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Expansion in Cleft Patients

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ABSTRACT

Expansion in cleft palate can be done by: Symmetrical widening and differential widening. The orthodontist in his therapeutic armamentarium has several effective expansion appliances including the W-arch, Quad helix, Hyrax, etc. In selecting the appliance of choice, certain prerequisites are required like it must be closely adapted to the palate, it should not be bulky, it should be easy to clean and it should act as retainer for long period of a time. After closure of a cleft lip and palate, the patient often experiences a collapse of the maxillary fragments, resulting in a poor occlusion and an inability to chew properly. While early surgical intervention improves the patient's quality of life lip repair and Closure of the palatal cleft also tend to constrict the maxilla and produce anterior cross-bite. The resulting maxillary deficiency is probably the most common problem observed in such cases.

Keywords: Expansion, Expansion appliance, Cleft lip and palate

INTRODUCTION

Angle taught that ideal occlusion requires a full complement of teeth and that an ideal occlusion provides such functional efficacy that it will be sufficient to ensure a permanent result. Thus arch expansion to such a degree as to accommodate a full complement of teeth was thought to be the only way to ensure treatment stability [1].

A major portion of the treatment rendered in any orthodontic practice is concerned with lack of space – the transverse and sagittal crowding of teeth within the alveolus. Orthodontic philosophies over the years have vacillated between a strict non-extraction approach and an approach, which requires the extraction of teeth [2].

Since the only undisputable yardstick for measuring success in orthodontic treatment is the appearance and stability of the case, a substantial time out of all retention has to be given its due importance [3].

Basic considerations in maxillary translation

The maxilla can be considered as a bone held within the facial area of the skull by a series of calcified bony inter digitations [4], some of which are permanently connected to other bones of the cranium, such as the frontal, zygomatic, and palatal bones, by connective tissue fibers which form the suture system. In simple terms the bones can be moved in any of three ways- laterally, anteriorly or posteriorly but not medially without extensive resorption of sutural bone margins. Appreciable lateral movement of the maxilla requires, first, forces sufficiently high to either exceed the tensile strength of or induced changes in the sutural connective tissues so that they no longer resist movement of bones, and, second forces which overcome the extramaxillary muscular and interdigital occlusal forces. The latter may with the changing relation of bones, then become a factor contributing to translation of the maxilla.

If the maxilla is to be moved anteriorly, the same sets of potential resistances are present, but here the interdigitations of the sutures may come into closer contact so that they oppose movement. In this situation there are two alternatives; (1) continued application of force with the objective of inducing resorption of bony serrations so that the two bones eventually slide across one another; and (2) separation of the bones so that the sutures no longer interdigitate followed by anterior translation of the maxilla. The second approach appears to be the logical choice.

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The nature of sutures

Sutures [3-8] are structures joining two bones by a connective tissue complex which has its peripheral fibers inserted into the calcified bone margin. Different forms of sutures, adapted to the local tensions and pressures exerted on bones are found in the skull. Sutures permit translation of bones and marginal addition of bone tissue during growth and development as well as movement of bones relative to one another during muscular function. That is to say, sutures have two functions: (1) they act as sites of secondary growth; and (2) they provide a shock-absorbing system which protects the cranial contents during normal bodily function.

The maxillary sutures differ in different species, at different ages, and range from essentially two thin flat plates of bone in the young rat to the highly convoluted and interdigitated system in man. In the latter form, one projection of the bone margin is located within the socket provided by two projections from the opposing side and the arrangement of connective tissue fibers is similar to that seen in the periodontal space.

Changes are produced primarily in the underlying skeletal structure rather than by the movements of teeth through alveolar bone. It not only separates the mid palatal suture but also affects the circumzygomatic and circummaxillary suture system. After the palate is widened, new bone is deposited in the area of expansion so that the integrity of the mid palatal suture usually is re- established. Rapid Palatal expansion is the best example of orthopaedic expansion.

Sutural growth and its regulation

The majority of the facial and cranial bones of the vertebrate skull are of intramembranous origin. Growth [5] of these bones takes place by opposition and resorption at the periosteal surfaces and by sutural growth. Reshaping of facial and cranial bones occurs by opposition and resorption at the periosteal surfaces an increase in thickness occurs by a higher opposition than resorption rate.

Expansion of the skull in a growing vertebrate is possible by the presence of cranial and facial sutures. The sutures in the skull have several functions. They unite bones, they absorb forces, they act as joints that permit relative movement between bones, and they play a role as growth sites in the growing skull. Troitzky attributed even bone growth limiting properties to the sutures.

It has been questioned for a long time whether sutures are autonomous or active growth centers, or whether sutural growth is adaptive to the growth of surrounding structures. Advocates of the former view are Massler and Schour, Sicher, Baer and Weinmann and Sicher. These authors claim the sutures to be autonomous growth centers having intrinsic growth potency like epiphyseal plates. Growth takes place by sutural tissue proliferation exerting a separating force on the bony edges. Prahl also believes that sutures are active growth centers. In an overlapping suture the fibers connecting the ends of the bony edges run obliquely. Prahl claimed that shortening of these fibers during maturation can cause separation of the bony edges of the suture.

The other view is held by such authors as Gilblin and Alley, Moss, Young, Scott, Moore, Moss and Salentijn and Hoyte. They consider the suture to be an adaptive growth center, its activity predominantly determined by surrounding structures.

In the view of Moss, the non-skeletal tissues and the functioning spaces of the head, like the periosteal matrix and the growing brain being a capsular matrix, act like functional matrices, which determine skeletal and consequently sutural growth. Young already explained this by stating that intracranial pressure forces are converted by the sutural fibers in tension stimuli, which are known to stimulate osteogenesis. Prahl however, showed that sutural fibers in the coronal suture of young rats are directed in such a way that they can with stand extra cranial pressure forces. Increasing the intracranial pressure initially leads to relaxation of these fibers. Tensional forces will be exerted on these fibers only when the bony edges are separated sufficiently.

In the concept of Van Limborgh which is a synthesis of several earlier theories, sutural growth is controlled by few intrinsic genetic factors and many local epigenetic factors that originate in adjacent structures of the head and the skull cartilages. Furthermore, sutural growth is influenced by local environmental factors occurring in the form of compressive and tensile forces. General epigenetic and environmental factors are thought to play only a minor role.

A comparable view is held by Oudhof. The results of his transplantation experiments suggested that the position and the structures of sutures are determined hereditarily. Environmental factors however are required for these characteristics to develop. Furthermore, Enlow assumed that the genetic information is inadequate to account for the morphologic complexity found in any given bone. Enlow stated that a suture is a growth region with its own localized, specialized circumstances, just as all other parts of the bone have their own regional growth processes.

Response of sutures to extrinsic mechanical forces *in vivo*

Clinical orthodontic techniques involve the correction of dentofacial disharmonies by influencing periodontal and sutural tissues with forces exerted by orthodontic or orthopedic appliances [5].

Sutural tissue response has been studied mainly in vivo on various types of animals of different ages with use of different forces and different load/deflection rates. These studies mainly provide histologic observations of sutural tissue response.

Short-term effects

Investigations of short term effects of force application can be divided into experiments in which a force is applied directly to a single suture and experiments in which a force is applied to the entire maxillary complex.

Direct force application to a single suture

Ten Cate, Freeman and Dickinson exerted an expansion force with a spring on the sagittal suture of adult rats. The maximal opening of the suture was 2 mm. An immediate response consisting of traumatic tears, exudates, death of fibroblasts, disruption of collagen fibers and acute inflammation was observed. Although these effects could not always be demonstrated at the light microscopic level, they were always visible at the electron microscopic level. Within 3 to 4 days, bone formation was observed at the edges of the suture, together with collagen deposition and remodeling of fibroblasts. During diminution and cessation of the expansive force (which took place within 2 to 3 weeks), remodeling of the bone and the suture occurred until normal morphology was re-established.

Several investigators have reported comparable midpalatal sutural responses following rapid expansion in other animal experiments. Further histologic evidence of tissue trauma incident to rapid expansion, notably minor fractures of bony interdigitations, has been presented for monkeys and for human beings.

The severity of the trauma is related to the increase in sutural width, which in turn is related to the magnitude of the exerted force. Following force application, bone formation starts at the bony edges of sutures. The newly formed trabeculae reflect the direction of the expansive force. Ten Cate, Freeman and Dickinson noticed that the first bone, which was formed 3 to 4 days after force application, was laid down in lamellae along the sutural edges. Debbane applied expansion forces to the palatal suture of full grown casts. Woven bone was deposited perpendicular to the matrix of existing bone. Deposition in the suture was unevenly distributed.

Only a few studies are known in which an attempt was made to quantify the relationship between external forces and the resulting tissue response in a suture. In most studies the main objectives were to qualify the ultimate effect of palatal expansion on the midpalatal suture or to describe the effect of extraoral forces applied to the maxillofacial complex, including the sutures.

These effects have been studied in different sutures, in different species, and at different ages. The observations were predominantly of comparative and descriptive histologic nature and have dealt mainly with soft rather than bony tissues.

Adaptation of sutures to altered functional demands can also be observed in transplantation experiments. These studies showed that although a suture has the capacity to grow rather autonomously, sutural bone growth is adaptive to environmental demands. It is understood that an initial traumatic response takes place in the sutures after application of a force. Some authors suggest that this response gives relief to internal stresses and strains that are induced by force application.

After the initial response, a period of growth of the sutural connective tissue takes place. Growth at the bony edges takes place to reestablish the original sutural morphology. Until now little has been known about the mechanisms by which forces are transduced into cellular activity. However, we do know that the response of sutural tissues to mechanical forces is affected by duration and direction of the force, morphology of the suture, and age of the subject.

It is still unknown whether all sutures react in a comparable manner to a given force. In other words, it is still unknown whether (and if so, to what extent) a close response relationship exists between applied forces and resulting biologic tissue response in a suture.

An accurate study of the biologic response of a suture to a force system requires that all aspects of the force system be identified. *In vivo* conditions, it seems impossible to control all force variables that may influence the force system. The complex morphology of full grown sutures makes it difficult to predict how a force is dissipated in a suture. These difficulties in studying the relationship between suture response and force system variable *in vivo* suggest the value of developing an accurate *in vitro* model. Because of the reported traumatic responses, it is important to keep the sutural complex in culture under vital conditions for at least 1 week. With the aid of such an in vitro model, the existence and quality of a relationship between dose and response might be demonstrated. Information gathered from experiments in organ culture under such conditions will lead to a better understanding of sutural growth and its regulation.

The morphologic and biochemical effects on tensile force application to the interparietal suture of the Sprague-Dawley rat

A study was performed to correlate the histologic and biochemical responses of interparietial suture to a range of tensile forces [6]. Stainless steel spring implants, calibrated to generate expensive forces from 50 to 250 g, were placed across the interparietal suture in 85 female Sprague-Dawley rats. After experimental periods from 2 h to 14 days, the interparietal sutures were evaluated by radiography, histology and biochemistry. An *in vivo*/*in vitro* system was used for the biochemical analysis; total protein, proline incorporated, presence of collagen and alkaline phosphatase activity were measured. The radiographs and histological evaluation showed that *in vivo* suture expansion was achievable with 50 to 70 g of force, but heavier forces showed greater sutural opening, more cellular proliferation, and more bone formation. This increase in biological response by the heavier forces was substantiated by an increase in sutural protein and alkaline phosphatase activity but not in percent collagen. It was concluded that changes in the total protein content of a suture were not primarily caused by proliferation of osteogenic cells and fibroblasts but due to an influx of transudate. In contrast, the increase in incorporation of 3H-proline and alkaline phosphatase activity correlated with the observance of bone formation. This study indicated a positive correlation between the magnitude of tensile forces and osteogenic response.

Studies of orthopedic expansion of cranial sutures have carefully documented that the biologic response is a widening of the suture followed by the production of connective tissue components (Hinrichson and Storey, Storey, Cleall and associates, Murray and Cleall, Ten Cate, Freeman and Dickinson). By this remodeling activity, the suture reestablishes a configuration similar to its original form. The remodeling appears to be chemically mediated, but this is not well understood. Because collagen is the major protein of connective tissue, the metabolism of this molecule is important in understanding how tensile forces function.

Cleft is a congenital anomaly with a multifactorial etiology. The human embryo is most vulnerable influences during the first trimester of intrauterine life. Any inductive mechanism, genetic or environmental, that disrupts the organogenetic sequence in fetal development will cause a congenital malformation.

The cleft palate patients require extensive and prolonged treatment from birth to adulthood. This is one area where team approach is very necessary and an orthodontist plays a major role along with an oral surgeon and prosthodontist.

Cleft palate patients exhibit a variety of dental irregularities, the severity of which will be determined by the extent of the deformity and the manner by which it was surgically repaired.

Maxillary incisors rotations, collapsed dental arches, congenitally missing teeth, supernumerary teeth in the cleft area, ectopically erupted teeth, hypoplasia of labial surfaces of the maxillary incisors, arch length deficiencies, anteroposterior vertical problems and midline deviation may be found.

Cross-bites in complete clefts of the lip and palate often have certain characteristics. The medial displacement of the maxillary segments is usually much more severe in the canine region and indeed the molars may be in correct lateral relationship. There is also frequently a deficiency of vertical development, which is worst in the canine region just behind the cleft. Thus there is often a need to widen the upper arch considerably in the canine region but hardly at all in the molar region; in other words to produce differential expansion.

Expansion in cleft palate can be done by:

1. Symmetrical widening
2. Differential widening [7,8]

Symmetrical widening

The orthodontist in his therapeutic armamentarium has several effective expansion appliances including the W-arch, Quad helix, Hyrax, Haas expansion screws to resolve constricted maxillary arches. Of which ‘W’ arch and Quad helix can cause some amount of differential expansion. In selecting the appliance of choice, certain prerequisites are required like it must be closely adapted to the palate, it should not be bulky, it should be easy to clean and it should act as retainer for long period of a time. The ‘W’ arch and Quad helix seems to offer most of the requirements and soon also does not affect the speech of the patients. The only problem may be the amount of expansion possible as some of the patients have a completely collapsed arch.

Differential expansion

A differential palatal expansion appliance was described by Foster and Chinn [9] in 1977, which they modified in 1982. The appliance consists of a cast metal splint on each segment, joined by an expansion screw set in a circular housing on each side; the housing in turn is being fixed to the splints by means of locking plates. The screw is set well forward between the canine tooth and the circular housing consists of swivel joint which allows the segments to rotate. A fan type screw can also be used.

The modification to prevent molar expansion consists of a palatal bar which is linked to the splints in such a way that it allows the segment to rotate but does not allow increase of the intermolar width. The palatal bar is formed from a lingual bar, oval in cross section. Loops of 0.7 mm stainless wire are soldered to the splints on each side in the molar region and these are linked through 6 gauge half round clasp wire soldered to the ends of the palatal bar. In case of more severe discrepancies the screw can be easily changed without much relapse. The advantages of this appliance over the traditional appliance are:

It is capable of expanding the canine region more than the molar region

1. It produces rapid expansion in order to reduce treatment time
2. It is useful in cases where large range of action is required
3. It can be kept clean

Use of nickel titanium palatal expander in cleft-palate cases

After closure of a cleft lip and palate, the patient often experiences a collapse of the maxillary fragments, resulting in a poor occlusion and an inability to chew properly. While early surgical intervention improves the patient's quality of life lip repair and Closure of the palatal cleft also tend to constrict the maxilla and produce anterior cross-bite.

The resulting maxillary deficiency is probably the most common problem observed in such cases **(Figure 1)**.

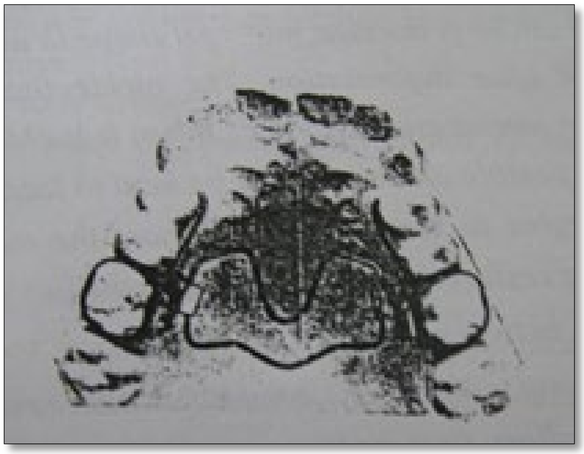

Figure 1. Nickel titanium palatal expander.

Although transverse expansion of the maxilla has been used by orthodontists for more than a century to correct maxillary anomalies, it can be extremely difficult to use cleft-palate patients.

Many clinicians rely on some form of rapid or slow palatal expansion for maxillary transverse corrections. Conventional palatal expanders, besides being uncomfortable for the patients, may require labor-intensive laboratory construction. Furthermore, the intermittent force application makes them inefficient, and they are often attached to maxillary first molars with preexisting mesiolingual rotations that the devices are unable to correct. Such rotation can distort the appliances, wasting much of the potential expansion time until the rotations are corrected.

The Nickel palatal Expander [10], developed by Arndt, produces light, continuous pressure against the midpalatal suture while simultaneously uprighting, rotating and distalizing the maxillary first molars. The action of the appliance is a consequence of Nickel titanium's shape memory and transition temperature effects. Activated by body temperature, the Nickel palatal expander automatically expands to its predetermined shape, requiring little manipulation by the clinician and permitting the patient to mitigate the pressure, if necessary, by drinking a cold liquid.

As with the NPE, the shape memory of the Trans palatal wire is activated by temperature. Below the transition point of 94°F, the metal is flexible enough for bending. After insertion, as the patient's mouth warms the wire, it tends to return to its original shape. The light continues force exerted by the wire assures patient comfort. The cleft palate cases can successfully treated with various sizes and versions of the Nickel palatal expander, using force levels between 230 g and 300 g. The appliance also rotates and distalized the maxillary first molars, but no attempt was made to calculate either the amount of distalization or the relative amounts of orthopedic versus orthodontic expansion.

SUMMARY AND CONCLUSION

To summarize the different directions and methods of dental expansion have certain characteristics in common that related to the technique of expansion and anatomical consideration. All together all types of maxillary expansion, anterior, lateral and posterior are more successful easier to perform and less subject to relapse than are the same procedures in the mandible. Less alveolar bone is present in the anterior segment of the mandibular dental arch than in the maxillary therefore there is lesser degree of freedom to move the teeth. In the posterior segments the ramus reduces the retromolar pad and permits leeway for posterior expansion

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