Control of the Maxillary Arch by Primary Bone Graft in Cleft Lip and Palate Cases

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As long ago as 1917, in a lecture to the Medical Society of London, it was stated by that sage of plastic surgery the late Sir Harold Gilles, "losses must be replaced by kind: bone for bone, cartilage for cartilage, and skin for skin", and, although this recommendation is not rigidly adhered to today owing to the use of silastic implants which appear to be inert, there is still a great deal to be said for adhering to his principle.

The application of this recommendation may be used to advantage in the patient with a total cleft of the primary and secondary palate (*3*). In the majority of these cases, there is a deficiency of both hard and soft tissue, and this lack of tissue must be adequately restored in order that the patient may be made functionally competent and aesthetically acceptable.

Restoration of the lip can usually be accomplished by the local transference of tissue. For example, the quadrilateral flap technique of Hagedorn (*2*), which he first used in 1892 and which was popularized by Le Mesurier (*4*), and the rotation advancement method of Millard (*6*) provide results which are near to normality. With both of these methods, adequate length of the lip may be attained at the expense of the width. By this manipulation of local tissue, an acceptable lip closure can be satisfactorily carried out.

Unfortunately this does not apply to the underlying bones. In order to emulate normality, it is necessary to restore the deficiency by supplementation. Autogenous bone grafts using bone from the 6th, 7th, or 8th rib (according to the amount of material required) forms a bony strut across the alveolar cleft.

Presurgical Orthopedic Correction

If a stress factor has been operative during the critical formative period of the middle third of the face (that is to say, between the fifth and tenth week of intrauterine life), which has caused a temporary cessation in growth, a cleft of the primary and secondary palate may result.

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It is interesting to note that, at this early fetal age, the deformity is limited to the cleft itself, but when the baby is born at full term the malformation is much more severe. The increased malformation is caused by a disruption of the normal pressures and counter-pressures which control the growth of the splanchnocranium. The interstitial growth of the nasal septal cartilage, which is unrestricted because there is no restraining counter-pressure from the lip in consequence of the cleft, pushes the premaxilla forward and laterally in the unilateral cases, and forward beyond the limits of normal arch alignment in bilateral cases. To add further to the deformity, the tongue, from the tenth week of intrauterine life, frequently invades the cleft and forces the lateral segments outwards. The overall picture at the time of birth, therefore, is gross deformity.

The first essential, in the control of the maxillary arch in these cases is to correct the malpositioned segments.

Presurgical orthopedic correction as advocated by McNeil (*5*) and Burston (*1*) does much to improve the shape and the size of the maxillary arch. After three to four months of arch correction, using intraoral corrective dental appliances and extraoral traction to retract the malpositioned premaxilla, the repositioned segments usually present an improved bony foundation (Figures 1 and 2) for the plastic surgeon to carry out soft tissue closure of the lip and primary palate (Figure 3).

At birth, the maxillary segments are in a state of equilibrium (that is, they are at rest within the soft tissues) and to reposition the bones disturbs this state of balance and in consequence the presurgically corrected arch is in a state of mechanical instability. Soft tissue closure of the lip assists in the retention of the corrected premaxilla, but unfortunately the contraction of the circumoral musculature which has been incompetent until lip closure, together with the pressure of the closed lip and the contracture of the scar tissue, frequently exerts an excessive medial pressure on the lateral segments which may cause the arch to collapse (Figure 4). It is essential, therefore, that this medial pressure be negated.

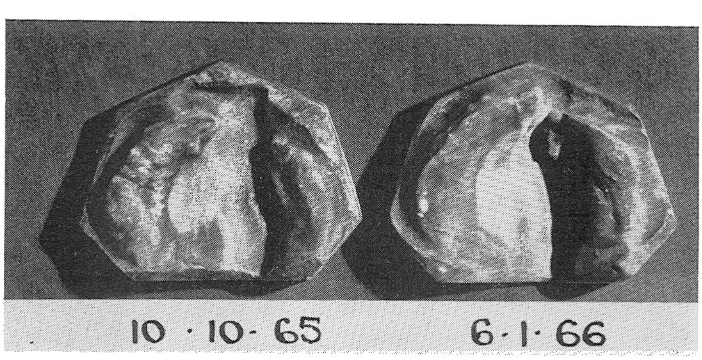

FIGURE 1. *Left:* At birth. *Right:* After presurgical orthopedic correction.

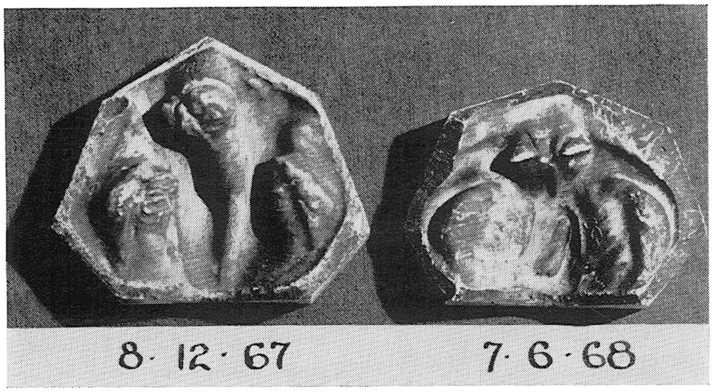

FIGURE 2. *Left:* At birth. *Right:* After presurgical orthopedic correction.

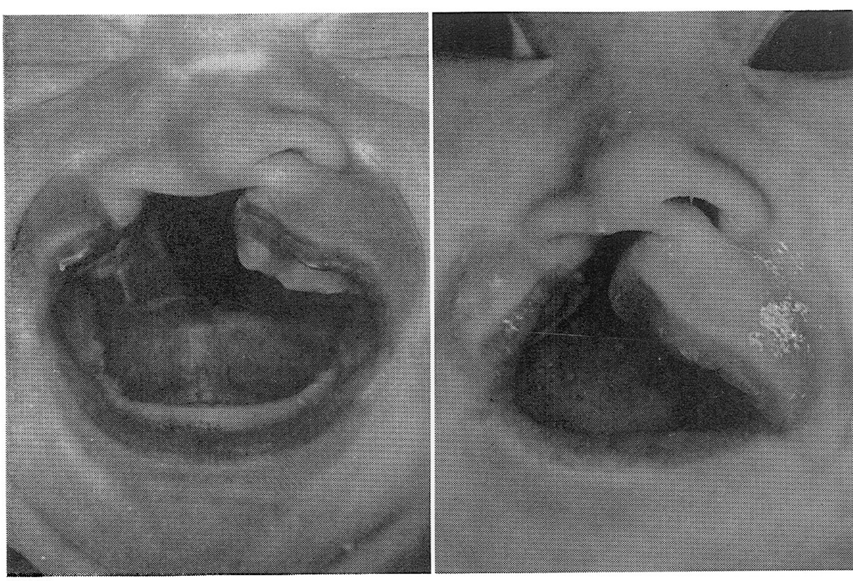

FIGURE 3. *Left:* Soft tissue appearance at birth. *Right:* After arch correction.

The use of retaining splints is one method of preventing postoperative collapse, and the baby usually tolerates the appliance until about eight months of age. At this time, the deciduous dentition is usually erupting and the splint becomes an increasing irritant. Also, at this time, the infant becomes intolerant to the wearing of any intraoral appliance. It is from this time of eight months to three and a half years, by which time the deciduous dentition has fully erupted, and a satisfactory intraoral appliance may be inserted, that the necessity of wearing a retaining splint is of great importance, and it is during this period, owing to the baby's intolerance to it, that the lesser segment may collapse.

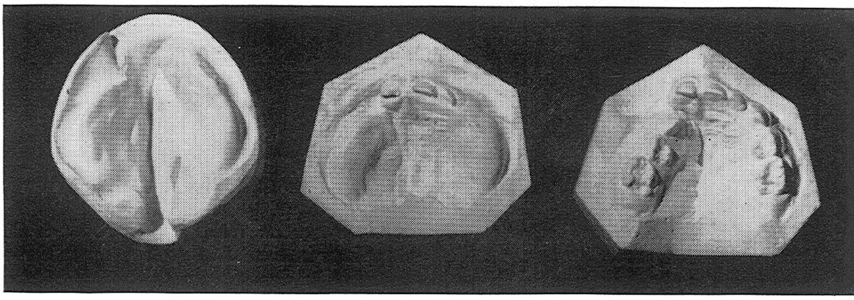

FIGURE 4. *Left:* Position of segments at birth. *Middle:* After presurgical correction. *Right:* Collapse of the lesser segment, two and a half years postsurgically.

The alternative method of preventing postoperative arch collapse is to insert autogenous bone into the alveolar cleft at the time of lip closure. A bed for the bone is created by using a split vomer flap as advocated by Stellmach (*8*), and chipped rib bone is then inserted into the alveolar bed as far back as the incisive foramen and upwards and laterally to support the depressed ala base. The lip is then closed over the chippings.

Preoperative plaster of paris models are kept to record changes in the shape of the maxillary arch and this serialization is carried on postoperatively at two monthly intervals. The overall picture of the serialized models is that the bone graft prevents collapse of the arch (Figure 5).

Radiographic examinations using occlusal films are carried out preoperatively, at one month postoperatively, and then at six monthly intervals in order to determine any change in the structure of the bone in the grafted area.

The presurgical films show the width of the cleft, which is helpful in determining the amount of rib bone to be resected and also allows the teeth at the cleft margins to be studied (Figure 6, left). One month postsurgically, the chippings can be seen filling the alveolar cleft and extending as far as the affected ala base to help to balance the nares (Figure 6,

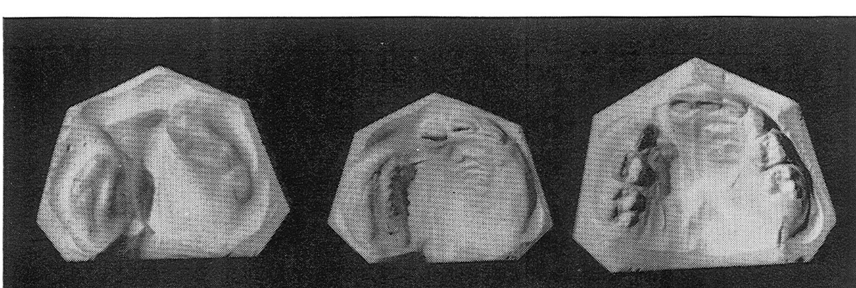

FIGURE 5. *Left:* Position of segments at birth. *Middle:* Position of segments after presurgical correction. *Right:* Three years postsurgically, the arch is retained in the presurgically corrected position due to stabilization by the bone graft.

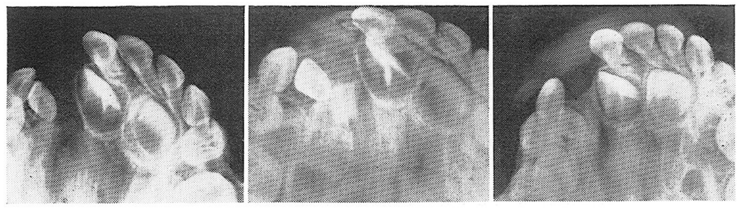

FIGURE 6. *Left:* Presurgical occlusal film showing the width of alveolar cleft. *Middle:* One month postoperatively, the rib chippings in situ. *Right:* The graft three years postoperatively. The grafted bone has attained a density equal to that of the approximating alveolar bone.

middle). Six months postoperatively, the chippings have coalesced into solid bone. At 18 months, it is usually found that there is a degree of resorption on the labial aspect of the grafted area but the grafted bone within the alveolus attains a density which, it is thought, must prevent collapse of the arch (Figure 6, right).

Twenty primary bone graft cases were studied where the deciduous dentition had erupted, and it was found that in four of these cases the canine teeth had erupted lingual to the lower arch, and in one of these cases both molar teeth and the canine teeth were within the lower arch. If one assumes, possibly incorrectly, that the lingual disposition of the canine tooth indicates a collapse of the lesser segment, this means that in these twenty bone graft cases there was approximately a 20% collapse of the arch. However, close examination of occlusal films showed that the grafted bone was continuous and of equal density with the approximating alveolar bone. This suggests that there was no true collapse of the lesser segment after the bone graft, but that the segments at the time of grafting were fixed in an adverse position. In other words the segments were fixed without adequate presurgical arch correction (Figure 7).

It is essential, therefore, that the maxillary segments are in good arch alignment prior to the fixation by bone graft, because faulty positioning at the time of bone grafting perpetuates the deformity and leads to future orthodontic problems which are very difficult to correct (Figure 8).

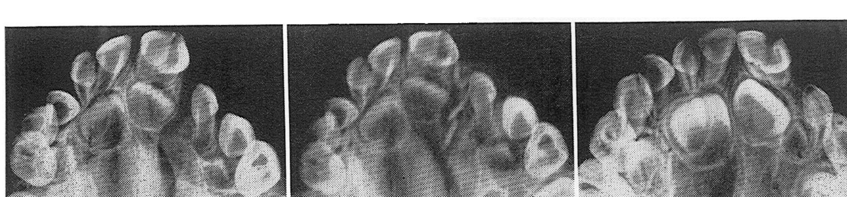

FIGURE 7. *Left:* Presurgical position of the segments. There has been inadequate arch expansion in this case. The left lesser segment is medially disposed. *Middle:* Fixation of the segments by bone graft in the adverse position. *Right:* Perpetuation of the deformity allowing BC to erupt lingually to the lower arch. *Note:* There has been no further medial collapse of the lesser segment postoperatively.

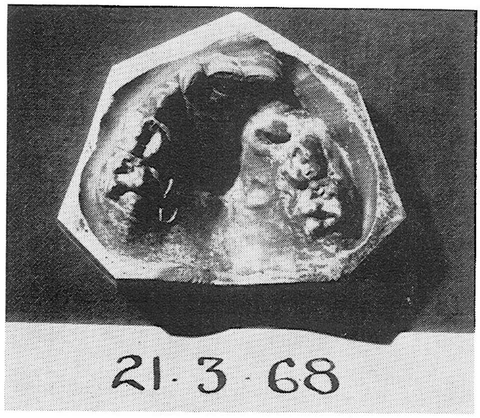

FIGURE 8. Perpetuation of the deformity by fixing the segments in an adverse position by the bone graft.

Growth Imbalance

The second essential factor in the control of the maxillary arch in these cases is the harnessing of the imbalance of growth.

Normal development of the head as a whole is the result of the interaction of a number of separate growth forces. Sutural bone growth is stimulated by the widening of the sutures caused by the growth of the several cartilagenous masses within the skull. The spheno-occipital and the spheno-ethmoidal synchondroses are, in part, responsible for the growth of the cranial base. The nasal septal cartilage is responsible for the sutural growth of the middle third of the face and the condylar cartilages for the growth of the mandible. As the several cartilagenous masses increase their size by interstitial growth, so the different bones which surround them are separated one from the other, causing a widening of the sutures which, in turn, causes bone to be deposited at the cambial layer by osteoblastic action.

Sutural bone growth, however, is but one facet of the complex development of the head. As the several synchondroses are growing, so the soft and hard tissue structures are enlarging, each of which has to be provided with accommodation within the skull. The growth of the eyes, the brain, the tongue, the formation of the alveolar processes which grow to support the developing teeth, and the formation of the paranasal air sinuses, which are no more then epithelial dimples at birth, are all simultaneously developing. But because the soft tissue organs are not growing at the same rate, so the bones that house them grow at different rates. In order that space is provided for these growing organs, the bones of the skull grow by apposition and resorption as well as by sutural growth, and each growing organ and each synchondrosis is growing concurrently in a state of delicate and coordinated balance which is ultimately to be finalized as the adult head.

It follows, therefore, that in the cleft palate patient from the tenth week of intrauterine life to the time of birth the detached lateral segment has lost seven months of growth potential in consequence of its detachment from the nasal septal cartilage and this loss of growth is irretrievable.

Postnatally, the lack of growth of the lesser segments continues but may be minimized by orthopedic correction. However, after lip and primary palate closure, at two to four months of age, to the time of ossification of the nasal septal cartilage, at four to four and a half years, the detached segment continues to lag behind developmentally. Growth does not cease completely because there is growth by apposition and resorption, but inevitably there is a three dimensional lack of development due to its detachment from its cartilagenous pacemaker.

A survey of 24 non-bone-graft cases was made and it was found that, of the 24 cases examined, sixteen had a reversed overjet. That is, the lower anterior teeth were in advance of the upper. In other words, they were prognathic (Figure 9). The remaining eight cases were in normal occlusion. The incidence of prognathia was, therefore, 66%.

The term prognathia is in fact a misnomer because the mandible, within the genetic variations of normality, is of normal size and it is the maxilla which is underdeveloped. The maxillo-mandibular relationship would be better described, therefore, as pseudo-prognathia.

In order to minimize this tendency to pseudo-prognathia, it would appear to be logical that the earlier the lesser segment is harnessed to the growth potential of the nasal septal cartilage by the bone graft the less the loss of growth will be and, in consequence, the final facial deformity will be reduced proportionally.

It is preferable, therefore, that the primary bone graft be inserted as soon as the baby is ready for the operation. There are three essential

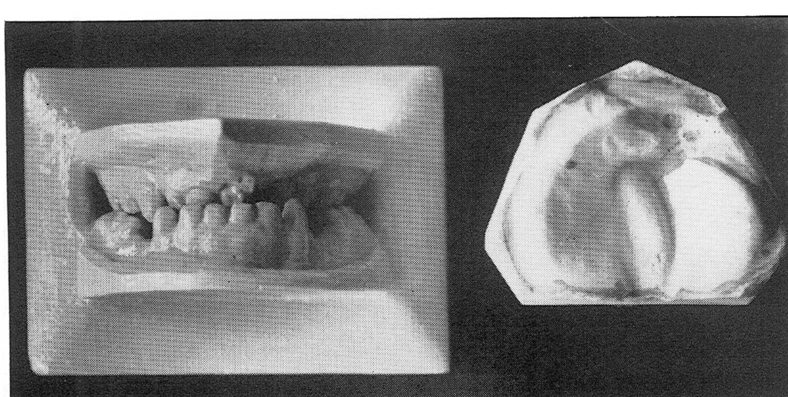

FIGURE 9. Reversed overjet in a soft tissue closure case caused by growth imbalance due to the lesser lateral segment being detached from the stimulus of the nasal septal cartilage.

factors to be considered. First, the baby's weight must be ten pounds or over; second, the baby must be healthy; and third, the maxillary segments must be in good arch alignment prior to the fixation by bone graft.

The length and the severity of the operation has been offered as a contraindication for carrying out surgery at this early age. However, in all cases the baby has been returned to the ward in good condition and the length of the operation is only prolonged by a quarter to half an hour as compared with that of soft tissue closure only, provided that a competent assistant is carrying out the rib resection at the same time as the plastic surgeon is preparing the lip for closure and the bed for the bone graft.

At this time, 38 cases have been treated in this way, and from this number 20 were selected for examination. The number of cases to be examined was limited to 20, because in the remaining 18 cases the deciduous dentition had not fully erupted and an accurate assessment of the maxillo-mandibular relationship could not be made.

Of these 20 cases examined, it was found that three had a reversed overjet, that is to say they were pseudo-prognathic. In one case, the incisal relationship was edge-to-edge and, in the remaining 16, the overjet was normal (Figure 10). In other words the incidence of pseudo-prognathia or reversed overjet was 15%. This figure shows a marked improvement on the non-grafted cases which had a 66% incidence of pseudo-prognathia. From this comparison, it would appear that the marked reduction in pseudo-prognathia in the grafted cases indicates that the bone graft, in uniting the lesser segment to the greater, brings the whole of the middle third of the face under the growth stimulus of the nasal septal cartilage. In other words, the middle third of the face grows as one unit.

In the noncleft population the incidence of reversed overjet is 1%. This is remarkably low when compared with the 15% incidence in the bone grafted cases. But when it is remembered that the cleft palate case has lost seven months of growth potential in utero, the discrepancy becomes

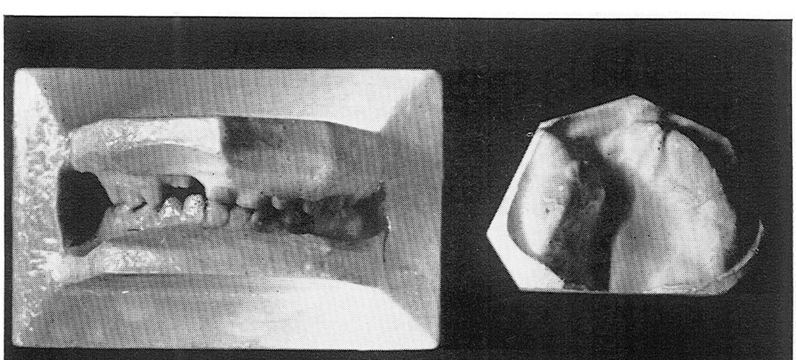

FIGURE 10. Normal occlusion resulting from improved maxillary growth in a bone graft case.

understandable, because, as has been mentioned previously, this loss of growth is irretrievable.

In the study of the maxillo-mandibular development of the head, lateral skull cephalostats are used to measure variations in growth.

For the purpose of this discussion, four bony points are essential for determining these variations: Point *S,* the center of the sella turcica; point *N,* the nasion (the anterior end of the fronto nasal suture); point *A,* the deepest point in the premaxilla between the anterior nasal spine and the prosthion; point *B,* the deepest midline point on the mandible between the infradentale and pogonion. Variations in the angles SNA and SNB will indicate the anteroposterior relationship of the maxilla to the mandible, that is, the skeletal base relationship may be determined (Figure 11).

The use of these cephalostats to compare the variations in the growth of the bone graft and non-bone-graft cases has proved to be very informative. In the cases of soft tissue closure only, the difference in the angles SNA and SNB was, on average, 4.35°. In the bone grafted cases, all of which had the bone graft inserted two or more years previously, the difference in the SNA and SNB angles was on average 9.3°. This shows a marked improvement in the maxillary growth of these patients, as compared with those which had not been bone grafted.

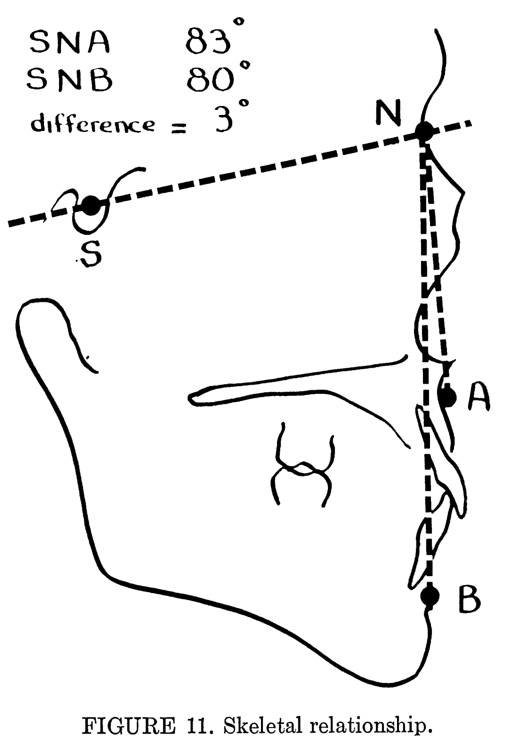

FIGURE 11. Skeletal relationship.

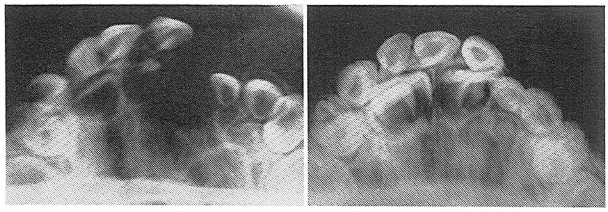

FIGURE 12. *Left:* Width of the cleft preoperatively. *Right:* Two years postoperatively. There is a marked migration of the teeth into the grafted zone.

Improvement of Interdental Articulation

The reduction of the incidence of reversed overjet due to the harnessing of the growth potential of the nasal septal cartilage in bone graft cases improves the interdental articulation. Further to this improvement, however, it is observed, using occlusal films, that teeth which have formed at the margins of the cleft (Figure 12, left) tend to migrate into the grafted zone (Figure 12, right). This migration improves the position of the teeth within the arch.

Boneless Bone Grafts

It has been suggested that a simplified operation may be used to control the maxillary arch in these cases. Joss[1] has demonstrated the technique of *boneless bone grafts.* He concluded his demonstration with the very interesting query, "Is primary bone grafting already outdated?"

The operation described was the same as that of Stellmach (*8*) insofar as the split vomer flap was used. However, having made a perichondrial bed for the bone graft in the alveolar cleft region, bone was not inserted and it was left to the chondroblasts, which, under favorable circumstances, are converted into osteoblasts, to generate their own bone, and, in so doing, the alveolar cleft was bridged by bone.

This operation would appear to be steering the middle course. It satisfies the advocates of soft tissue closure only, and also those who prefer to bone graft. The operation provides a two layer soft tissue closure in the alveolar cleft region which, according to Muir (*8*), is of the utmost importance in order to minimize the scar tissue in this essential area. Also the intervening space is ultimately filled with bone.

However, there would appear to be two possible contraindications for the non-insertion of bone. First, there must be a period of up to six months delay for the bone to be formed, and this means a six months' loss of growth potential of the detached lesser segment, and second, during this period of six months, there is a lack of stability of the lesser segment and in consequence it may collapse medially. One of our cases, treated in this way is, in fact, beginning to collapse two months postsurgically (Figure 13). It is, of course, too early to forecast the future

[1] George S. Joss, personal communication and demonstration, 1968.

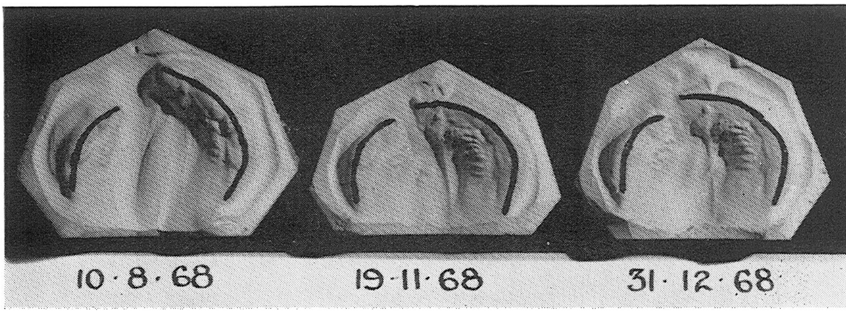

FIGURE 13. *Left:* Condition at birth. *Middle:* Position of segments after arch correction. *Right:* Medial movement of the lesser segment six weeks postoperatively.

success or failure of this technique, and the final results could be very interesting insofar as they could end the controversy as to whether to bone graft or not to bone graft.

Conclusion

It is not yet possible to assess the long-term benefits of primary bone grafts, as it will take several years before definite conclusions can be made. The final results can only be assessed by the approximation to normality in the adult head. However, after four and a half years of post-surgical follow-up using the serialized models, occlusal films, and cephalostats, the interim conclusions are that the primary bone graft a) prevents collapse of the maxillary arch; b) brings the detached segments under the growth mechanism of the nasal septal cartilage and, therefore, encourages the middle third of the face to grow as one unit; and c) improves the interdental articulation by the reduction in the incidence of pseudo-prognathia and by the tendency of the teeth which have formed at the cleft margins to migrate into the grafted zone.

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