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.

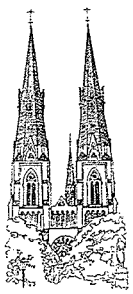
M. Marmy experimented with this operation in dogs' palates and found that, although union was exceedingly tough and almost as hard as bone, no true osseous tissue was formed. M. Ollier clarified the issue:

M. Ollier

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:

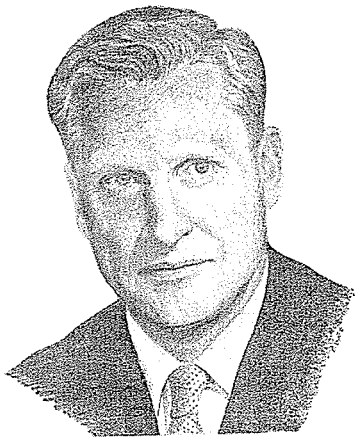
Orthodontists are frequently required to correct cases of malocclusion where the operation for cleft palate has already been performed and there has been a failure in getting union in the anterior portion of the cleft. In the operation that follows there may be some opening of the cleft. Does Dr. Babcock 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.



Tord Skoog

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.

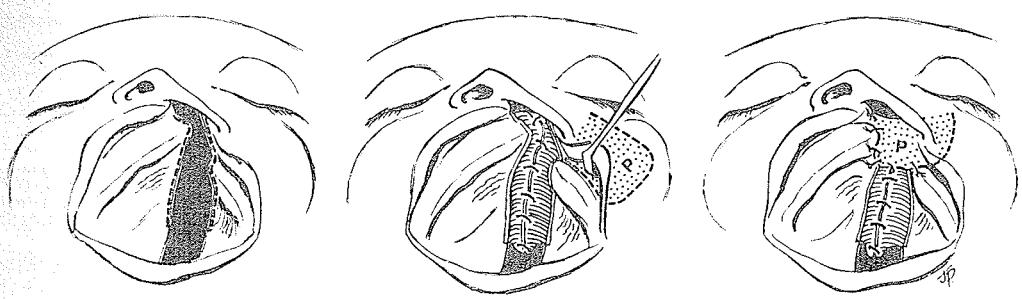
Then in 1967 Skoog reported, in the *Scandinavian Journal of Plastic and Reconstructive Surgery,* the use of periosteum and Surgicel for bone formation in congenital clefts of the primary palate. This principle has become known as the "boneless bone graft."

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:

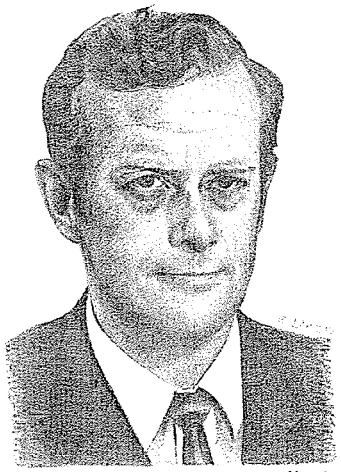
> In a study, using implant techniques, Björk (1966) confirmed that the anterior portion of the maxilla was never a growth site. There is thus little to suggest that maxillary development would be iatrogenically impaired when performing a periosteoplasty.

E. Engdahl

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



Rune Hellquist

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.

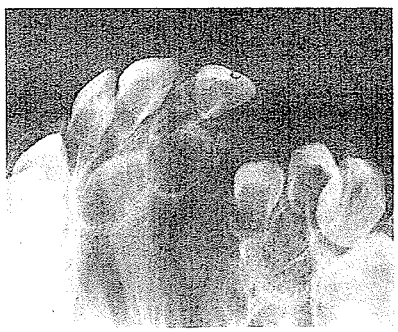
Skoog cited the following as favorable reports on the use of periosteoplasty: "Santoni-Rugiu 1966, 1971, 1972; O'Brien 1970; Bruck 1970; Joss 1972; Jackson 1972, 1973; Ritsilä et al 1972; Tortil 1973; Robbe 1973." He then outlined his 1974 conclusions on his periosteoplasty:

- 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 periosteal 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.

Unilateral cleft



Periosteoplasty at 3½ months; shows bone at 4 months post-op.

In fact, bone formation is not consistent or predictable and thus may require repeated periosteal "flaps" to create enough bone to be functional.

Complete cleft of lip and palate

Periosteoplasty at 3 months shows bone and tooth migration through newly formed alveolar bone at 2 years 9 months of age

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 periosteum 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.

George Joss

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!).

Greater excitement! Paper presented at International Congress, Rome, October, 1967. Permission to publish in *Transactions* refused by Rehrmann.

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

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.

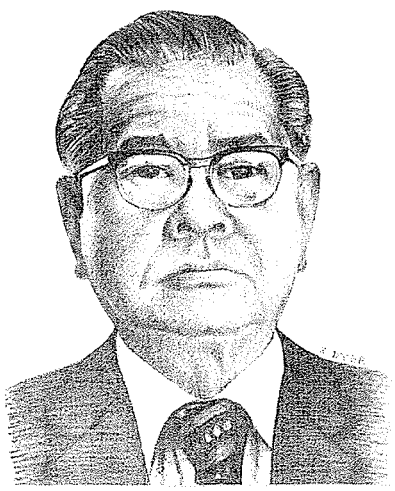
RINTALA

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:

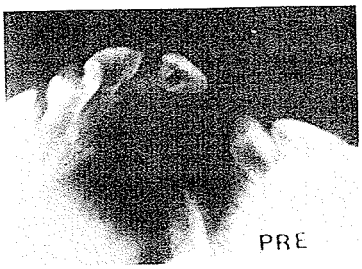
The periosteal flap formed a manifest bone bridge in 54% and a diffuse bridge in 22%, whereas no bone formation was seen in 24%. Whether implantation of Surgicel was performed in the same stage or omitted did not seem to affect bone formation, any more than it did the original width of the alveolar cleft.

OHMORI

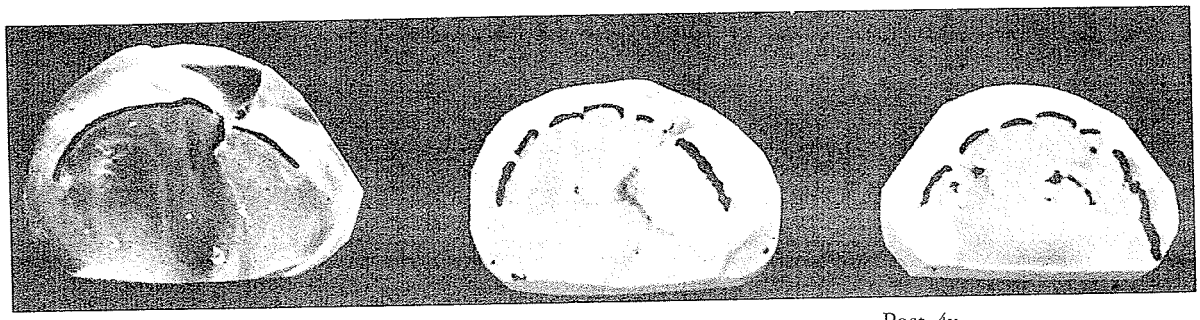
Seiichi Ohmori, the doyen of Japanese plastic surgery and an oriental Marco Polo in reverse, has ventured throughout the world in search of ideas to bring home to develop. Two of them were free flap transfer and Silastic implants in auricular reconstruction, and he is now involved in primary periosteoplasty. 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



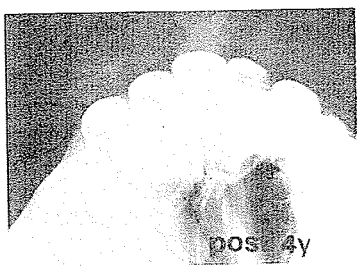
Seiichi Ohmori



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.



Pre Post 1y Post 4y



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:

Peter Holm

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.

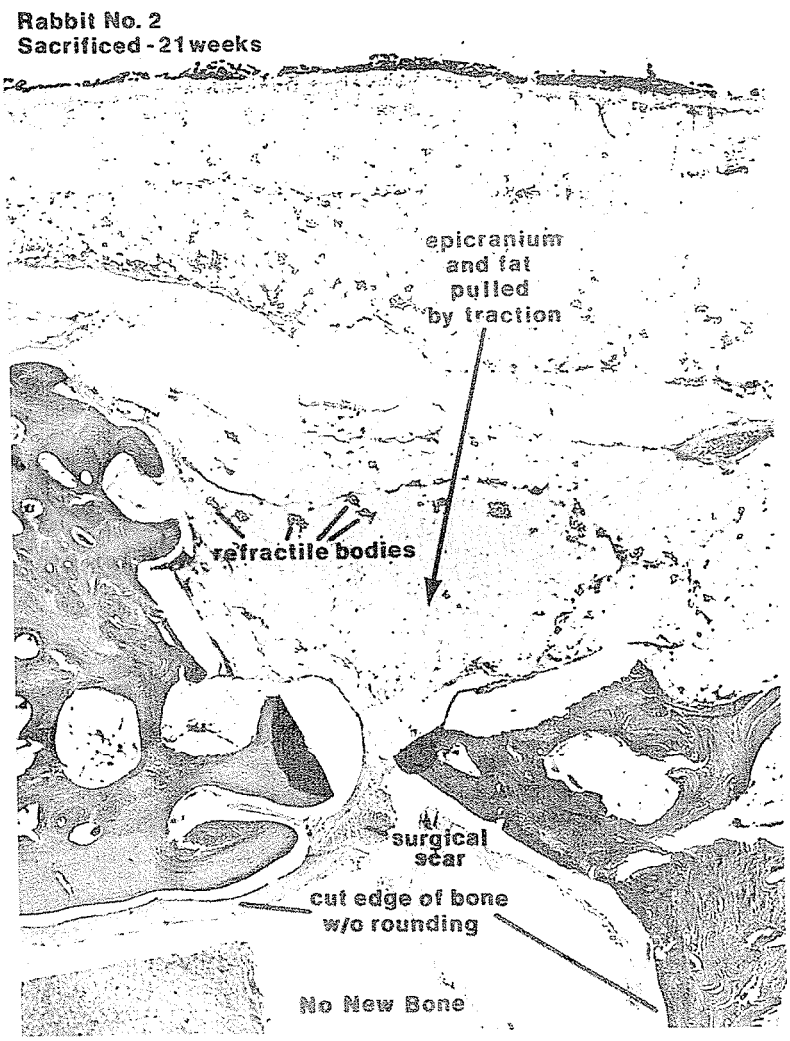
To evaluate appositional growth activity on the buccal aspect of the maxilla, periosteal biopsies from the region of the second deciduous molar on both sides were taken from the same children, revealing reduced appositional growth activity on the cleft side. Alkaline phosphatase reaction was twice as slow on the cleft side as on the non-cleft side. Biopsies of all nine children showed the same result. Biopsies from a conrol 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.

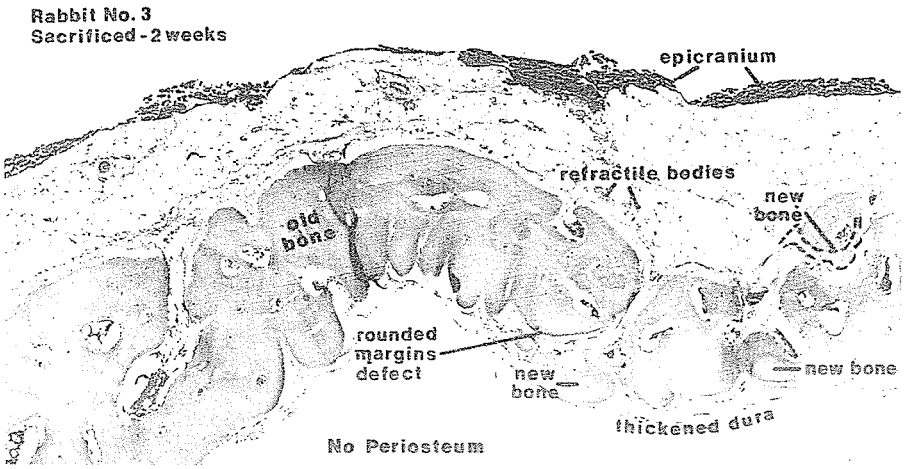
FREE PERIOSTEAL GRAFTS

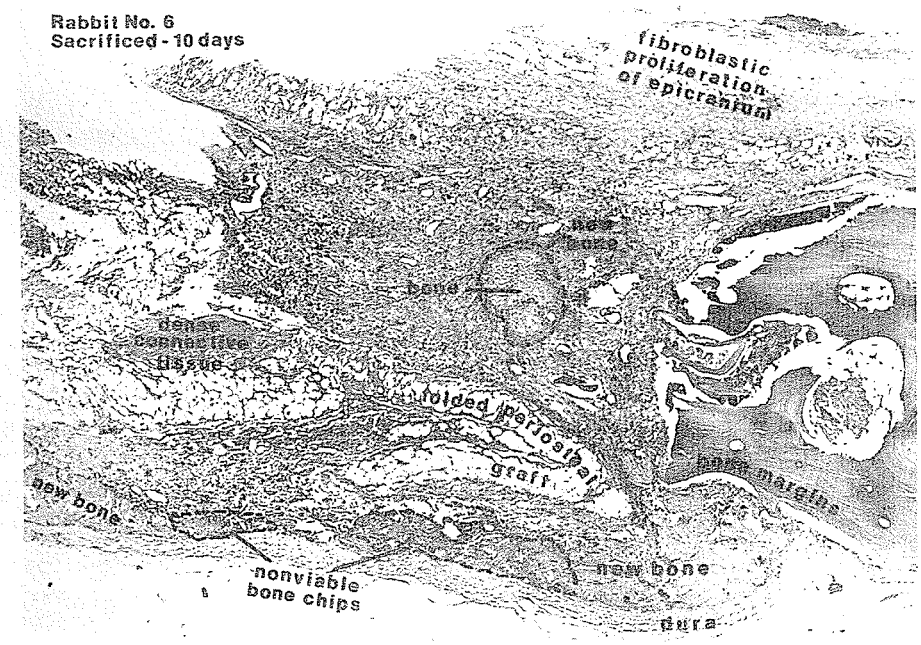
In 1969 at Jackson Memorial Hospital, Miami, Florida, during primary closure of a unilateral cleft lip, a student of Skoog's was available to create a "Skoog" maxillary periosteal flap which was thin and riddled with perforations, not unlike the finest Swedish lace. No bone formed in this cleft, and 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



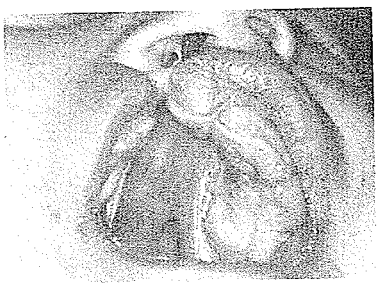
burr hole could be drilled in the skull. A free graft of periosteum taken from the opposite side of the skull was placed in the hole over the dura, osteal side up, and covered with Surgicel. Then the periosteal flap was replaced over the hole in the bone and the scalp closed to duplicate the principle 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.

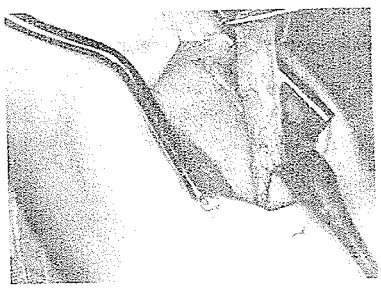


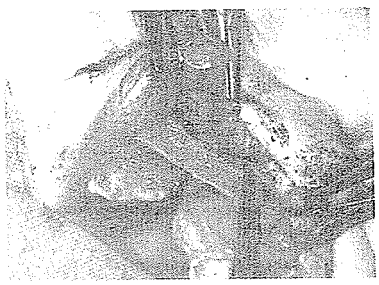


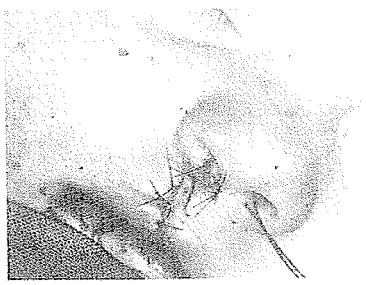
From this experiment it was difficult to show that free periosteal grafts were responsible for new bone formation. When the new bone did form in the periosteal pocket between the graft and the epicranial periosteum, rather than in scar or on the dural side, it was thicker at the edge of the defect and 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.









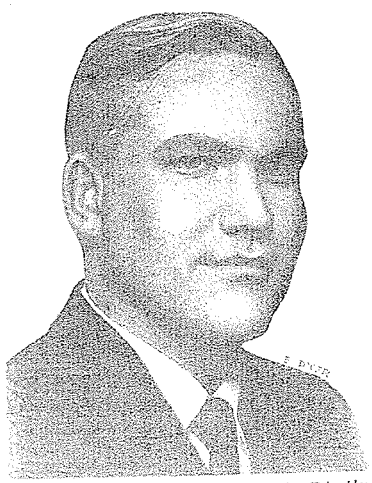
In 1972 the Finnish team of V. Ritsilä, S. Alhopuro, and A. Rintala reported their study of free periosteal grafts. In this first publication on the subject in the literature, they acknowledged the effectiveness of periosteal grafts in forming bone.

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 Ritsilä

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.

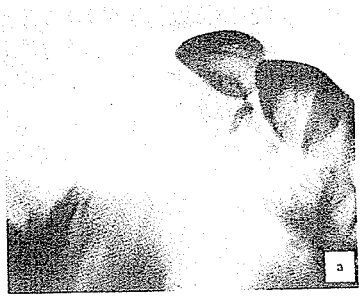
In 1976 he answered my question as to how he got interested in free periosteal grafts by commenting on the difficulty of cutting healthy flaps of periosteum with a wide enough base. Then he added:

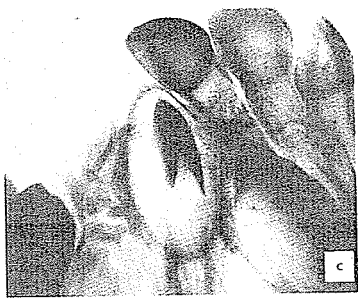
I have thought, too, that in maxillary cleft areas, there is often a growth disturbance per se, and it is unwise to use this "sick" maxillary periosteum from the area. The tibial periosteum has maybe a greater growth potentiality because it is planned to grow more rapidly than the maxillary periosteum. 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 persiosteal 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 undependable, 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.

Affiirmative: 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.

Edward Broadway

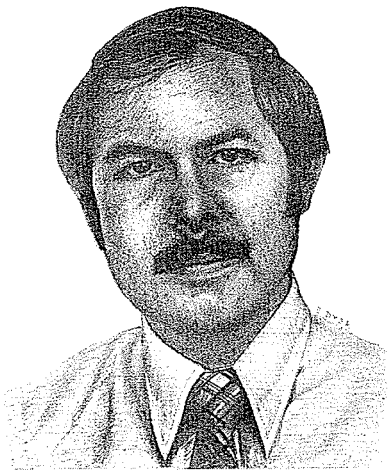
Then a vote was requested from the audience on how many would do primary periosteoplasties on the basis of the data presented and not on whether they had been doing the procedure previously. The show of hands was estimated at one-quarter yes and three-quarters no.

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.



John Finley

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.