperiosteal or bone flaps. This could minimize resulting facial growth problems.

Acland was less optimistic:

Particularly with regard to the treatment of large palatal defects, I don’t think our experimental evidence would support a clinical trial of the method.
LONG, long before presurgical orthodontics and alveolar bone grafting, lips were closed in the early months and the palate at about 1 year. In 1787 Gerard, comparing the effect of lip closure upon the palatal cleft in a 9-year-old and a 30-year-old patient, advocated that closure of the lip be done "at a tender age" to bring forward apposition of the cleft palate edges. The early lip closure served for Gerard as an orthopedic device to narrow the palatal cleft. Subsequently many surgeons were enticed by the possible advantages of more sophisticated presurgical orthodontics and primary bone grafting into the cleft. Some who ventured into these new vogues were later to return to the standard approach. Others never left and were not afraid to admit it.

HARDING

Robert Harding, in his typically quiet, sincere, effective way, presented his findings:

In following our patients quite closely it has been our feeling that most of our patients would benefit little, if at all, from a primary bone graft.

He explained that he was not opposed to maxillary orthopedics and bone grafting but looked at these as a secondary or later procedure. Harding considered that a child with cleft palate, which in itself varies in each case, has the potential for "normal"
growth within the limits of his own genetic heritage and metabolic environment. He expressed far more concern about avoiding raw areas with scar contracture by conservative surgery and waiting for subsequent gentle molding by united muscles, for, as he said,

"Growth is a gentle force and can be contained by an equal and opposing force."

When the patient attained 10 pounds, Harding simply closed the lip, unwilling "to dilute his attention" to other surgical procedures. He reported good results with a modified quadrilateral flap, a triangular flap or the rotation-advancement method, but warned:

"The first surgeon has the best chance!"

Then, slightly out of character, he slipped the baby a nippedled bottle for the first feeding two hours after surgery!

At the time of palate surgery, Harding reported 50 percent of patients with maxillary segment collapse, the other half showing resistance due to end-to-end contact of segments, a large inferior turbinate or the size and shape of the nasal septum and palatal shelves. At present Harding closes the palate at 1 year in two stages, the hard palate with a one-layer vomerine flap leaving the alveolar cleft open and, four months later, simple approximation of the soft palate, accepting a short palate primarily. In his series are palate cases which were closed at 6 months and others in the older age periods. Without adequate statistical data, he expressed a general feeling that his "early" surgery did not cause any more maxillary growth disturbance but did seem to improve speech results. His final defense of the conservative stand included "both the patient and the surgeon do better" and "our complications are minimal with no mortalities in 2000 cases."

MAZAHERI

Harding's orthodontic teammate and co-captain, Mohammad Mazaheri, backed his surgeon's conservative stand and outlined his figures following this sound treatment in unilateral cleft lip and palate cases:
1. Seventeen percent of all cleft samples were found to have some kind of transverse crossbite.

2. A large majority of the crossbites discovered involved only the anterior region.

3. The incidences of crossbite, either anterior, posterior or both, in unilateral and bilateral cleft lip and palate are:
   - **unilateral**: deciduous 47.5 percent; mixed 60 percent; permanent 17.2 percent.
   - **bilateral**: deciduous 20 percent; mixed 40.9 percent; permanent 26.7 percent.

Mazaheri concluded:

Treatment of these cases is no real orthodontic problem to us.

In 1972 Harding and Mazaheri repeated their conservative stand in reference specifically to 80 bilateral clefts, stating:

We decided to repair bilateral clefts of the lip and palate by as simple a procedure as possible, and to leave the alveolar clefts open so that the maxillary segments would be relatively free to mold and adapt.

Repair of the lip with good restoration of the functional muscle matrix reduced the subsequent width of the cleft in the maxillary segments—as we had expected. For example, a Simonart’s band is often all that is needed to contain the maxillary segments. The difference in the maxillary widths between the bilateral and the unilateral cleft lip and palate groups, although great at birth, became less significant after repair of the lip.

There was a constant change in the segmental relationship of the premaxilla and the lateral segments during various stages of the arch development. In most patients in whom an overlap of the premaxilla over the lateral segments was present both before and after lip surgery, the segmental relationships began to change prior to 3 years of age and terminated with an end-to-end relationship after eruption of the deciduous dentition. Evidently spatial relations will improve with dento-alveolar adaptation, provided the segments are not locked in by a surgical design or by fibrous tissue, and provided the tongue is normal. Underdevelopment of the mid-face with retraction of the maxilla is, we think, the result of the individual’s genetic heritage or of a false maxillary ankylosis secondary to surgery. Considerable progress has been made in cleft palate surgery in providing anatomical restoration which will restore function. It appears that we should revise our emphasis in favor of a better balance between effects on growth and early function, because the two will ultimately be interdependent.
In 1976 Mazaheri made a pertinent observation:

In patients we have followed longitudinally over the past 14 years, we have found that the major variable in acceptable oralfacial growth pattern is the surgeon. Of course, besides the surgeon, the type of surgery also has a great effect on this pattern of growth. Yet the type of surgery does not mean much if the surgeon does not do his job well.

**Krogman**

Wilton M. Krogman, anthropologist and director of research at H. K. Cooper Institute, Lancaster, Pennsylvania, recalled:

My concern with bones and growth stems from early childhood. At the age of nine while playing “buried treasure” with my twin brother, I struck bone in one of our random holes in a vacant lot. Further digging uncovered a skull which turned out to be that of a horse, followed by its entire skeleton more or less as articulated in life, lying on its side. . . . Time passed and in my Freshman-Sophomore high school years, I grew 8 inches at a greatly accelerated rate to 6 foot, 4½ inches. Thus a fast grower grew into a growth student.

I am, I think, the only active craniofacial growth researcher who spans the total progress in the field: craniometry (skull); cephalometry (head); roentgenographic cephalometry (x-ray head film). This trilogy of research methodologies is basic to the knowledge and interpretation of craniofacial and cephalofacial growth and development, both normal (non-cleft) and abnormal (cleft).

The increase in size and change in proportions, the maturational age-changes, the sex differences, and the racial differences of the human skeleton have been combined by me into a sub-specialty, “Forensic Anthropology.” My *The Human Skeleton in Forensic Medicine*, 1962, is on the shelves of every law enforcement agency in the world. I am known as “the bone detective.” In the 1930’s, I was consultant to the Scientific Crime Detection Lab of the Cleveland Police Department, and still have my Police Card, signed by Eliot Ness (of TV “Untouchables” fame), who was Director of Public Safety. As a lab-man, I was never on the “firing-line.”

In 1975 Wilton Krogman, with Mazaheri, Harding, Ishiguro, Bariana, Meier, Canter and Ross stated:

It has been our feeling, here at Lancaster, that conservative surgery (properly timed, and offering a minimum of mucoperiosteal involvement) should not result in deviant and/or dysplastic maxillo-facial growth.
After 24 staggering pages filled with numerical tables and charts on growth measurements, they concluded simply:

On the basis of our two serial samples, CP and unilateral CL(P), we have observed that there is a general post-operative catch-up growth in both cleft types, more so in CP. It is our conclusion that conservative surgery has facilitated rather than inhibited or deviated growth in both the maxillofacial skeletal complex and the soft tissues of the labiofacial complex. In the data presented in this study, our hypothesis has been sustained.

If we swing from the conservative unit in Lancaster, Pennsylvania, to one in Sussex, England, the report is similar.

GLASS

Orthodontist Denis Glass reported in 1970 with C. R. McLaughlin as the surgeon:

At the East Grinstead Centre, no primary bone grafts are carried out as the cleft lip and palate team feel that the benefits, if any, . . . are out of all proportion to the severity of the surgical procedure involved.

So at East Grinstead, the "merry ol'" standard approaches are used, with conservative vomerine resection for setback of the premaxilla in severe protrusion and lip closure at 3 months, and the palate closure at 18 months. The only treatment then is speech therapy until, at 4 years, when the anterior arch collapse and premaxillary protrusion receives dental orthopedic treatment to realign the segments of the maxilla in three to four months. This rapid expansion is accomplished with a CC spring appliance of two acrylic segments anchored to the lateral teeth with Adam crib and cap splints. It is designed for anterior, and not the posterior, expansion by a heavy stainless steel wire bent into the form of a double C. No bone grafting is used.

PRUZANSKY DEFENDS THE STANDARD APPROACH

Partially discounting the Graber, Slaughter, Brodie and Subtelny scare of years before, Sam Pruzansky balked at delaying palate
surgery pending completion of a major portion of maxillary growth. He stated:

It has become increasingly clear that the damage to maxillary growth lamented a decade ago was largely the byproduct of surgical practices no longer in vogue in the larger centers. The present generation of treated patients does not present the maxillary deformity that was untreated by conventional orthodontic means.

He favored early lip closure with maxillary molding and standard, atraumatic palate closure with orthodontia available to correct any discrepancies in the adult dentition. He later elaborated at the 1969 Second International Symposium on Early Treatment of Cleft Lip and Palate, held in his hometown of Chicago. Having controlled his emotions through the afternoon of the second day, he finally rose, mentioned that the Proceedings of the First Symposium in Zurich had recorded a “Tower of Babel” and questioned whether this second symposium was not a repetition of the first! He then dropped a Pruzansky “cocktail”:

One fact is inescapable. That is, whether you use maxillary orthopedics and/or bone grafting, or whether you do not, some cases succeed and some fail. . . . Why? Never mind the percentages. Everyone knows that you do not achieve 100% success. What are the mechanisms for success and failure? Is it in the kind of surgery? Is it in the age at which you operate? Where is the difference?

Pruzansky concluded:

Let me summarize by stating that a survey of our cases indicated that, in the present practice of plastic surgery, the following variables inherent within the patient dictate whether the arch will collapse or not:

1. Size and shape of the alveolar processes adjacent to the cleft.
2. Size of the palatal processes.
4. Size and slant of the nasal septum.
5. Size and shape of the inferior turbinate on the side of the cleft.

Howard Aduss, orthodontist of Chicago, once played running guard in Big Ten football at Purdue University weighing only 175 pounds. Later he was trained by Sam Pruzansky and again proved his toughness by continuing to work closely with him
while maintaining his own identity. In 1964, and again in 1967 and 1968, he co-authored papers on the cleft palate with Pruzansky and twice was senior author. At the Cleft Palate Symposium at Duke University in 1973 Aduss pointed out:

Initial State
Among unoperated infants with complete unilateral cleft lip and palate, excluding those with Simonart's bands, there is considerable variation in presurgical morphology and the spatial interrelation of the cleft segments. Longitudinal studies, utilizing dental casts and cephalometric radiographs, have demonstrated that these differences often predict the effect of lip repair on the shape or form of the arch as follows:

1. The size and shape of the alveolar process adjoining the cleft is determined by the number of developing teeth at the margins of the defect. The presence of well-formed or even bulbous alveolar borders acts as a buttress to prevent "collapse" of the segments.

2. The size and shape of the inferior turbinate on the side of the cleft also determines the amount of medial movement that may occur. Where the turbinate on the cleft side fills the nasal chamber, contact between the deviated septum and turbinate may also prevent approximation of the segments.

3. The size, inclination, and degree of deviation of the septum, coupled with its relationship to the turbinate, may limit medial movement.

4. The size and spatial relation of the palatal shelves to each other have been shown by stereophotogrammetry to be highly variable. When the shelves are displaced "horizontally" toward each other, the tendency toward medial movement will be more inhibited than if the shelves are at a more acute angle.

Subsequent State
Repair of the lip allows the previously defined morphologic variables to interact as determinants of arch form.

A review of ninety infants at the University of Illinois has shown that after lip repair, three types of arch form were discernable: (1) symmetrical ( . . . 35.5%), with approximation of the segments and a butt-joint at the alveolar border; (2) overlap, or "apparently collapsed" arch form ( . . . 43.3%); and (3) symmetrical arch form, but without contact at the alveolar border ( . . . 21.1%).

Aduss noted the similarity of the crossbite reported at the University of Illinois and that reported by Bergland in Oslo.
Neither had used presurgical orthopedics or bone grafting but had relied upon standard closure of the lip and palate. He also noted that there was less crossbite (less collapse) in these groups than in those using presurgical orthopedics and primary bone grafting.
22. The Perceptive Passavant and His Controversial Pad

At one time surgeons were obsessed with closing the hole of the cleft without great concern for functional velopharyngeal closure. The soft palate was considered a flap valve working like a trapdoor. In the latter half of the nineteenth century there was a Teutonic rise to power in medicine, spearheaded by Rudolf Virchow, and on the crest of this wave was the remarkably perceptive Philip Gustav Passavant of Senckenberg Hospital, Frankfurt, Germany. He wrote 23 scientific papers on such subjects as typhus, psoriasis, anal strictures, burns, tracheotomy, epispadias and cleft palate. In fact, in 1863 he published a monograph on “closure of the pharynx in speech,” which postulated a theory he expounded more fully in 1869.

In his 1869 classic dissertation Passavant described the velum as a muscular structure opposed by another pharyngeal muscular structure which was to become known as “Passavant’s pad.” He noted the “forward swelling at the level of the base of the uvula,” which he deduced formed a pharyngeal ridge that was “an essential condition of normal pronunciation.” After dissecting both frozen and alcohol-hardened specimens to trace the origins of the superior constrictor muscle, he found the fibers running in the pharyngeal wall at the level of his ridge and spanning hamulus to hamulus.

Passavant described what he considered normal physiological action of the palate and pharynx:

The velum is raised, but not as far back as the back wall of the pharynx, which stays fairly still: the back wall of the pharynx approaches the velum,
at the same time coming forward in a swelling at that height of the pharynx at which the approach of the side walls of the pharynx to each other also takes place. . . . This (bulging of the superior constrictor), accompanied by the raising and pushing back of the velum, causes the closing of the palate-flap which is essential for intelligible speech. This sentence is the most essential content of the whole of my earlier work. . . . There are then, in my opinion, two ways in which the palate closes: the first is necessary for speech and is caused by the activity of the levatores palati and the upper pharynx constrictor, or rather perhaps, the part of this muscle known as pterygopharyngeus, arising from the hamulus: the second is that occurring in swallowing, choking, vomiting, etc., here, the closing is further strengthened by the contraction of the pharyngopalatini.

As noted by Calnan, Passavant’s theory of nasopharyngeal closure was accepted throughout the world without question and with only an occasional minor modification by most of the early doyens of palate surgery.

Claude Bernard’s rather cynical 1865 remark, What we know may interfere with our learning of what we do not know, suggests the difficulty of exploding myths. It often takes an elephant gun to kill a “traditional” flea, but any pages devoted to this controversial pad have important information on the anatomy and physiology of the velopharyngeal mechanism.

Von Luschka, who was compiling his treatise on anatomy, at first opposed Passavant’s theory that the superior constrictor caused approximation of the two halves of the uvula in a cleft palate when the patient said “ah.” He later agreed that the superior constrictor muscle was partly responsible.

In 1935 and 1936 Denis Browne of London argued that the soft palate was a curtain shielding a contractile muscle ring of two overlapping slings, the levator palatini and the superior constrictor. He considered this ring similar to the anal sphincter and regarded the ridge on the posterior pharyngeal wall as being due to the palatopharyngeus muscle. In 1941 Michael Oldfield of Leeds, accepting the idea of levator and superior constrictor slings, added lateral slings of the salpingopharyngeus and pharyngopalatine muscles. George Dorrance of Philadelphia had an opportunity in 1932 to study two palates in action from above after complete destruction of the nose. In one, Passavant’s cush-
ion was impressive; in the other, only rudimentary. He concluded that Passavant’s theory was correct and acknowledged that the ridge was formed by the superior constrictor muscle. Wardill of Newcastle accepted Passavant’s theory in 1928, suggesting that his cushion acted as a valve seating for the upper surface of the soft palate.

In 1942 L. Stein stated that in speech, nasopharyngeal occlusion was due to elevation of the soft palate toward the transverse fold known as Passavant’s cushion, which is probably formed by the raising and folding of the pharynx wall.

He suggested that enunciation of vowels, energetically carried out during speech training, is a stimulus to greater activity of the velum and pharyngeal wall and, further, develops the muscular substratum of Passavant’s “cushion,” ensuring better closure of the nasopharyngeal cavity. In 1954 Hagerty and Hoffmeister used the distance between the soft palate and Passavant’s ridge as an index to speech after cleft palate closure. Barrett Brown gave his usual sound analysis in 1955 but included the myth, stating: In the repair of cleft palate one goal should be to obtain the best possible function of the soft palate. This will require pliable tissue, sufficiently long to meet the posterior wall of the pharynx (Passavant’s pad) in the sphincter-like action of this region that closes the opening between the nose and throat.

BATTLE OF THE BULGE

James Calnan, professor at Post-Graduate Hospital, London, was the fair-haired favorite of Nuffield Professor Kilner during his later years. While at Oxford under Kilner, Calnan beheaded a tradition in a learned and comprehensive treatise on “The Error of Gustav Passavant” [and his pad], which was presented at Coronado, California, in 1953 and awarded second prize by the Foundation of the American Society of Plastic and Reconstructive Surgeons. As one of his most effective thrusts against the importance of Passavant’s pad, Calnan used the renowned Victor Veau, noting that in 1943, after study with radiographic methods, Veau had said:
What does Passavant’s ridge do, that mysterious formation which has already brought a century’s immortality to a Frankfort surgeon? Naturally we have had some experience of it. We have operated on 1,747 cases of cleft palate. First of all, Passavant’s fold exists hardly at all in one-fifth of the cases. It is used perhaps in deglutition. It has nothing to do with speech. A fold which projects for 1 cm. cannot in speech close an orifice 3 to 5 cm. in diameter. But the main question for us is to know if such a fold could be of useful help in assuring occlusion in those cases where we have reconstructed an insufficient palate. Behold that which experience has taught us: more often this fold is sited below the point where the velum seeks to meet the roof of the cavum—and that is understandable; the fold is formed by the functional hypertrophy of the upper fibres of the superior constrictor muscle of the pharynx, and as you have seen this constrictor stops at the level of the atlas.

He did allow that

There are some fortunate cases, which are rare, where the fold helps occlusion . . . but speech is not of good quality.

Browne’s modification of the Passavant theory compared the velopharyngeal sphincter to the sphincter ani. Calnan again used Veau to counter this stand:

Veau goes further and suggests that if the speech mechanism is comparable to the sphincter ani then man would long ago have found some other way in which to express himself.

Then, too, Veau’s speech analyst, Madame Borel-Maisonny, noted in 1950 that the posterior pharyngeal wall was always immobile in normal speech; movement, as indicated by a transverse fold, was taken as a sign of an incompetent nasopharyngeal sphincter.

Calnan confirmed Veau’s opinion but from his observations reduced the dimensions of the velopharyngeal orifice to a width nearer 2.0 to 2.5 cm., and the anteroposterior diameter to 1.0 to 1.5 cm. His measurement of the projection of Passavant’s ridge, moreover, was usually less than 1 cm. With lateral x-ray films of the palate and pharynx of various cases and key overlay sketches, he maintained his objections to Passavant’s theory and presented his final argument in five parts.
1. Inconsistent. Calnan noted that Passavant observed his ridge in only one of 50 normal subjects while using a postnasal mirror, and he hazarded the guess that Passavant was recording a gagging reflex rather than normal speech. Other inconsistencies presented pointed out the occurrence of Passavant’s ridge in less than 25 percent of unoperated cleft palates, but in all those cases it would rise, evidently if being required for speech. It appeared in the 1-month-old infant and the adolescent but was more common in the adult, and even varied greatly in the same individual over a period of time. When viewed from above after removal of the maxilla for carcinoma in four patients, there was no evidence of forward motion of the posterior pharyngeal wall during speech, but a pronounced ridge was observed at low level on gagging and swallowing.

2. Uneconomical. It would be a waste of effort and energy to ruck the posterior pharyngeal wall forward if a normal velum can reach and occlude the nasopharyngeal isthmus. Lateral closure or narrowing of this isthmus by salpingopharyngeus and palatopharyngeus muscle contractions is more efficient since the elevated velum is unable to occlude the lateral pharyngeal recesses.

3. Ridge too low. Passavant’s muscle bulge occurs on the posterior pharyngeal wall at the level of the arch of the atlas, but the height to which the normal soft palate lifts back during speech is about 1 to 2 cm. above the level of the atlas. As there are no superior constrictor muscle fibers above the arch of the atlas, the ridge rises at too low a level to play an active part in speech. Calnan condemned several surgical procedures with:

This is further confirmed by the consistent failure to obtain normal speech of all forms of pharyngoplasty which try to imitate Passavant’s ridge.

4. Contraction too slow. The relatively slow contraction and relaxation of the ridge, the stage of contraction lasting invariably for more than 1 to 2 seconds, contrasts sharply with the rapid movements of the velum, which are in the order of 0.1 to 0.01 second. In 1936 Wardill declared that the ridge remained erect throughout speech and did not relax until the velum returned to its position of rest. Calnan did not agree and noted no radiographic evidence of this assertion.
5. Its fatigability. Passavant’s pad becomes fatigued. In some adult patients with cleft palate, a well-marked ridge may be seen on the posterior pharyngeal wall on phonation of “ah.” If this sound is repeated at one-second intervals, the ridge becomes less marked and eventually unrecognizable after a few minutes. In sharp contrast is the effortlessness of normal rapid speech, which can be uttered at a rate of more than 60 words per minute for several hours.

Calnan’s concluding statement in 1954 was:

That Passavant’s ridge can and does occur in association with cleft palate is recognised; that it is a factor in normal speech is denied.

In 1957 Calnan’s continued interest in the truth about Passavant’s ridge stimulated him to collect further information. In 1956 Ardran and Kemp had studied a series of bulbar poliomyelitis patients using cineradiography. In one case, when the constrictor muscles of the pharynx were paralyzed, a Passavant’s ridge appeared on swallowing. In no case was a Passavant’s ridge seen when the posterior pillars of the fauces were paralyzed. The implication was that the palatopharyngeus muscle, not the superior constrictor, produces the ridge.

These findings, along with other data, caused Calnan to admit:

The ridge has been found to be of muscular origin but the muscle responsible for it has not yet been settled.

Calnan’s final conclusions in 1957 were consistent with his previous stand, but his emphasis had shifted:

In only four cases (of 158 cleft palate patients) did Passavant’s ridge make contact with the levator eminence of the elevated soft palate, and so play a part in . . . speech. In every patient the quality of rapid conversational speech was spoiled by obvious nasal escape. The adenoid pad is more important than Passavant’s ridge, for it is usually sited well above the latter. Adenoidectomy may cause nasal escape in speech irrespective of any damage done to the posterior pharyngeal wall.

He continued:

“Passavant’s ridge” should be mentioned only in small print as a footnote, in works dealing with speech, for its interest as the basis of another medical myth.
In 1968 Carpenter and Morris offered additional evidence that in some individuals the pad’s activity appeared to be compensatory in nature, in terms of the reduction of the velopharyngeal opening and in terms of the appropriate and consistent manner in which this reduction takes place.

In 1969 Raymond Massengill, Thomas Walker and Kenneth Pickrell of Duke University reported that out of cinefluorographic films of 190 postoperative cleft palates, 18 demonstrated a Passavant’s pad. Although the presence of the pad did aid in velopharyngeal closure, there appeared to be no relationship between the presence of the ridge and the size of the velopharyngeal gap.

It is probably true that in the normal speech mechanism Passavant’s ridge is too low, too slow, inconsistent, inefficient and unnecessary, but in cleft palates, where the velopharyngeal sphincter needs all the aid it can muster, the heroic compensatory action of the superior constrictor muscle and/or palatopharyngeus muscle rucking a ridge may offer some help to a few, and any help is appreciated.

THE OMNISCIENT PASSAVANT

Passavant is best known for his pad, but his contributions outreach this ridge. In his critical evaluation of the results of the von Langenbeck operation, Passavant observed nasal intonation in speech following successful closure of the cleft palate. He ascribed this deficiency to the inability of the velum to reach the pharyngeal wall and, as early as 1862, began to develop procedures to facilitate closure of the velopharyngeal opening. During his surgical career his ingenuity led him to attempt almost every principle used today to reduce the velopharyngeal aperture. He achieved posterior extension of the palate by suturing the posterior pillars of the fauces together. He created a velopharyngeal synechia. He pushed the palate back. He brought the pharynx forward by folding a pharyngeal flap on itself. He fitted a collar-button obturator into a transverse velar incision to increase posterior projection of the velum. He did indeed spur the evolution of cleft palate surgery with the goal of not merely closing the cleft hole but correcting velopharyngeal incompetence.