Section III. Orofacial Growth and Dentistry

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A Historical Perspective

In the late 1960's and early 1970's, the period when primary bone grafting and maxillary orthopedics were in vogue, an objective of much neonatal clinical treatment for cleft lip/palate was to "make things anatomically correct." That is, the goal was to align maxillary segments as early as possible, then, hopefully, to stabilize this segmental relationship with bone. With little supporting data the proponents of this philosophy claimed many benefits from maxillary orthopedics such as: stimulating palatal growth, preventing maxillary palatal malformations caused by dental crossbite, aiding surgical repair of the lip and palate, improving infant feeding and weight gain, satisfying the psychological needs of the parents, and improving speech development. This treatment philosophy was readily accepted because of its strong emotional appeal. It was hoped that well documented clinical research would soon be forthcoming which would determine the validity of the claims.

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Early Bone Grafting

The insertion of bone grafts as a primary procedure originated in Europe in the mid 1950's. The graft was usually of autogenous rib which was inserted into the alveolar area via a buccal approach. Often presurgical realignment of palatal segments was performed between birth and 12 weeks of age. The lip and soft and hard palate clefts were all closed at various intervals before two years of age. Critical reviews of these procedures were missing from the literature until recent times. Robertson (1968, 1973) revised his treatment procedures after finding that children with bone grafts had poorer occlusion and facial development. Since there was a greater incidence of anterior and buccal cross-bite in the grafted series, he concluded that primary bone grafting not only failed to prevent maxillary collapse but that the reverse was true. By the 1970's, many who had earlier advocated the procedure had abandoned it because their results showed a negative effect on the growth of the maxilla and midface. From a five-year study of a bone-grafted series, Jolleys and Robertson (1972) concluded that no advantages existed for the procedure. To the contrary, they found reduced antero-posterior maxillary development with an increased incidence of crossbites. Robinson and Wood (1969) and Matthews, Chir, and Broomhead (1970) had strong doubts about the benefits of primary bone grafting. Peat (1974) did not recommend bone grafting for stabilizing the maxillary palatal position after orthopedics but suggested that it might have a place as a secondary procedure after six years of age. This opinion parallels that of Johanson et al. (1974), Hogeman et al. (1972), Matthews (1974), and Obwegesser (1971), all of whom recommended secondary bone grafting after development of the adult dentition, especially as an aid to or-

thodontic and prosthetic reconstruction. There are still some advocates of early bone grafting: Fara (1972), Schroder (1973), Matthews (1974), Nylen et al. (1974), Schmid et al. (1974), Monroe (1974), and Rosenstein (1975). None of these investigators found attenuation of maxillary development in patients who had undergone bone grafting.

Presurgical Orthopedics

The controversy concerning the effects and advisability of performing neonatal arch manipulation has not been settled. Emphasis now, however, is not on whether or not the palatal arches can be manipulated but rather on the utility of the procedure. Although its advocates claim that it tends to normalize feeding, tongue posture, and swallowing and to guide physiological growth of the palatal segments, no conclusive evidence has been reported to support these claims (Rosenstein 1973). Hotz (1973) indicates that they used maxillary orthopedics to induce arch form changes prior to lip surgery. The appliance was worn full-time after lip closure until the appearance of the first deciduous molars. As a rule three plates were necessary. Active expansion was restricted to narrow bilateral cases or to unilateral clefts with overlapping segments. Although good occlusal results were seen in the deciduous and early mixed dentition, arch instability was a problem, and they admitted to some arch collapse when retention was removed. No claim of growth stimulation was made although maxillary development fell within the range of normal variation. This appears to contradict Fish (1972) who alleged that palatal growth in infants with post-alveolar clefts could be stimulated. Huddart and Bodenham (1972), and Huddert (1974) described favorable short-term results (prior to lip closure) but felt that, at the age of five, pre-surgical orthopedics had not preserved improvements in occlusion or arch form. Norden et al. (1973), comparing the occlusal status between a group of children who had neonatal orthopedics and primary bone grafting and a group that had neither found no significant difference in the incidence of cross-bite between the groups but still advocated its use. O'Donnell et al. (1974) claimed a more favorable occlusal relationship in the deciduous dentition as a result of early orthopedics. Rosenstein (1975) cited less dental cross-bite after neonatal manipulation and went on to state, "It is still too early for a definitive yes or no but hopefully, we think orthopedics is of value." Others, however, are not taking a wait-and-see attitude and have already come to definite conclusions about the procedure. Robertson (1973) reported a significantly better occlusion in his orthopedic group when compared to non-treated cases and concluded that the difference in long-term results may be due to the quality of surgery. Graf-Pinthus and Bettex (1974) decried a dearth of long-term follow-up studies on this procedure which has been in vogue for more than 20 years. They observed that the presurgical manipulation of the palatal segments did not appear to reduce the time required for later orthodontic therapy. Peat (1974) did not recommend orthopedics for complete unilateral cleft lip and palate (CUCL/P) cases since he found no better arch relationships during the deciduous dentition in treated than in non-treated children.

It is important to stress that, in *all* of the long-term evaluation studies on early arch manipulation, the presence of dental cross-bite of the canines and/or buccal teeth was still evident albeit to a lesser degree. Troutman (1974) evaluated his neonatal expansion cases and found that in over-expanded cases a greater number ended up in buccal cross-bite relationship than when no active expansion was attempted. Most of these studies identified problems in arch form retention leading to a deterioration of the occlusion after primary bond grafting.

Presurgical Orthopedic Appliance as a Feeding Device

Feeding infants with palatal clefts is often laborious and time-consuming. Many devices with various shaped nipples and special designed liquid containers have been introduced to improve feeding. These have met with variable degrees of success.

Studies by Drillien et al. (1966), Good-

stein (1961), and investigators at the Hospital for Sick Children in Toronto, Canada (1960), have shown that height and weight of children with clefts of the palate is lower than in siblings or other controls. A significant correlation has also been found between severe feeding problems in infancy and below average weight in later childhood.

One of the major benefits claimed for presurgical orthopedics is its function as a feeding appliance. A study by Pashayan and Lichtenstein presented at the 33rd American Cleft Palate Association meeting in 1975, described the growth pattern of infants with unilateral cleft lip and palate treated with presurgical oral orthopedics as measured by weight gain, height, and head circumference. It demonstrated consistent weight loss in the first month of life, followed by slow weight gain through infancy and childhood at 18 months. Weight gain was below the 3rd percentile on the growth charts. This same pattern was noted for measurements of body length, but head growth measured by head circumference followed a more normal curve. Their conclusion was that the presurgical oral orthopedic appliance was not effective as a feeding appliance since it did not provide a means for adequate intake to support normal general body growth. The authors postulate that its use as a feeding appliance may actually be detrimental as it may provide a *false sense of security* to parent, dentist, and physician. They noted further that anxiety might be aroused concerning the fit of the appliance. Feeding failures were documented in cases where the infant had multiple congenital malformations or chromosome abnormalities or when the mother had not accepted the child born with a cleft. In the latter case, correction of the emotional problem led to success.

Presurgical Orthodontics and Its Effects on Middle Ear Infections

There are no new data to support the beneficial use of prosthetic obturators on middle ear disease. The old data regarding the effects of variation in treatment such as prosthetic obturation versus surgical closure and time of surgery are rather equivocal.

The Questionable Advantages of Neonatal Orthopedics

1. An Aid to Palatal Growth and Development?

There is no conclusive evidence that neonatal orthopedics stimulate soft tissue or palatal development beyond its normal growth capacity or that the persistence of a moderate cross-bite during the primary dentition adversely influences maxillary growth (Bergland, 1973).

2. An Aid to Infant Health and Growth?

Pashayan and Lichtenstein (1975), in an unpublished study of children who had undergone presurgical orthopedics, reported no significant feeding benefits without supportive nutritional counselling. No evidence has been reported to support the thesis that tongue function is abnormal in the presence of a cleft and is normalized as a result of oral orthopedics thereby enhancing infant feeding.

3. An Aid to the Developing Occlusion?

No studies have been reported which demonstrate that pre-surgical oral orthopedics prevented or greatly reduced the need for orthodontic treatment in the permanent dentition.

4. Satisfied the Psychological Needs of the Parents?

Although there is speculation that the parents feel secure when the appliance is first inserted and are pleased that something is being done, there has been no long-term study to verify this conclusion. In fact, there have been statements made that there may be some anxiety created if the parents find the orthopedic device to be ill-fitting or unacceptable to the child.

Maxillary Orthopedics in the Deciduous Dentition

Troutman (1974) suggested that it is best to postpone maxillary arch expansion until the deciduous dentition is completely erupted and when the children can be more easily managed. Bergland and Sidhu (1974) advocated a delay in orthodontic treatment until the complete eruption of the permanent anterior teeth. Then segmental alignment can be corrected simultaneously with the manipulation of the anterior teeth.

The Relationship of the Clefting Process and Contiguous Skeletal Structures

Some recent studies have suggested that the clefting process does not produce an isolated anatomical defect but may be a syndrome phenomenon with ramifications in contiguous and often remote structures. Dahl (1970), in a study of Danish males, suggested that, in persons with cleft palate with or without cleft lip, there may be ramifications for distant craniofacial structures and their development. Farkas and Lindsey (1972) identified consistent variations in facial morphology in the cleft population and concluded that the cleft defect was not an isolated factor. They reported that the normal side of the face in unilateral cases was not so normal and that the anomaly influenced development of the face equally on both affected and unaffected sides. Chierci et al. (1973) and Bishara (1973 a,b.) found a relative retrusion of the maxilla and mandible as well as increased steepness of the mandibular plane in various cleft types. Krogman et al. (1975) found significant differences in the cranial base size and in configuration and growth direction in the cleft population. They concluded that the clefting process has growth and/or development repercussions for contiguous cranial base and facial structures as well as for the maxilla. Bishara (1975) reported that posterior positioning of the maxilla and mandible relative to the anterior cranial base may result from the influence of the cleft on the contiguous skeletal structures and that clefting affects maxillary development and facial morphology. Hayashi et al. (1976) investigated cranial growth of a large sample of complete unilateral CL/P subjects from four to 18 years of age and found that the cranial base angle was more flattened and the maxilla more retruded and that underdevelopment in both the maxilla and the mandible was more pronounced in cleft females than in cleft males. They speculated that upper face height was less than normal due to interferences with nasal septal growth, suture growth, and remodeling of the nasal floor. Bishara et al. (1976) studied unoperated adult Indians with clefts of the lip and alveolus only, unilateral lip and palate, and bilateral CL/P. They observed that the maxilla and cranial base were not different from a matched normal population and that the relation of the maxilla and mandible to the cranial base varied according to cleft type.

Mandibular Development

Recent studies have revealed a series of oftentimes subtle differences in the morphology of the mandible in persons with CL/P. Dahl (1970) and Chierci et al. (1973) found that, in clefts of the hard palate only, the mandibular plane was steeper and the gonial angle more obtuse than in a normal population. Mazaheri et al. (1971) noted that mandibular length and width were significantly smaller in CP only than in CL/P and normal groups. While Aduss (1971) observed that the mandibular gonial angle in unilateral CL/P patients was more obtuse and the anterior cranial base appeared to be elevated, Rosenstein (1975) found the mandibles to be smaller with steeper mandibular plane angles. Bishara (1975) studied Danish children with repaired cleft palate only. In this and again in a later study (1976) of patients with unilateral complete CL/P, he noted that the mandible was significantly more posterior when related to the cranial base and its mandibular plane steeper than normal. Krogman et al. (1975) found no difference in mandibular dimensions in the bilateral CL/P population other than their having a more obtuse gonial angle. They also found the temporo-mandibular joint to be more retropositioned so that its effective length was less than in the normal population. Robertson and Fish (1975), comparing mandibular arch dimensions, showed no significant differences between normal and cleft children either at birth or at three years of age.

Orofacial Growth

1. *The Neonatal Cleft Palate: Is it Deficient in Mass and/or Displaced in Space?*

Dahl (1970) stated that the cleft maxilla was positioned more posteriorly within the skull than in normal faces. The findings of Huddart (1970) indicated that palatal segmental displacement and palatal tissue deficiency existed in both the unilateral and bilateral CL/P. Mazaheri et al. (1971), us-

ing zerographic techniques to study serial cases with cleft palate only and those with cleft lip and palate, demonstrated laterally expanded palatal segments in the latter cases. From cephalometric observations Momma et al. (1973) stated that, in complete clefts, the maxilla was smaller in all dimensions. However, Bishara (1973 b), in a study of adults with unoperated clefts, concluded that, although the palates were geometrically displaced, they had developed within normal limits. Troutman (1974), without describing the mechanism, concluded that some cases of complete unilateral CL/P had collapsed arches. Peat (1974) indicated the neonatal cleft palate when it involves the lip can be displaced either laterally or medially and only rarely may be deficient in mass. However, Wada and Miyazaki (1975), studying complete unilateral CL/P, found that the neonatal palatal size was within normal limits in all three dimensions. Ortiz-Monasterio et al. (1974) showed that unoperated complete cleft adults demonstrated good facial growth although the palatal segments were displaced laterally. Nakamura et al. (1972) found significant difference in maxillary and mandibular dimensions as a function of sex. Berkowitz et al. (1974) measured various cleft palate casts three dimensionally using stercophotogrammetry. He demonstrated that the cleft palate was geometrically distorted in all frames of space and that, in complete clefts of the lip and palate, the lateral segments were laterally displaced.

2. *The Phenomenon of "catch-up growth"*

Mapes et al. (1974), in a serial study of patients with repaired cleft lip and palate, concluded that non-traumatic palatal surgery permitted the acceleration of the maxillary growth rate so as to reach more normal dimensions within the following years. Robertson and Fish (1975) came to the same conclusion after measuring complete unilateral CL/P segments. They detected a relative deficiency in some palatal segments as determined by their widths and noted that this relative deficiency decreased within three years to approach normal size. Berkowitz et al. (1974) demonstrated that, in the complete bilateral cleft lip and palate patient, the palatal surface area doubled from birth to 1 1/2 years of age. Also, in an isolated cleft palate of a Pierre Robin Syndrome, there was a 50 per cent increase in palatal surface area from birth to 1 year of age. This rate of change gradually tappered off in both instances.

Animal Studies as They Relate to Habilatative Technology and Orofacial Development

1. *Lip Repair*

The influence of soft tissue forces on skeletal growth was the topic of several studies. Ritsila et al. (1973), for example, reported on an investigation using two-week-old rabbits in which the normal median cleft of the upper lip was closed by paring the edges, approximating, and suturing. No other surgery was performed. At six months, there was "slight shortening" of the maxillas, "marked shortening" of the body of the mandibles, and alterations of several mandibular angles.

Duker and Harle (1974) reported effects of other soft tissue manipulations on growth of the maxilla. The study involved surgery in the right vestibule and/or upper lip in three groups of normal four-week-old inbred rats. The group having only a linear incision in the vestibule showed slight but significant deflection (0.6 degrees) of the snout toward the operated side when sacrified at six months. The group having a triangular excision of vestibular mucosa followed by closure with "the advancement technique" showed a deflection nearly five times as great, and those with a repaired excision which included lip tissue showed a deflection six times as great. No observations of changes in maxillary length or dental occlusion were reported.

Questioning the assumption that lip repairs have little influence on anteroposterior growth of the middle face, Bardach and Eisbach (1977) reported findings from an experiment which entailed monitoring of postsurgical lip pressure and subsequent midfacial growth. Drawing on results from a methodological study by Verwoerd-Verhoef (1974) in which rabbits

were used as subjects, the authors created unilateral clefts of the lip, alveolus, and hard palate in three groups of six-week-old rabbits. Comparisons of pressure and facial growth data from (a) an unoperated control group, (b) a group in which the clefts were created but not repaired, (c) a group in which the lip was repaired by the Millard technique, and (d) a group having a Bardach type repair, led Bardach and Eisbach (1977) to conclude that pressure exerted on the alveolus by the repaired lip was considerably greater than normal in the early postsurgical weeks and probably contributed an additive retrusive influence to that already provided by the surgical creation of the clefts.

2. *Palate Repair*

In a set of related experiments, Latham et al. (1973, 1974) and Calabrese et al. (1974) tested the hypothesis that new tissue could be induced to form in the growing face by application of appropriately controlled physical stress. The first experiment, in weaning dogs with surgically created clefts of the posterior hard palate, involved gradual closure of the cleft by use of a pinned-screw appliance. The eight mm. wide clefts were closed in about two weeks. Since the clefts had been limited to the medial parts of the horizontal process of the palatine bones, the mobilized segments had been allowed to move by adjustments in their suture systems. Histologic examination confirmed that new bone had been formed and resorbed as necessary to maintain skeletal continuity. The authors suggested that their results demonstrated the potential usefulness of techniques utilizing judicious application of physical forces to facial joints.

A subsequent study by Latham et al. (1974) elaborated on the same theme by creating an "artificial suture" which was then subjected to gradual separation. This experiment also used weaning dogs with surgically created clefts of the hard palate, but clefts here involved palatal processes of both the palatine and maxillary bones with additional transpalatal cuts through oral mucosa and bone medial to the molar alveolar processes. The gradual closing of pinned-screw appliances accomplished closure of the midline clefts in seven to 10 days with formation of new bone in the lateral osteotomy sites.

In a third experiment, Calabrese et al. (1974) used a similar technique to accomplish snout lengthening in a small group of young dogs. A series of transverse osteotomies was used to sever the skeleton of the anterior part of the snout from the posterior part and divide the nasal septum. A pinned-screw appliance attached to the palate was then gradually opened between 10 and 16 days to produce five to eight mm. divergence of the osteotomy margins. Marked maxillary protrusion was seen in each animal. The pups were sacrificed four to eight weeks after surgery. The cleaned skulls showed bridged bone across the osteotomy sites and new cartilage in the septal cartilage gap. The authors suggested that elaborations of techniques such as this might provide useful alternatives to some of the procedures now used in correction of congenital and posttraumatic deformities.

Kremenak et al. (1976) reported a series of follow-up studies based on earlier work showing that surgical denudation of palatal bone adjacent to deciduous teeth in dogs had resulted in inhibition of maxillary growth (1970, 1971). The more recent efforts by this group focused on the contraction phase of early healing of surgical wounds on the canine palate first to establish whether such contraction actually occurred in palate wounds then, if so, how it might be regulated to clinical advantage (Kremenak et al. 1974, 1975, 1976).

Olin et al. (1974) reported acceptance of the hypothesis that early postsurgical contraction in palatal mucoperiosteal excision wounds was similar to that previously reported for skin wounds (Gabbiani and Badonnel 1976, Madden et al. 1974) and presented data based on measurements between tattoo points on wound margins on hard palates of young beagles. Those data indicated that tattoos on margins converged by 15 to 40 per cent of their original distance during early healing, while similar markers in unwounded areas diverged eight to 12 per cent in the course of normal growth of the palatal mucosa. It was also

noted that major interruptions of increases in arch width coincided with the period of soft tissue contraction leading the authors to suggest that postsurgical wound contraction was the first link in a causal chain leading eventually to secondary skeletal deformities.

Kremenak et al. (1976) reported further evidence that the contraction seen in palatal mucosa was analagous to that reported in healing of skin wounds. Data were from one study in which attachments between wound margins and central granulation tissue were periodically severed resulting in reduction of both contraction and jaw growth aberrations; from another in which gingival attachments of teeth adjacent to wounds were periodically severed resulting in unimpeded contraction but reduced jaw growth aberrations; and from another in which it was shown that transplantation of autogenous free grafts of other oral mucosa into hard palate mucoperiosteal excision wounds resulted in reduction of contraction and was followed by normal or "supranormal" increases in maxillary arch width (Koopmann et al. 1975).

Additional follow-up studies, by the same group, aimed at elucidation of the mechanism of contraction showed that granulation tissue from palatal wounds in young dogs contained abundant myofibroblasts between postsurgical days 5 and 15 (as identified by electron microscopy; and that the cells contained actin-like protein as demonstrated by immunocytochemistry) (Kremenak et al. 1976).

3. *Contractility in Non-Muscle Systems*

It is becoming apparent that the factor of contractility in some types of nonmuscular connective tissue cells may be a common denominator for research on surgical wound healing as well as for research on normal and abnormal growth and function in the craniofacial complex. A large body of recent literature deals with advances in understanding of contractile phenomena. Much of it is collected in recent bibliographical review (Morris and Kremenak, 1976). Reports by Madden et al. (1974), Gabbiani and Badonnel (1976), and Azuma et al. (1975) serve as excellent overviews of this area of inquiry.

Dentition

Supernumerary teeth or aplasia occur more frequently in cleft lip and palate children than in normal children (Bohn, 1963). The incidence reported has varied in different papers because it is difficult to distinguish between variations from congenital causes and those related to surgery. Recently, it has been observed that supernumerary teeth are more common in the primary dentition while aplasia is considerably more frequent in the permanent dentition (Byloff-Clar and Droschl, 1972; Ranta, 1972; Ringqvist and Thilander, 1975). The incidence of supernumerary teeth is greatest in cases of cleft lip only and decreases as the extent of the cleft increases. The relationship is the opposite in cases of aplasia, i.e. incidence is lowest for cleft lip only and cleft palate only and increases proportionally with the extent or complexity of the cleft.

An explanation for variation in the number of involved teeth is that the initiation of the cleft lip is thought to produce a fold in the dental lamina and the attached tooth germ causing the formation of extra tooth germs. A larger defect in the alveolar process could result in aplasia due to rupture of the bilameller dental epithelium (Bergland et al., 1975). This theory may even explain why the lateral incisor sometimes develops in the premaxilla and at other times in the lateral cleft segment. It would depend upon whether the rupture occurred on the distal or mesial side of the tooth germ. A fold in the dental lamina could affect the permanent central incisor on the cleft side and cause it to be rotated or tipped and often to have abnormal form.

In association with facial clefting, dental development is, except for the third molars, delayed for all teeth, both maxillary and mandibular (Ranta, 1972, 1973 a,b). Asymmetrical development of tooth pairs with delayed development on the cleft side was recorded in approximately half of a group of children with congenital L/P clefts (Haataja et al., 1972). This agrees with the observation that eruption is delayed in both dentitions on the side having

a cleft (Ranta, 1971; Ringqvist and Thilander, 1975). Delayed eruption and asymmetrical development in the dentition of the cleft children may be due to nutritional disturbances and surgical intervention. The most probable cause, however, is doubtless a genetic factor which is responsible for the occurrence of the cleft and the associated malformations. Zilberman (1973), from a study on clefts of the lip and alveolar structures, and Mirsa et al. (1972), after investigating clefts of the lip and palate, reported that unilateral clefts are more frequent on the left side and are more common in males than in females. Both found increased frequency of dental abnormalities in the area of the cleft. Zilberman found an equal number of supernumerary medial fissured teeth in both sexes. The distal fissured tooth was more frequent in males. Mirsa reported that the most frequent missing tooth in the line of the cleft tended to be lateral incisors rather than central incisors. Zilberman also noted that the incidence of tooth agenesis was higher in males than in females, and the size of the maxillary incisor on the cleft side was smaller than this same tooth on the opposite side.

The incidence of malocclusion reported in patients with CL/P has varied widely in studies by Huddart and Bodenham (1971), Hellquist (1973), Norden et al. (1973), Bergland and Sidhu (1974), Nylen et al. (1974), Ranta et al. (1974), Hellquist and Skoog (1976). This may be due to the fact that the patients had varying types of clefts and had been classified at different ages. Rehrman et al. (1973) found the incidence of malocclusion in the mixed dentition to be twice that found in the primary dentition.

In cases of cleft palate only Ranta et al. (1974) found but a slight increase in the occurrence of anterior crossbite at the transition from the primary to the mixed dentition. A noticeable increase in the incidence of anterior crossbite in the mixed dentition in complete unilateral CL/P cases was reported by Bergland and Sidhu (1974) irrespective of the arch configuration in the deciduous dentition. They also reported that palatal segments stabilized early after lip repair and that further collapse was unusual. Contrary to the findings cited above, Nylen et al. (1974) found no increase in anterior crossbite frequency in a mixed dentition group.

The Protruding Premaxilla in Complete Bilateral Cleft Lip or Lip and Palate

It has been suggested that the nasal septum attached to maxillary components is responsible for normal midfacial growth. Burston (1958) speculated that, should the lateral palatal segments be disconnected from the nasal septum, they would be deprived of their growth impetus and in the neonatal period would be permanently underdeveloped and even retroplaced. Bergland (1973) denied this role for the nasal septum. He reported that, in complete bilateral clefts of the lip and alveolus with intact palates, the premaxilla was protrusive but that the palate size was within normal limits. In these instances the septum was detached from the normally developed palates, and the protrusion of the premaxilla was interpreted as representing a premature release of the normal growth pontential of the septum. The premaxilla apparently reached its geometric position within the skull at an earlier time. Yet, the palatal segments followed a normal growth rate. Pruzansky (1971) used metal implants on either side of the premaxillary-vomerine junction to demonstrate cephalometrically that this region was a major site of overgrowth. He suggested that the overgrowth was probably a secondary reaction to the lack of restraint from the cleft orbicularis oris muscle. The findings of Pruzansky were supported by Friede (1973) and Atherton (1974) who described the premaxillary vomerine suture as resembling other facial sutures. Bone apposition was observed at this suture, and this was interpreted as resulting from tension creating forces. Latham (1973) reported that premaxillary protrustion was identifiable as early as the 10th week in utero. He suggested that a contributing factor in producing the projecting premaxilla was the shortening of the septopremaxillary ligament which drew it forward. Friede and Morgan (1976) con-

firmed the presence of small islands of cartilage in the suture. These were secondary occurrences resulting from mechanical stresses.

Management of the Protruding Premaxilla

Findings by Bishara and Olin (1972) supports the conclusions drawn from earlier facial growth studies (Pruzansky 1953, 1955; Subtelny, 1955; Berkowitz, 1959) that the protruding premaxilla tends to be molded back by lip pressure and can in some instances be aligned within the lateral palatal segments without the need to resort to palatal orthopedics.

They stress that surgical set-back of the premaxilla be avoided at the neonatal period. Hanada and Krogman (1975) from a longitudinal study on the soft tissue profile of bilateral CL/P from birth to 6 years of age reported that the profile became more harmonious in appearance with growth. They concluded that early dento-facial orthopedics was not a necessary precursor to lip and palate closure for profile changes. Most clinicians agree that atraumatic conservative surgery is not the cure-all for correcting complete bilateral CL/P and advocate the respositioning of the premaxilla only when the facial growth pattern dictates that it is the procedure of choice. Some investigators still contend that it is more advantageous to bring the premaxilla into alignment as soon as possible. Atherton (1974) reports that there is nothing inherently wrong with resorting to orthopedic or surgical repositioning of the premaxilla at the neonatal period. The type of operation which slides the premaxilla over the vomer would appear to have few drawbacks and permit the subsequent growth at the bony surfaces of the premaxilla-maxilla suture. He stated that a prominent premaxilla when compared to the lateral palatal segments, as seen at birth, does not become more prominent with age. However, Rosenstein (1973) believes that surgical retropositioning was a warranted technique in only extreme situations. Graf-Pinthus and Bettex (1974) after serial investigators of the effects of combining early surgical setback of the protruding premaxilla with bone grafting concluded that this procedure interfered with maxillary growth. Attempting to establish objective measure from cast analysis for determining when early premaxillary retropositioning might be justified, Friede and Pruzansky (1973) proposed that surgical setback at the time of lip repair be performed when the distance between the anterior margins of the maxilla and the pre-maxilla exceeded 20 mm. When the protrusion was less and when soft tissues permitted, lip closure without setback was the procedure of choice. The strength of this approach was that it left to the surgeon the option of late setback or excision based on the dynamics of function and growth.

The purpose of and procedures for retropositioning the premaxilla by physical means have received special attention from many investigators. Viale-Gonzalez et al. (1973) reported that they rarely used external elastic traction to reduce premaxillary projection prior to lip repair when using a one-stage surgical procedure. Georgiade and Latham (1973, 1975) proposed the use of intraoral traction to attain a rapid retraction of a severely protruding premaxilla with or without collapsed maxillary segments. Unfortunately, long-term effects of this procedure have not been reported. Peat (1974) cautioned against too much external pressure being exerted against the premaxilla for retraction purposes so that the nasal septum would not buckle and create a concave profile. He stressed the importance of maintaining a convex facial profile in the early years to allow for increased flattening of the facial profile as the mandible develops.

The Effect of Periosteoplasty on Maxillary Growth

In 1965 a technique was described by Skoog which was claimed to encourage bone bridge formation over the alveolar cleft space either by using a pedicle flap from the maxilla and septum or by the use of the so-called free periosteal graft taken from the patient's tibia (a preliminary evaluation of this technique was given by Ritsila et al. (1972). Bone growth has been reported by Rintala et al. (1974) and

Hellquist and Skoog (1976) in about 50 per cent of the cases. To enhance bone growth Skoog (1967) and Thilander and Stenstrom (1974) have suggested the use of surgicel in the cleft area, however, Rintala et al. (1974) reported that there was no conclusive evidence that it encouraged osteogenic activity.

Prosthetics

In two papers by M. Mazaheri and E. Mazaheri (1973 and 1974), a thorough description outlining the indications and contraindications for and the evaluation of speech prostheses was presented. Emphasis was placed on the need for the early diagnosis of velopharyngeal inadequacies. They stressed in particular that the success of palatal-lift appliances depends upon gradual velar elevation as well as early treatment. The basic procedures involved in the construction and design of such a prosthesis have changed little since their use was first described.

Many recent reports acknowledge that the palatal lift prosthesis improves velopharyngeal competency in slected cases. Kipmueller and Laney (1972) reported that the palatal lift and modified palatal lift have a marked effect on intelligibility of speech as shown by the reduction of errors in identifying consonants by untrained listeners and judgments of improved skills in articulation by trained listeners.

Holley, Hamby, and Taylor (1973) reported that the palatal lift prosthesis can help control nasal air flow by reducing lumen size, thus reducing hypernasality. Both of these studies used lateral cephalometrics and recordings to evaluate results.

Clinicians utilizing speech prostheses appear to rely greatly upon auditory impressions for verification of success. There is a strong need for using objective measuring devices to determine not only if the prosthesis is successful but also whether it is functioning at its optimal level. While the two-dimensional lateral cephalometric film has limited value, it is useful in assessing a three-dimensional lumen. The use or abuse of prosthetic management depends to an extent on the clinician's knowledge of the non-linear relationship between palatal incompetency and speech performance.

Weiss and Lewis (1972) described the technique of applying pressure indicator paste to complement judgements of acoustically perceived hypernasality and nasal emission in an attempt to be more accurate in assessing where and how much to reduce the pharyngeal segment of an obturator. They reported that a speech prosthesis cannot totally compensate for bad speech habits acquired by having a faulty speech mechanism.

Fletcher, Sooudi, and Frost (1974) evaluated "nasalance" with an instrument called Tonar II. These authors measured the degree of pretreatment nasalance in speech and suggested modifications to the palatal lift appliance in order to gain full benefit from the prosthesis.

Long-term results in patients treated with the palatal lift prosthesis are lacking. Since velopharyngeal incompetency is due to a variety of etiologies, the effectiveness of palatal stimulation still needs to be determined.

Future Studies Which Are Needed

1. Evaluate maxillary orthopedics as to the amount of resources expended in relation to and correlated with the advantages achieved to determine if any psychological benefits are gained by the parents and if any benefits accrue to the infant in feeding, tongue function, and speech development.
2. Compare dental relationships and maxillary development at various ages according to original cleft type, extent of clefting, sex, type and timing of surgery to the type of oral orthopedics utilized.
3. Determine the growth potential of the palatal shelves and if it is the same in each cleft type. Is "catch-up" growth characteristic of all cleft types?
4. Evaluate the type and timing of surgical procedures with respect to the most harminous relationship to normal growth and development.
5. Assess the long-term effects of palatal lift prostheses.

A Plea for Multi-Institutional Collaboration – the Time Has Come

Even though it is impossible to define and control all of the variables which de-

termine the success or failure of rehabilitative procedures (such as the kind of palatal surgery that has been performed) the time has come for inter-institutional collaboration in order to perform in-depth studies of longitudinal records that are presently in storage and have been studied only in part. Unfortunately, because of the lack of funds and pertinent technology necessary to perform both quantitative and qualitative studies of palatal casts, much important information goes unappreciated or unnoticed with respect to the nature of the cleft defect and the influence of surgical procedures on facial and palatal development.

Large-scale computer studies may be expected to assume an increasingly important role in cleft lip and palate research. Nevertheless, researchers without this technology but using the present state of knowledge and time-tested investigative techniques can continue to make significant contributions. Of specific value are long-term follow-up studies of cases grouped according to cleft types, extent of clefting, age, sex, type and timing of surgery, and orthopedic procedures performed. By taking meticulous care to document results from studies of individuals from birth to adulthood, pertinent data can be compiled to establish the inter-relationships among the various treatment modalities and facial development. Meaningful commentary can then be made about the various philosophies underlying clinical decision making.

Diligent clinical reporting coupled with large-scale statistical analyses can lead to a consensus in clinical treatment, answer many basic questions about the natural history of the cleft defect, and lead to significant new questions which have not yet been considered.

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