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INTRODUCTION

Rapid maxillary expansion (RME) is a dramatic procedure with a long history. **Emerson Collon Angell** reported on the procedure in 1860, and since then it has gone through periods of popularity and decline.

This approach was opposed strongly by **McQuillen (1860)** and **Coleman (1865)** who opposed that the separation of the maxillary bones was both impossible and undesirable. Until 1900's claims both pro and con were subjectively based by default, given that the radiographs were not yet available to substantiate the orthopedic expansion of the maxilla.

Haas reintroduced rapid maxillary expansion. His experimental studies in animals (1959) and later clinical studies on orthodontic patients (1961,1965) formed the early foundation of this procedure

INDICATIONS FOR RME:

- Patients who have lateral discrepancies that result in either unilateral or bilateral posterior crossbites involving several teeth are candidates for RME. The constriction may be skeletal (narrow maxillary base or wide mandible), dental, or a combination of both skeletal and dental constriction.

- Anteroposterior discrepancies are cited as reasons to consider RME. For example, patients with skeletal Class II, Division 1 malocclusions with or without a posterior crossbite, patients with Class III malocclusions, and patients with borderline skeletal and pseudo Class III problems are candidates if they have maxillary constriction or posterior crossbite.

- Cleft lip and palate patients with collapsed maxillae are also RME candidates.

- some clinicians use the procedure to gain arch length in patients who have moderate maxillary crowding. Selected arch length problems to avoid the profile disturbances so frequently associated with removal of teeth.

- Cases of inadequate nasal capacity exhibiting chronic nasal respiratory problems.

- According to Bell, the enhanced skeletal response that accompanies RME redirects the developing posterior teeth into normal occlusion and corrects asymmetries of condylar position.

CONTRAINDICATIONS OF RME

- Patients who cannot cooperate with the clinician are not candidates for RME.

- Patients who have a single tooth in crossbite probably do not need RME.

- Patients who have anterior open bites, steep mandibular planes, and convex profiles are generally not well suited to RME.

- Patients who have skeletal asymmetry of the maxilla or mandible, and adults with severe anteroposterior and vertical skeletal discrepancy.

The following factors need to be considered during treatment planning to determine whether to expand the dental arches conventionally or with RME:

- The magnitude of the discrepancy between the maxillary and mandibular first molar and premolar widths; if the discrepancy is 4 mm or more, one should consider RME,

- The severity of the crossbite, that is, the number of teeth involved, and

- The initial angulation of the molars and premolars— when the maxillary molars are buccally inclined, conventional expansion will tip them further into the buccal musculature; and if the mandibular molars are lingually inclined, the buccal movement to upright them will increase the need to widen the upper arch.

ETIOLOGY OF TRANSVERSE DISCREPANCIES

The causes of buccolingual discrepancies could be either genetic or environmental. According to **Graber, Harvold, Cheirici and Vargervik,** many constricted maxillary dental arches are the result of abnormal function.

Harvold in his experimental work created narrow maxillary dental arches in rhesus monkeys by converting them from nasal to obligatory oral respiration.

All patients considered for RME should be examined for nasal obstruction and, if obstruction is found, they should be referred to an otolaryngologist before orthodontic treatment for examination and treatment of the problem.

MAXILLARY EXPANSION APPLIANCES

A. **SLOW MAXILLARY EXPANSION**

Quad Helix, W- arch, Coffin spring, Nitanium expander

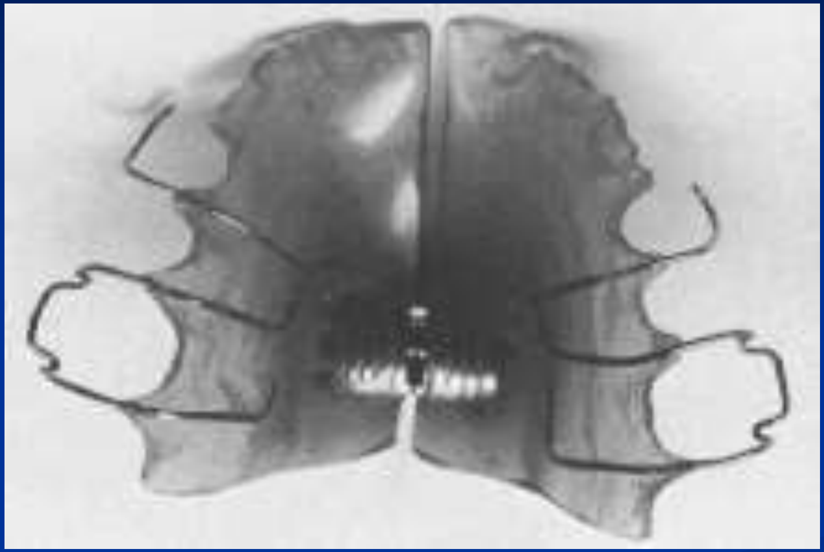
B. **SEMIRAPID MAXILLARY EXPANSION**

Active plates

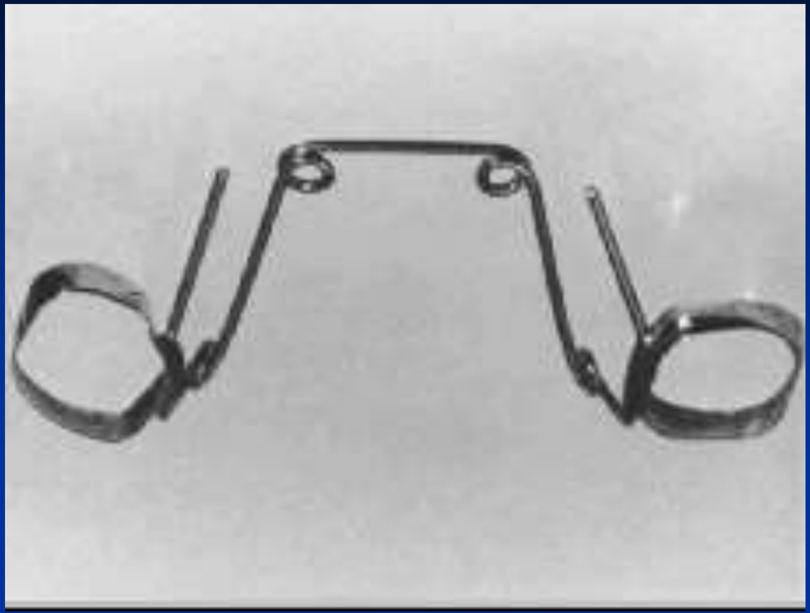
C. **RAPID MAXILLARY EXPANSION**

1. **Tissue borne: Haas type expansion**
2. **Tooth borne : Banded – Hyrax or Biedermann type**
   Bonded maxillary expansion
   Minne Expander or Isaacson type

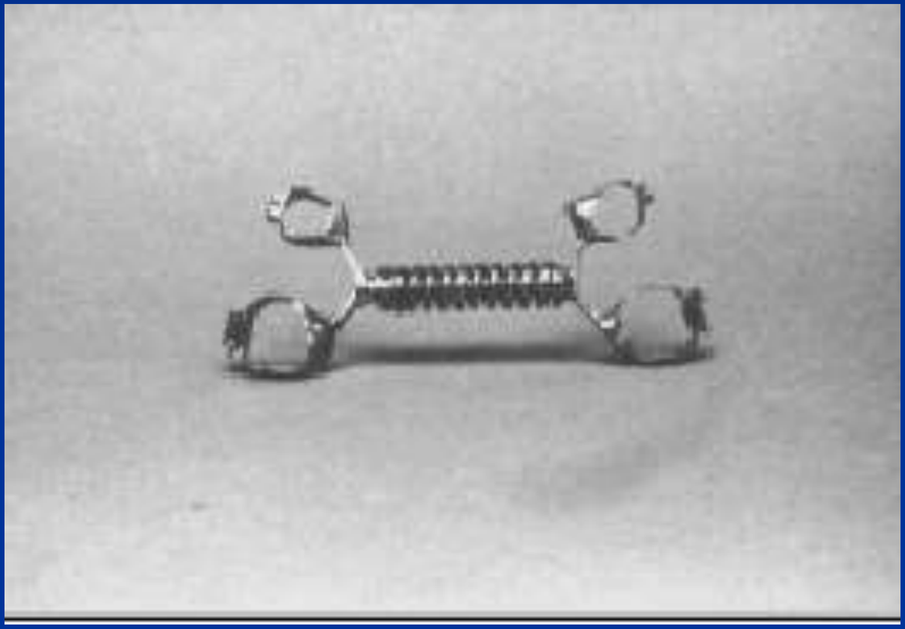
DESIGNS OF VARIOUS EXPANSION APPLIANCES



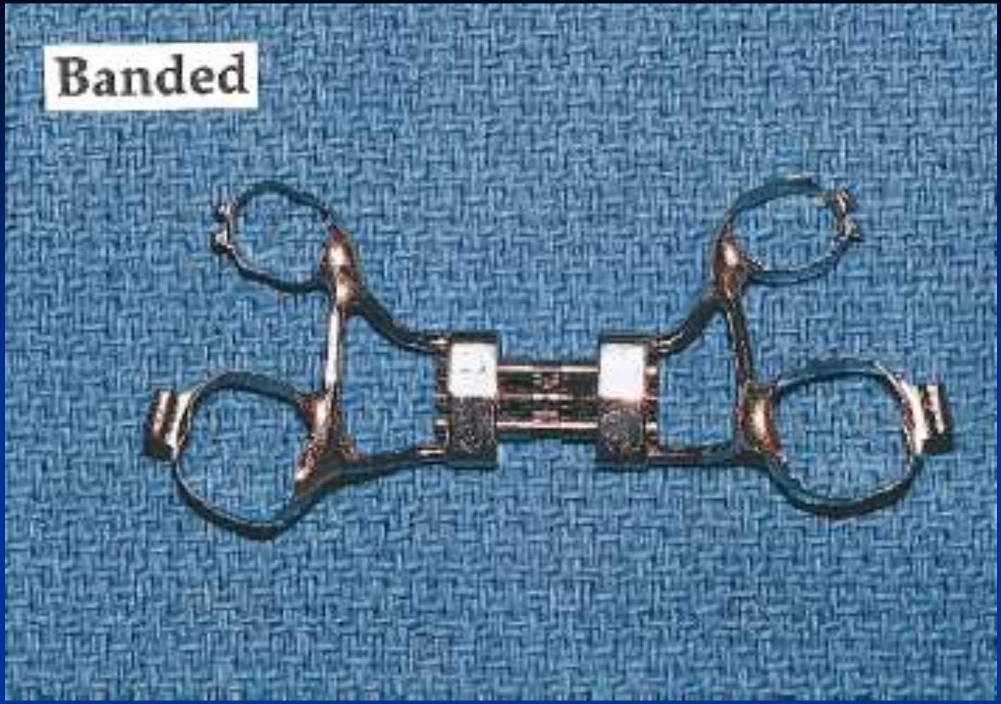
Removable appliance: This acrylic palatal appliance also has a centrally located jackscrew for activation. The retention of the appliance is obtained by means of the Adams clasps on the molars and circumferential clasps on the premolars.



- **Quad helix**: This is a fixed appliance, which is cemented to the maxillary deciduous second molars or first permanent molars. Expanding the appliance, prior to cementation, does the initial activation.



Minne-expander: This is a fixed appliance cemented to the first permanent molars and first premolars. Turning the adjustment screw, thereby compressing the coil spring, which activates the appliance.



Hyrax appliance: It is tooth-borne appliance, either banded or bonded acrylic pads that cover the occlusal surface of the buccal and extends over the buccal and lingual surfaces of the teeth, which is similarly cemented to the first permanent molars and first premolars. It is activated by means of a centrally located jackscrew.

Haas appliance: This fixed appliance is similar in construction and activation to the Hyrax, except for the inclusion of the acrylic button, molded to the palate, in which the jackscrew in embedded and to which the bands are attached.

Chaconas and Caputo (AJO 1982) compared five appliances— the Haas expander, Minne expander, Hyrax, quad helix, and a removable expander.
They found that each appliance produced different load-activation characteristics. Stresses produced by fixed appliances were concentrated in the anterior region of the palate, progressing posteriorly toward the palatine bones. These stresses radiated superiorly along the perpendicular plates of the palatine bones, the lacrimal, nasal, and zygomatic bones, and the pterygoid plates of the sphenoid.

The authors believed that the quad helix, although it caused palatal separation, was the least effective orthopedic device. They also observed that the removable expanders were displaced before producing sufficient pressure to cause midpalatal splitting.

EXPERIMENTAL STUDIES IN RME

The mechanism of action RME initially became clarified through the studies of cats **(Debbane 1958)** and pigs **(Haas 1959).** Both these studies demonstrated that the mid-palatal was opened using this technique.

The monkey studies of **Starnbach and colleagues (1966)** demonstrated that the effect of this technique was not only in midpalatal suture but also on the circummaxillary sutural system. These finding were supported by investigations of **Biederman (1972), Chaconas and Caputo (1982), and Tanne and associates (1986).**

Melsen (AJO 1975 and 1982) described mid-palatal sutural morphology and postnatal palatal development based on human autopsy material and on biopsies performed on children.

In two studies, **Melsen (AJO 1975)** used autopsy material to histologically examine the maturation of the mid-palatal suture. The sample for the first study included 33 boys and 27girls, aged 0 to 18 years who had died "without prior illness." Micro enabled the localization of growth activity.

Melsen divided sutural maturation into three stages based on its morphology.

In the "infantile stage", the suture was broad and smooth,

But by approximately 10 years of age had developed into a more typical squamous suture with overlapping sections. **Melsen** called this stage the "juvenile stage."

Finally, the “adolescent stage” was seen at the ages of 13 to 14 years, where the suture was more wavy with intergitations. This interdigitation could not be separated without fracturing them.

Melsen in (AJO 1982) extended his study, which evaluated the suture from 30 individual, aged new born to 27 years. The suture in the oldest individuals was classified as “adult stage,” though no specific were given to distinguish this category. Adult suture demonstrated numerous bony bridge formations across, and synostoses were noticed. The sutures appear as serpentine lines in their anatomically location.

In another study, **Persson and Thilander (AJO 1975)** quantified suture closure by evaluating the degree of obliteration in the suture.

The sample consisted of 24 subjects, 14 males and 10 females who had died. The earliest closure seen in any portion of the suture was in 15year-old female, but no closure was seen in 4 to 7 individual less than 20 years of age.

Although a marked degree of closure is rarely found until the third decade, sutural obliteration progresses rapidly during that time. The authors concluded that mid-palatal suture is highly variable.

From these studies, it is suggested that patients who have passed their pubertal growth spurt may have difficulty in undergoing traditional orthopedic maxillary expansion. The increased interdigitation of the suture may require excessive force to separate.

CLINICAL STUDIES IN RME

Short-term treatment effects

The initial clinical study of **Haas (1961)** indicated that not only the mid-palatal suture opened during RME, but also that the suture became re-ossified with 90 days of the completion of expansion. Thus most clinicians today maintain the rapid maxillary expansion appliance in place for at least three months following cessation of expansion.

Kreb (1964) found that RME had differing effects on the naso-maxillary complex. Using posteroanterior cephalograms in patients in whom metallic implants were placed, Krebs found that the average amount of expansion at the dental arches was 6.0mm, whereas in the maxillary apical base the amount of expansion was 2.3mm, and in the nasal cavity the average increase was 1.4mm.

His observations are similar to those of **Hicks (1978)**, who had demonstrated that the maxilla separates in a triangular fashion as viewed in the frontal plane and much of the dental arch expansion is a result of dental movement.

In addition **Krebs (1964)** observed a tendency for the effect of expansion therapy in the maxillary bony base to decrease with age: although increase in dental arch width were less age dependent, finding indicated more dentoalveolar response in older individuals.

In addition **Wetz (1970)** also noted a triangular widening of the maxilla with the apex at the posterior nasal spine and its base anteriorly in the midline diastema that usually develops between upper central incisors.

Studies of Long-term stability of RME

Haas(1970) reported on a series of patient who were followed with posteroranterior head films for one year after expansion therapy. Haas noted that increases in nasal cavity and apical base widths of the maxilla remained stable. In a follow-up study in 1980, Hass reported that none of the patients in the previous study showed any relapse in nasal cavity or apical base width after 5 years.

Investigations of **Timms** were quite the opposite of **Haas**. **Timms** examined RME subjects out of retention for twelve months or more and noted and average relapse of 41% with a range of 31-82%. This study has drawbacks like the appliance design was non-rigid which caused tipping of molars, which returned to pretreatment values during retention and poor patient cooperation during the retention period

Herberger (1987) evaluated 55 subjects who had been treated with RME. The average age was 11years(range8.8-13.4yrs). Records were taken initially and posttreatment at 14.4 years and about six years later at 21years(range 17 to 32yrs). The long- term effects of treatment were determined by analyzing serial dental casts and P.A. cephalograms.

He noted an increase in transpalatal width following the removal of the appliances of about 4.5 to 6.8mm. After analyzing the long-term record, 85 to 94% of the increases in arch width present at the end of treatment were still evident six year after appliance removal.

The author concluded that the use of RME (Tooth or Tissue borne) with fixed appliances was reasonably stable during post treatment.

RAPID VERSUS SLOW EXPANSION

There are two schools of thought concerning the speed of palatal splitting.

Advocates of "rapid" expansion (1 to 4 weeks) believe that it results in minimum tooth movement (tipping), and maximum skeletal displacement.

Advocates of "slower" expansion (2 to 6 months) believe that it produces less tissue resistance in the circummaxillary structures and better bone formation in the intermaxillary suture, and that both factors help minimize postexpansion relapse.

Slow expanders can transmit forces ranging between several ounces and two pounds. They can separate the maxillae, particularly in the deciduous and mixed dentitions. The rate of separation varies between 0.4 and 1.1 mm per week and can result in an increase in intermolar width of up to 8 mm. Skeletal changes are estimated to be 16% to 30% of the total change and vary with age.

The rate of rapid maxillary expansion is 0.2 to 0.5 mm per day and can result in an increase in intermolar width of up to 10 mm. Skeletal changes are approximately 50% of the total change.

EXPANSION APPLIANCE ACTIVATION SCHEDULES

Zimring and Isaacson (ANGLE 1965) recommend the following turn schedules:

Young growing patients— two turns each day for the first 4 to 5 days, one turn each day for the remainder of RME treatment;

Adult (non-growing) patients— because of increased skeletal resistance, two turns each day for the first 2 days, one turn each day for the next 5 to 7 days, and one turn every other day for the remainder of RME treatment.

FORCE APPLICATION AND RESIDUAL LOADS

Zimring and Isaacson (ANGLE 1965) found that the maximum load produced by a turn of the jackscrew occurred at the time of turning and began to dissipate soon after.

Isaacson, Wood, and Ingram (ANGLE 1964) reported that 3 to 10 lb of force can be produced by single turns of the jackscrew appliance with cumulative loads of 20 lb or more after multiple daily turns. Separation of the central incisors occurred between the ninth and 12th turns in all patients, and was not accompanied by any increased subjective symptoms or drop in recorded load.

An age differential was noted in the time required to dissipate loads produced by the appliance. Younger patients dissipated the load produced by a twice-daily activation schedule for a relatively longer period of time than did the older patients.

Isaacson, Wood, and Ingram, (ANGLE 1964) and Zimring and Isaacson (ANGLE 1965) suggested that slower rates of expansion would allow for physiologic adjustment at the maxillary articulations, and would prevent the accumulation of large residual loads within the maxillary complex.

Brin, Hirshfeld and Shanfeld (AJO 1981) studied the response of bone at the midpalatal suture to the application of tensile forces in young and old animals, through an examination of the osteoblastic staining pattern for cAMP and cGMP.

The midpalatal suture was rapidly expanded for 0, 10, and 15 days, respectively, in three young and three old cats. Fresh, frozen, unfixed, undecalcified maxillae were sectioned transversely and stained immunohistochemically for cAMP and cGMP.

The staining intensity for both nucleotides was increased in the osteoblasts of` the young treated animals, while in the old animals the osteoblasts were only faintly stained for cAMP and cGMP. These results demonstrated that bone cells of old animals are less responsive to tensile forces than the corresponding cells in young animals.

These observations indicates that in the young animal mechanical forces evoke osteoblastic responses mediated by increased levels of intracellular cyclic nucleotides. A decline with age of the membrane-bound protein kinase and adenylate cyclase activity was reported, and found that cAMP levels decreased during aging of normal human fibroblasts.

EFFECTS OF RME ON THE MAXILLARY COMPLEX

Rapid maxillary expansion occurs when the force applied to the teeth and the maxillary alveolar processes exceed the limits needed for orthodontic tooth movement. The applied pressure acts as an orthopedic force that opens the mid-palatal suture. The appliance compresses the periodontal ligament, bends the alveolar processes, tips the anchor teeth, and gradually opens the mid-palatal suture.

MAXILLARY HALVES

Krebs (1958) showed that the two halves of the maxilla rotated in both the sagittal and frontal planes.

Haas(ANGLE 1961) and Wertz (AJO 1970) found the maxilla to be more frequently displaced downward and forward.
Haas suggested when the midpalatal suture opens, the maxilla always moves forward and downward. This is probably due to the disposition of the maxillocranial sutures.

Sicher calls attention to the fact that these sutures are oriented in such a manner that growth would produce a downward and forward vector of maxillary movement.

Since these hafting zone sutures are disengaged by the palatal expansion procedure, an effect similar to immediate growth is manifested in a downward and forward displacement of the maxilla.

Although for some patients it is beneficial to have an increase in vertical dimension, often it is an unwanted characteristic.

The bite opening can be favourable when the patient has a Class III skeletal pattern, but is more frequently undesirable if Class II pattern predominate.

Silva, Boas and Capelozza et al (AJO 1991) studied the effects of RME in primary and mixed. They concluded that banded rapid maxillary expansion incited an increase in the vertical dimensions of the face because of the maxillary and mandibular downward and backward rotation. This increase was noticed in the

- Upper facial height (N-ANS) as a result of the downward displacement of the maxilla,
- In the lower facial height (ANS-Me) as a result of the mandibular rotation, and
- In the total anterior facial height (N-Me) because of the rotation of both the maxilla and the mandible. The increase in the lower facial height is caused by the downward displacement of both the maxilla and upper teeth.

Sarver and Johnston et al (AJO 1989) studied skeletal changes in vertical and anterior displacement of maxilla with bonded rapid palatal expansion appliances using the lateral cephalograms.

They compared these changes with those reported by Wertz who used similar measurements to evaluate skeletal changes with a banded jackscrew.They found that the vertical displacement of the maxilla, as measured by the distance between SN and PNS, was significantly less in those patients who had the bonded appliance.

They concluded that the downward and anterior displacement of the maxilla may be minimized or negated with the use of the bonded appliacance.

Asanza et al (ANGLE 1997) also compared the effect of bonded Hyrax appliance with that of a banded Hyrax, studying 14 adolescents.

They found that the bonded group displayed less increase in the total facial height as measured between ANS and menton, as well as less inferior maxillary displacement at posterior nasal spine. It appears that the bonded appliance does tend to minimize inferior movement of the maxilla.

In a retrospective study **Noel and Joydeep ghosh et al (AJO 1999)** compared the treatment outcomes with a banded versus a bonded rapid palatal expansion appliance followed by edgewise orthodontics.

Both lateral cephalometric radiographs and orthodontic study casts were evaluated at pretreatment and posttreatment time periods.

Result suggests that in overall, the banded rapid palatal expansion group had more vertical change than the bonded group. However, most of these changes were less than 1° or 1 mm and may be considered clinically insignificant. This study could not establish superiority of one type of rapid palatal expansion technique over another.

In the **frontal plane,** the fulcrum of rotation for each of the maxillae is said to be approximately at the frontomaxillary suture. Using implants, **Hicks et al (AJO 78)** concluded that the maxillae were found to tip anywhere between – 1° and +8° relative to each other. This tipping explains some of the discrepancy observed between molar and sutural expansions. Tipping of the two maxillae results in less width increase at the sutural level than at the dental arch level.

As reported by Wertz, with increased age the fulcrum of maxillary separation tends to be displaced more inferiorly, nearer to the activating force. In children, the fulcrum may be as high as the frontomaxillary suture, whereas in adolescents the fulcrum is much lower. These differential, age-dependent effects may be attributed to the increased resistance to maxillary separation by the circummaxillary structures because of increased calcification in the sutural skeletal structures.

Stanley Braun et al (AJO 2000) investigated the biomechanics involved in the motion of the palatal halves and suggested improvements in the design of the appliances commonly used in rapid maxillary sutural expansion. He concluded that,

If less tipping were desired (in the frontal) and more linear opening of the maxillary suture anteroposteriorly (in the occlusal view), the fabricated stucture joining the sutural opening mechanism to the teeth would have to be more rigid, as would the guides and activating screw of the Hyrax appliance itself.

By increasing the rigidity of both the sutural expansion appliance and the wires joining it to the teeth, the moment induced by necessary offsets from the dentomaxillary centers of resistance are reduced or countervailed, resulting in reduced moment to force ratios at the center of resistance.

This cause the center of rotation to migrate superiorly in the frontal view, reducing the degree of tipping, and in the occlusal view, the center of rotation would further migrate posteriorly, resulting in a more linear separation of the mid-palatal suture.

In occlusal view, a more linear opening may also be achieved by locating the sutual opening mechanism more posteriorly. This would reduce the offset and thus the moment to force ratio would be reduced, driving the center of rotation further posteriorly. However, this may not be as practical as increasing the appliance rigidity, since patient access for repeated activation of the appliance would be more difficult.

PALATAL VAULT

Fried (ANGLE1961, 1965) and **Haas (AJO 1965)** reported that the palatine processes of the maxilla were lowered as a result of the outward tilting of the maxillary halves. On the other hand, Davis and Kronman reported that the palatal dome remained at its original height.

Spillane et al also noted that palatal vault height decreased significantly during RME. Palatal height returned to pretreatment values one year after expansion and increased an average of 0.5mm two years after treatment.

ALVEOLAR PROCESS

Issacson et al (ANGLE 1964) reported that because bone is resilient, lateral bending of the alveolar processes occurs early during RME.

BIOLOGIC RESPONSE OF MID-PALATAL SUTURE TO MAXILLARY EXPANSION

Ten Cate et al studied the biologic response of midpalatal suture to maxillary expansion. The immediate effect of applying force to the suture results in trauma. Small, localized tears occurred within the suture from the localized blood vessels. These small defects were filled with exudate, a few extravasated red blood cells, scattered filaments of fibrin, and a few fine collagen fibrils.

A transient polymorph response was noted in the region of the defects in the first 12 hours and thereafter was not seen again. Following the polymorph response, an influx of macrophages and pioneer fibroblasts into the defect occurred by 24 hours.

The pioneer fibroblasts were characterized by long, slender processes forming a delicate reticulum throughout the defect. Intracellular collagen profiles were occasionally found within the pioneer fibroblasts.

Within 3 to 4 days, bone formation had begun at the margins of the suture achieved by the pre-existing and undamaged osteoblasts. These formed successive lamellae along the suture margin. In the following time period (approximately 1 to 2 weeks), during which the force applied to the suture was progressively decreasing, the fine structural appearance of the suture was one of overwhelming fibrogenesis and osteogenesis. No evidence of fibroclasia could be detected during this period.

The collagen fibers and cells were aligned transversely across the suture corresponding to levels of tension. New bone formation now occurred along the same axis as trabeculae formed at right angles to the lamellae deposited initially at the suture margins.

With diminution and cessation of the expansion force (2 to 3 weeks), remodeling of both the bone and the suture occurred by the osteocytic and fibrocytic cell series until normal sutural dimensions were achived.

During the entire period of expansion, the uniting layers remained intact. The constituent fibroblasts showed a marked hypertrophy, indicative of increased synthetic activity, but evidence of fibroclasia was not seen.

Cobo and vijande et al (JCO 1992) measured the course of bone formation after rapid maxillary disjunction and to evaluate bone densitometry as an effective means of monitoring bone repair.
Six 14-year-old patients with constricted maxillary arches were treated with fixed Hyrax appliances.

A sequence of occlusal x-rays was taken of each patient at the beginning of treatment and then weekly for five weeks. Radiographs were made at a standardized 75° angulation.

Authors concluded that, sutural density had returned to its pretreatment level only two weeks after the cessation of expansion, indicating a high level of sutural bony activity in a short time. Another investigation showed that mineral content in the suture rises rapidly during the first week, and that most of the remineralization occurs within the first month.

Chang and Garetto et al (AJO 1997) studied the angiogenic and the subsequent osteogenic responses during a 96-hour time-course after sutural expansion.

Fifty rats were divided into: (1) a control group that received only angiogenic induction through injection of 5 ng/gm recombinant human endothelial cell growth factor (rhECGF); (2) an experimental group that received orthopedic expansion and rhECGF; (3) a sham group that received expansion and sodium chloride (NaCl) injection; and (4) a baseline group that received no expansion or injection. All rats were injected with 3H-thymidine (1.0 µCi/gm) 1 hour before death to label the DNA of S-phase cells. Demineralized sections (4 µm thick) were stained with hematoxylin and eosin. Angiogenesis and cell migration were analyzed with a previously established cell kinetics model.

Results showed that angiogenesis is a limiting factor in the osteogenic response because supplemental rhECGF enhances angiogenesis in the expanded suture but has no effect on the nonexpanded suture. This result also suggests that rhECGF is an angiogenic enhancer rather than an initiator. A supplement of rhECGF in the early stage of wound healing (12 hours after expansion) not only enhances but also sustains the angiogenic effects. Data also suggest that pericytes are the source of osteoblasts in an orthopedically expanded suture.

The role of angiogenesis with regard to sutural bone formation, particularly the relationship between blood vessels and osteoregulation, has been a puzzle for some time. It is hypothesized that, when the suture is stimulated, new bone is the result of activation of quiescent preosteoblasts in the cambium layer. The results of this study provided indirect evidence that some osteoblasts originate from preformed postcapillary venule pericytes

Shito saito and Noriyoshi (AJO 1997) investigated the effects of low-power laser irradiation on bone regeneration during expansion of a mid-palatal suture in 76 Wistar stain rats. Gallium-aluminum-arsenide diode laser 100mW irradiation was applied to the mid-palatal suture during expansion carried out over 7 days, 3 days, and 1 day.

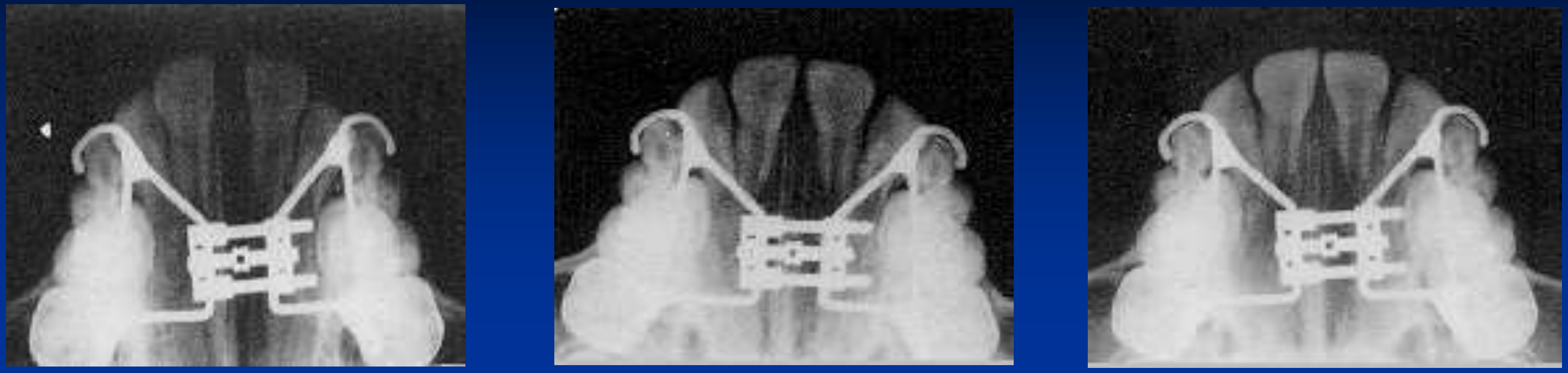
The bone regeneration in the mid-palatal suture was estimated by histomorphometric method. In the 7-day irradiation group showed significant acceleration at 1.2- to 1.4 fold compared with that in the non-irradiated rats, and this increased rate was irradiation dose-dependent These findings suggest that low-power laser irradiation can accelerate bone regeneration in a mid-palatal suture during rapid palatal expansion and that this effect is dependent not only on the total laser irradiation dosage but also on the timing and frequency of irradiation.

Ozawa et al (1995) reported that the number of calcified bone nodules formed by isolated rat calvarial osteoblasts was significantly increased by low-power laser irradiation and concluded that laser irradiation early in the cell culture period is more effective in inducing nodule formation due to differentiation of osteoblasts and that osteoblasts may have a specific optimal dosage of irradiation for acceleration of differentiation.

Because osteoblasts may be recruited along the bone edges from undifferentiated precursor cells in the expanding mid-palatal suture, laser irradiation could potentially stimulate the recruitment and/or maturation of osteoblasts. This possible mechanism is also supported by the results of several other studies indicating that laser irradiation is effective when applied at healing sites, such as those of bone fracture, bone defect, tooth extraction, and transplantation of bone morphogenetic protein.

MAXILLARY ANTERIOR TEETH

From the patient's point of view, one of the most spectacular changes accompanying RME is the opening of a diastema between the maxillary central incisors. One can understand how the opening of such a space would alarm both patient and parents. It is estimated that during active suture opening, the incisors separate approximately half the distance the expansion screw has been opened, but the amount of separation between the central incisors should not be used as an indication of the amount of suture separation.



Following this separation, the incisor crowns converge and establish proximal contact. If a diastema is present before treatment, the original space is either maintained or slightly reduced. The mesial tipping of the crowns is due to the elastic recoil of the transseptal fibers. Once the crowns contact, the continued pull of the fibers causes the roots to converge toward their original axial inclinations. This cycle generally takes about 4 months.

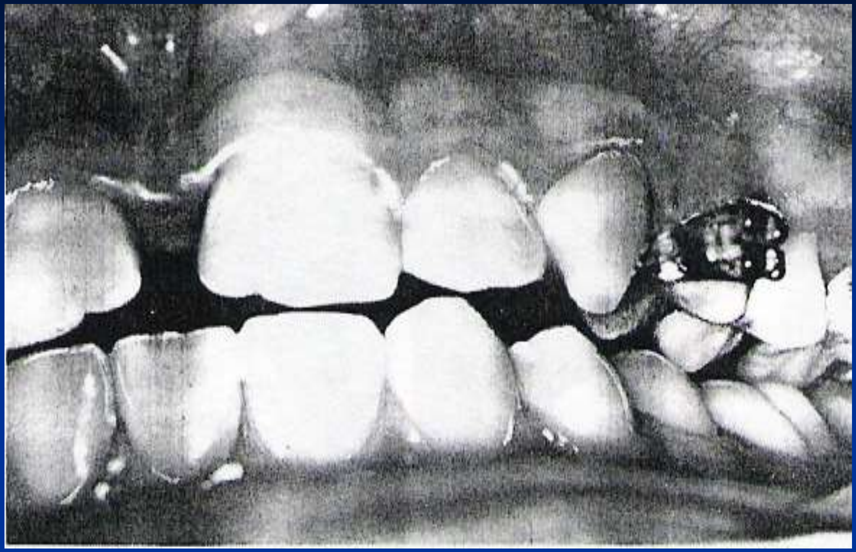
MAXILLARY POSTERIOR TEETH

With the initial alveolar bending and compression of the periodontal ligament, there is a definite change in the long axis of the posterior teeth.

Hicks et al found that the angulation between the right and left molars increased from 1° to 24° during expansion. Not all of the change, however, is caused by alveolar bending, but is partly due to tipping of the teeth in the alveolar bone. This tipping is usually accompanied by some extrusion.

Brust et al (1992) noted that the bonded rapid palatal expansion produces virtually no changes in maxillary molar angulation during treatment, with a 0.7˚ change in the RME group and a – 1.7˚ in the RME/Schwarz, as compared to a 1.2˚ change in the control group.

At the time of Phase II records, the RME –only group remained stable while RME/Schwarz group had a decrease in angulation – 3.4˚, whereas the control group demonstrated an increase in angulation of 3.1˚.



Overexpansion is done to produce a tendency towards buccal crossbite (an attempt normally made to maintain contact between the lingual cusp of the upper posterior teeth and the buccal cusps of the lower posterior teeth. Therefore, one can appreciate the need for overcorrection of the constricted dental arches to compensate for the subsequent uprighting of the buccal segment and to prevent relapse.

EFFECTS OF RME ON THE MANDIBLE

Isaacson and Zimring showed that because of the resistance of the midpalatal suture and circummaxillary articulations to the expansion forces, microfractures within the buccal cortical plate were generated before the breakage of the suture. These microfractures cause buccal tipping and extrusion of the lingual cusps of the maxillary posterior teeth.

Both of these orthopedic and orthodontic side effects on the maxilla produce a change in the mandibular position: The mandible autorotates in a backward and downward direction. This results in an increase of the facial convexity and the vertical dimension of the lower face

The undesirable dental and skeletal effects of palatal expansion may be critical in patients exhibiting skeletal open bite tendency, large interlabial gap, or severe Class II skeletal pattern with long lower facial height and increased facial convexity. Indeed, even a minor extrusion of only 1 mm at the maxillary first molar may result in an increase of 2 to 3 mm at the central incisors and lips. Therefore it may be beneficial to try to counteract the iatrogenic orthodontic and orthopedic side effects during RPE therapy.

Haas reported that the change in maxillary posture invariably causes a downward and backward rotation of the mandible, which **decreases the effective length of the mandible and increases the vertical dimension of the lower face.**

Silva, Boas, and Capelozza (AJO 1991) studied effect of RME in primary and mixed dentition. The downward displacement of the maxilla has a direct effect in the spatial positioning of the mandible when related to the anterior cranial base. The mandible rotates downward and backward. This mandibular rotation induces other alterations such as opening of the bite, occlusal plane inclination, increase in the mandibular plane angle and the y-axis, and a downward and backward displacement of menton.

It is generally agreed that with RME there is a concomitant tendency for the mandible to swing downward and backward. There is some disagreement regarding the magnitude and the permanency of the change.

The fairly consistent opening of the mandibular plane during RME is probably explained by the disruption of occlusion caused by extrusion and tipping of maxillary posterior teeth along with alveolar bending. RME should be cautiously performed on persons with steep mandibular planes and/or open bite tendencies.

Dipaolo (JCO 1970) suggested that a vertical chin cap might be used concurrently with RME to reduce the vertical dimension in the posterior region and to significantly improve dental and skeletal open bite. He noted that the application of an intrusive force at the lingual cusps of the posterior maxillary teeth during and immediately after the use of RME offers potential control of both the extrusive and buccal tipping side effects created by the RME.

Basciftci and Karaman et al (ANGLE 2002) determined the sagittal, transverse, and vertical effects of a modified acrylic bonded rapid maxillary expansion (RME) device used with a vertical chin cap on dentofacial structures.

The study group consisted of 34 patients (25 girls and 9 boys) who were selected without regard to their skeletal class and gender. All subjects had permanent dentition (mean age, 12.7years) and needed maxillary expansion. Study Group I (RME only) was composed of 17 subjects, and study Group II (RME with vertical chin cap) was composed of 17 subjects. Twenty-nine measurements were made on the patients' cephalometric films and plaster models.

They found that the maxilla moved anteriorly relative to the anterior cranial base. The nasal width, maxillary width, intercanine width, mandibular intermolar width, maxillary intermolar width, and overjet all increased, while the upper molars tipped buccally in both groups In Group I, the mandible rotated posteriorly, the lower anterior facial height increased, and the overbite decreased. These effects were reduced in Group II.

Author's concluded that the vertical chin cap is an effective appliance for preventing the adverse vertical effects of RME in patients with a crossbite and a vertical growth pattern.

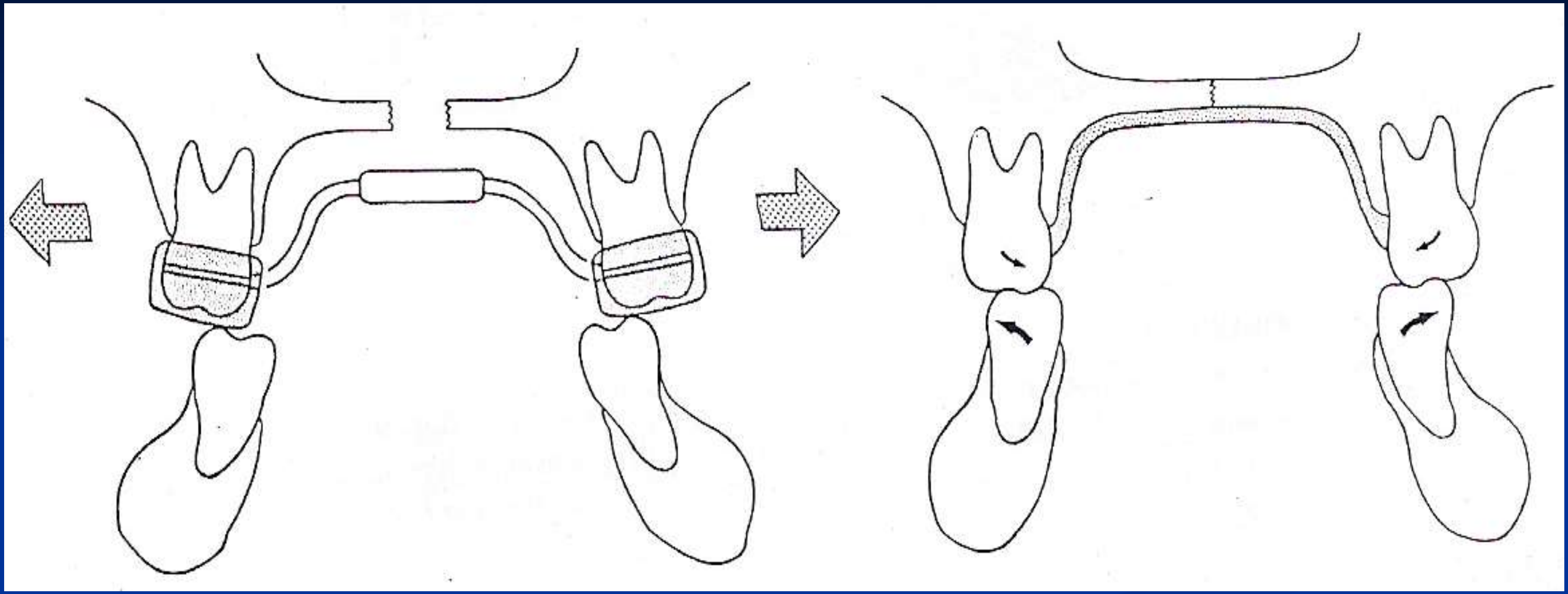
EFFECTS OF RME ON THE MANDIBULAR TEETH

Following RME, the mandibular teeth have been observed to upright or to remain relatively stable over the short period of treatment.

Grayson (ANGLE 1977) recorded changes in maxillary and mandibular intercanine and intermolar widths before and after expansion in 38 patients. The ages of the groups ranged between 6 and 13 years.

The mean increase in the mandibular intermolar width was 0.4 mm; most patients either had no change or showed an increase of up to 1 mm. There was no correlation between the change in mandibular intercanine and intermolar distances with respect to the increase in maxillary intercanine and intermolar distances. Therefore, one can conclude that in general RME could influence the mandibular dentition, but the accompanying changes are neither pronounced nor predictable.

Brust et al (1992) noted in the lower arch, the greatest increase in uprighting of the buccal segments was in the bonded RME/Schwarz group °-12, with –4.7° observed in the bonded RME only and -.2° in the control group.



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EFFECTS OF THE RME ON ADJACENT FACIAL STRUCTURES

Kudlick et al in a study on a human dry skull that simulated in vivo response of RME, concluded the following:
All craniofacial bones directly articulating with the maxilla were displaced except the sphenoid bone,

- The cranial base angle remained constant,
- Displacement of the maxillary halves was asymmetric, and
- The sphenoid bone, not the zygomatic arch, was the main buttress against maxillary expansion.

Gardner and Kronman,(AJO 1977) in a study of RME in rhesus monkeys, found that the lambdoid, parietal and midsagittal sutures of the cranium showed evidence of disorientation, and in one animal these sutures split 1.5 mm. Therefore, RME could affect relatively remote structures and is not limited to the palate.

RME IN CROSS BITE

The most commonly recognized indication for RME is the correction of a posterior crossbite. It is very common for one or more of the maxillary posterior teeth to be in a lingual orientation relative to the mandibular dentition. Through the widening of the mid-palatal suture, the correction of a posterior crossbite is accomplished quite readily in-patient in whom the maxillary sutural system is still patent.

McNamara also has observed the spontaneous correction of mild anterior crossbites after maxillary expansion has been produced. Clinical research of Haas (1961,65,70), Wertz (1970) and the experimental studies of Dellinger (1973) have shown that 1-2mm of anterior movement of Point A has been observed is some individual treated with RME.

Serdar and Mustafa et al (AJO 2002) evaluated the effects of an asymmetrical maxillary expansion (AMEX) appliance. Patients with true unilateral posterior crossbites were included in the study. The treatment group consisted of 18 patients who had a mean age of 14 ± 2.3 years. Treatment effects were evaluated on posteroanterior radiographs, dental casts, and photographs of the dental casts.

All unilateral posterior crossbites were corrected in a mean expansion treatment time of 3.3 ± 0.48 months. As a result of expansion, maxillary interfirst molar, interfirst and second premolar, and intercanine arch widths increased significantly.

Comparison of the 2 sides showed that the teeth on the crossbite side moved and tipped more buccally than the teeth on the noncrossbite side. Of the total expansion gained, 75.8% to 91.7% was due to the buccal movements of the teeth on the noncrossbite side.

Author's concluded AMEX appliance was found to be effective in correcting true unilateral posterior crossbites, and therefore it can be recommended for clinical use.

RME IN ADDITION OF ARCH LENGTH

McNamara used the transpalatal width of the patient measured between the upper molars, as a diagnostic guide to determine whether the patient might be a candidate for rapid maxillary expansion to correct a transverse arch-length discrepancy.

A transpalatal width of 35-39mm is considered ideal for an adult and 33-34mm for a mixed dentition. Any discrepancy in this measurement indicates palatal expansion.

Adkins and Nanda (AJO1990) estimate that every 1mm of increase in posterior arch width produced by RME translates to 0.7mm of increased arch perimeter. This additional arch length may lead to an overall reduction in the patient undergoing extraction of permanent teeth due to tooth-size arch-size problems.

RME AND CLASS II MALOCCLUSION
(SPONTANEOUS CORRECTION OF SAGITTAL MALOCCLUSIONS)

Clinicians traditionally have viewed a Class II malocclusion as primarily a sagittal and vertical problem. The post-RME correction of the Class II problem indicates that many Class II malocclusions have a strong transverse component. The over expansion of the maxilla, which subsequently is stabilized through the use of removable plate, disrupts the occlusion.

It appears that the patient becomes more comfortable by positioning his or her jaw slightly forward, thus eliminating the tendency towards a buccal crossbite and at the same time improving the overall sagittal occlusal relationship.

The placement of a bonded maxillary expansion appliance immediately causes an increase in the vertical dimension of the face because of the posterior occlusal coverage.

The teeth themselves acts as a endogenous funtional appliance, encouraging a change in mandibular posture and, ultimately a change in maxillomandibular relationship.

This changes is beneficial in most patients, in that the increase in the vertical dimension patient prevents extrusion of the posterior teeth during the expansion process and also may result in an upward and slightly forward displacement of the maxilla. During the post-RME period, a removable plate is worn, the patient postures forward the mandible because of the over expansion of the maxilla.

Thus the spontaneous correction of patients with a tendency towards a Class II malocclusion does not occur during active expansion period but rather during the time that of the maintenance plate being worn (RETENTION PERIOD). This phenomenon usually happens during the first 6-12months of the post-RME period.

RME AND CLASS III MALOCCLUSION

(SPONATENOUS CORRECTION OF CLASS III MALOCCLUSION AND MOBILIZATION OF THE MAXILLARY SUTURAL SYSTEM)

Midfacial orthopedic expansion has, in itself, shown to the beneficial in the treatment of certain types of class III malocclusion. **Oppenheim (1944)** was one of the first to discuss the possibility. **Haas (1961,70,73)** has demonstrated that rapid palatal expansion can produce a slightly forward movement of Point A and a slightly downward and forward movement of the maxilla and **Dellinger (1973)** has also shown this phenomenon in non-human primates. In patients in whom no increase in transverse dimension is desired, RME is still activated for 8 to 10 days to disrupt the maxillary sutural system and to promote maxillary protaction **(Haas 1965**).

The use of a bonded RME appliance also can lead to spontaneous occlusal correction in a patient with a tendency towards a Class III malocclusion. This phenomenon seems paradoxic, given the previous discussion concerning the sponatenous correction of Class II tendency problems. The mechanism of Class III, however, is distinctly different than that described previously. An examination provides the explanation for this phenomenon.

The placement of an acrylic splint expander that opens the bite vertically 3mm not only provides an intrusive force against the maxilla, presumably because of the stretch of the masticatory musculature, but also may produce a slight forward repositioning of the maxilla.

In addition, the placement of a bonded expander with acrylic coverage of the occlusion helps eliminate a tendency towards pseudo-Class III malocclusion. Any discrepancy between centric occlusion and centric relation is eliminated immediately as soon as the patient wears the appliance.

So any spontaneous correction of a Class III malocclusion usually occurs during the active phase of treatment (within the first 30 to 40 days)

When planning the treatment for a Class III tendency patient with RME and facial mask, facial mask hooks may be attached to the expansion appliance to facilitate the use of a facial mask.

Although **Petit (1983)** has recommended a number of different intra-oral devices, fixed and removable to which elastics can be anchored, McNamara strong preference to use a bonded rapid maxillary expansion appliance.

The major modification in the appliance is the addition of facial mask hooks in the region of the upper first deciduous molar. In patients in whom treatment is started before the eruption of the upper first molars, the appliance is designed to incorporate the first and second deciduous molars as well as the deciduous canines.

RME is activated once per-day for 8 to 10 days to disrupt the maxillary sutural system and to promote maxillary protraction. Once positive horizontal and vertical overlap RME are removed and retained using simple maintenance appliance, FR3 or chin cup.

Merwin and Peter Ngan et al (AJO1997) evaluated the treatment effects of patients younger than 8 years old (5 to 8 years) and patients older than 8 years old (9 to 12 years).

Thirty patients were treated with maxillary protraction and expansion Cephalometric radiographs were taken 6 months before the initiation of treatment, at the initiation of treatment, and after 6 months of treatment).

Results indicated strikingly similar therapeutic response between the younger and older age groups. These data suggest that similar skeletal response can be obtained when maxillary protraction was started either before age 8 (5 to 8 years) or after age 8 years (8 to 12 years).

Shanker and Peter Ngan et al (AJO 1996) compared 25 Chinese children treated with maxillary protraction/hyrax expansion with untreated Class III patients matched for age, sex, and race. No significant differences were found in the horizontal or the vertical movement of Point A during the 12- month observation period. These studies suggest that patients treated with facemasks continue to grow similarly to Class III patients after treatment.

Baccetti and McGill et al (AJO 1998) evaluated the treatment effects produced by orthopedic facemask combined with a bonded maxillary expander. The records of 46 mixed-dentition Class III patients were compared with those of 32 untreated subjects with Class III malocclusion. Two subgroups were established in each study group, according to stage of dentitional development (i.e., early vs. late mixed dentition).

The major findings were as follows:

1. Treatment of Class III malocclusion with maxillary expansion and a face mask in the early mixed dentition induced more favorable changes in the craniofacial skeleton compared with similar treatment started in the late mixed dentition. In particular, effective forward displacement of maxillary structures was achieved as an outcome of early treatment, whereas the late-treatment group showed no significant improvement in maxillary growth with respect to matched untreated controls.

2. Even though both early and late facemask treatments reduced mandibular protrusion, significantly smaller increments in total mandibular length associated with more upward and forward direction of condylar growth was recorded only in the early-treatment group.

Omar Gabriel (AJO 1998) assessed the results of the treatment of patients with Class III malocclusion at an early stage (deciduous or mixed dentition), with an efficient of rapid maxillary expansion plus maxillary protraction.

Mean treatment time of 8 months induced positive changes in the sagittal configuration of the face with statistically significant cephalometric results. The patients were instructed to use 14 daily hours of maxillary protraction until the overcorrection of incisor relationship was attained.

Cephalometric results show skeletal and dentoalveolar changes. Skeletal changes are the maxillary forward movement and the downward and backward mandibular rotation, with a decrease of prognathism. These changes have induced favorable changes in the facial profile. Dentoalveolar changes are mainly the linguoversion of the lower incisors and the labial inclination of the upper incisors.

Toros and Ahmet Keles et al (AJO 2000) used a modified portaction headgear with full coverage rapid maxillary expansion to eliminate the upward and forward rotation of maxilla while protracting.

Seventeen patients with Class III malocclusion as a result of maxillary retrognathism were treated for 3months; their average age was 12 years. A full coverage acrylic cap splint-type rapid maxillary expansion appliance was cemented and activated twice a day for 5 days. After sutural separation, a maxillary modified protraction headgear was worn and 750 g of force was applied.

The maxilla was displaced anteriorly by downward and backward rotation. The mandible was displaced downward and backward due to anterior elongation of the maxilla. Extrusion and lingual tipping of the upper incisors and intrusion of upper molars and downward and backward rotation of functional occlusal plane were observed.

In conclusion, maxillary expasion with maxillary modified protraction headgear can be used effectively in Class III patients with retrognathic maxilla and anterior open bite tendency.

Vaughn and Mason et al (JDR 2001) initiated a randomized clinical trial to examine the effects of palatal expansion on maxillary protraction. One group was treated with facemasks and active palatal expansion, the other with facemasks and passive expansion appliances.

The results of this study showed no differences between the expansion and the non-expansion groups in any cephalometric variable, in overall treatment time, or in the time for initial crossbite correction. The results suggest that without other reasons for expansion, such as maxillary width or space deficiency, expansion does not significantly aid in Class III correction.

RME IN CLEFT PALATE

Unlike other malocclusion treated by RME, the cleft palate does not have a mid-palatal suture, which requires orthopedic forces to open. Instead there is mid-palatal cleft covered with repaired and scarred palatal tissue limiting the rate and amount of expansion.

The slower rate of expansion and the lower force magnitude allows the soft tissue of the palate to stretch and adapt to the increasing maxillary width, avoiding a breakdown of the scar tissue that result in an oronasal fistula. This type of orthodontic expansion treatement is ofter timed to precede the surgical placement of an alveolar bone graft in the mixed dentition.

Because the palatal suture is missing, the buccal dental segments must first be leveled and aligned to allow better retention of the expansion appliance. Once the posterior teeth are aligned expansion appliance is constructed, and a jackscrew is selected according to the amount of expansion needed.

The average activation period is from one to two weeks, depending on the degree of maxillary constriction and the resistance of the patient's maxillofacial structures. A 2-3mm overcorrection at the molars is recommended to counteract a relapse.

RME IN FUNCTIONAL JAW ORTHOPEDICS

Severe Class II malocclusions also benefits from rapid maxillary expansion. In instance in which a patient is being prepared for functional jaw orthopedics, an initial phase of rapid maxillary expansion may be indicated.

Not only the maxilla will be widened, but also any intra-arch problems (tooth size/arch size discrepancies) can be addressed.

RME IN ORTHOGNANTHIC SURGERY

In instances in which mandibular surgery alone is indicated to correct an anteroposterior problem, prior RME therapy during the presurgical phase of orthodontics may be necessary because the mandible will be advanced into a narrower part of the dental arch.

In some non-growing patients, an initial phase of rapid maxillary expansion, even with a surgical assist, may be indicated because of pre-existing arch length problems.

In situations in which the patients is to undergo either maxillary surgery or maxillary surgery combined with a mandibular procedure, a two-piece Lefort I osteotomy may be used to widen the maxilla during the surgical phase of treatment

RME AND CONDUCTIVE HEARING LOSS

Conducting hearing loss is one of the auditory disorders characterized by elevated air-conduction thresholds. The air and bone conduction thresholds interweave in normal hearing. The difference between these two thresholds is called the air-bone. The air-bone gap of 20-30 dB indicates a mild conductive hearing loss, 30-45dB a moderate conductive hearing loss, and 45-50dB a maximum hearing loss.

Laptook in (AJO 1981) used RME for the treatment of a patient who had conductive hearing loss and reported improved hearing in the first 1.5weeks and also noted that this improvement continued during the active phase of the treatment. He suggested that the orthopedic effect of the RME procedure helps improve hearing loss because of a more normal functioning of the pharyngeal ostia of the eustachian tubes.

Hazar et al reported on a patient with conductive hearing loss who showed significant improvement in hearing loss and a decrease in air-bone gap within four weeks of RME.

Ceylan and Oktay et al (Angle 1996) performed RME in 14 patients with conductive hearing loss, and they found that hearing level with significantly improved during the active expansion period. They observed some relapse in the hearing level after the retention period, but it did not significantly affect the overall results obtained.

Fatma and Bishara et al (Angle 2003) evaluated the effect of rapid maxillary expansion on conductive hearing loss in 35 subjects (21girls and 14 boys) with an average age of 14 year 6 months. All patients have maxillary with a high palatal vault and a conductive hearing loss.

Pure tone audiometric records were used to determine the hearing levels at four time intervals, namely before RME, after sufficient mid-palatal suture opening obtained (18days), after the retention period (six months), and a final set two years after the retention period. The same otolaryngologist evaluated records.

Result indicates that significant changes occurred in both the hearing levels and air-bone gaps in both timing and frequency after the active treatment period. These findings are similar to observation by **Laptook, Timms, Hazar and Ceylan et al**

For most patients these improvements were maintained two years after active treatment.

MECHANISM OF RPE IN CORRECTION OF CONDUCTIVE HEARING LOSS

The middle ear is connected by the eustachian tube to the nasopharnyx, which in turn communicates with the nasal cavities and the oropharynx. Oropharnyx and palate may both influence the functioning of the eustachian tube. RME has certain effects on the nasal cavity and palate. In addition, tensor veli palatini may affect hearing improvements.

This muscle has its orgin at or near the Eustachian tube orifice and inserts into the soft palate and plays a role in the opening of eustachian tube orifice. After RME, this muscle may extend and open the eustachain tube orifice. As a result, air passes through the tube, and ossicular chain function normally.

Improvement in conductive hearing loss is considered as a possible additional benefit of RME treatment. It does not indicate that people with conductive hearing loss should consider this a treatment approach without an accompanying maxillary constriction

RME AND NASAL AIR FLOW

Schwartz (1955) estimated that in an eight-year-old boy the nostril is 40 sq. mm in area and the nasal cavity 50 mm high. If the nasal floor is widened by 1 mm the improvement in the airway is more than the area of one nostril. In bilateral crossbite with nasal stenosis, rapid expansion is only part of the treatment plan.

James et al (JCO 1968) reported a certain type of Class II division 1 malocclusion there is an extreme narrowing of the upper arch associated with a unilateral or bilateral crossbite with nasal stenosis. There is often impairment in the nasal airway and mouth breathing. In this type of case there is immediate improvement of the nasal airway and correction of the crossbite with rapid maxillary expansion.

Wertz (AJO 1970) expanded the mid-palatal suture in two groups of patients with bilateral posterior crossbite— one group had difficulty in nasal respiration and the other group had normal nasal breathing.

Nasal airflow was measured at rest and after mild exercise before and after RME. In the group with breathing difficulty, he found that only one of four experienced an increase in nasal airflow; the other three experienced a mild decrease. The group with no difficulty in respiration experienced either a mild increase or mild decrease in nasal airflow. All patients recorded an increased capacity for nasal air volume when measured during maximum effort.

All patients recorded an increased capacity for nasal air volume when measured during maximum effort. Wertz concluded that opening the mid-palatal suture for the purpose of increasing nasal permeability cannot be justified unless the obstruction is shown to be in the lower anterior portion of the nasal cavity and accompanied by a relative maxillary arch width deficiency.

Graber (1975) believes that the claims of improved nasal breathing apparently as a result of RME are most likely only temporary. More important, 12-year-old children have much more lymphoid tissue than adults and the lymphoid tissues can act to block nasal breathing. Spontaneous regression of lymphoid tissues during growth automatically improves nasal breathing, even if nothing is done to the palate.

Therefore, it can be concluded that the effect of RME on the nasal airway will to a great extent depend on the cause, location, and the severity of the nasal obstruction. Hence, the effect can vary from no appreciable change to a marked decrease in nasal airflow resistance.

Derishsweiler claimed an increase in nasal width, lowering of the palatal vault, and straightening of the nasal septum due to RME allowing many mouth breathers to adapt to the use of the nasal passage for respiration. The maxilla comprises of the external walls of the nasal cavity laterally, and expansion results in an increase in the inter-nasal capacity.

Warren et al (AJO 1987) found that nasal area increased 45% after the RME and 55% following the SARME. The expansion became particularly effective in increasing nasal valve size and the area width. Researchers suggested that an RME would not be useful by itself in cases with turbine hypertrophy, nasal polyps, enormous adenoids, or septal deviations.

RME IN CORRECTION OF AXIAL INCLINATIONS OF POSTEIOR TEETH

One of the common concerns is the orientation of the lingual cusps of the upper posterior teeth lie below the occlusal plane. This common finding in cases of malocclusion is due to the maxillary constriction and subsequent dentoalveolar compensation in which the upper posterior teeth are in a slight flared orientation.

Several choice of treatment protocols available. Conventional edgewise mechanics and rectangular wire can be used to correct the buccal root torque of upper posterior teeth, but it is contra-indicated in instance of severe maxillary constriction because of the possibility that the roots of the maxillary teeth may erode through the buccal cortical plate.

Alternative approach is a two-step sequence of the treatment.

First, a rapid maxillary expansion is used to widen the maxilla, moving the roots of the upper posterior teeth into a more ideal orientation. Application of RME will produce a tendency towards a buccal crossbite

Subsequently, only tipping movement rather than application of buccal posterior teeth is necessary to align the upper and lower dentition. Some spontaneous correction of the lower posterior teeth also may be considered in-patient who undergo RME.

RME IN BROADENING OF SMILE

Perhaps the use of RME least supported by clinical research in widening the maxilla to make the smile of the patient more attractive. **Vanarsdall (1992**) has termed “Negative space” that shadow that occur in the corner of the mouth during similing in some patients with a narrow, tapered maxilla.

Maxilla is widened and the distance between the upper canines is increased, eliminating or reducing the dark space between the teeth and the inside surfaces of the cheeks. The facial proportions of the patient (e.g., brachyfacial and dolicofacial) must be taken into consideration when evaluating this treatment option.

EFFECT OF AGE ON RME

Growth at the midpalatal suture was thought to cease at the age of 3 years. By means of implants, **Björk and Skieller** found that growth at the suture might be occurring as late as 13 years of age.

Kreb et al studied orthopedic expansion of the palate using the implants. This study confirmed 50% dental movement and 50% skeletal movement in young children. In adolescents, however, only 35% of the movement was skeletal and 65% was dental.

Brin and associates (AJO 1981) evaluated the relationship between RME and cyclic nucleotides in the suture. They concluded that older animals are less responsive to the applied forces than younger animals, hence the decreased ability of the older group to adapt to the forces of RME.

Most investigators agree that RME with midpalatal splitting can be accomplished in both youths and adults, but with advancing maturity, the rigidity of the skeletal components limits the extent and the stability of the expansion.

Wertz (AJO 1970) reported an interesting age difference in intermolar width changes following RME. He divided his sample into 3 age groups: under 12, 12 to 18, and over 18 years. He found that after expansion and during fixed retention there was little relapse in any of the three groups (– 0.5, – 0.6, and – 0.5 mm, respectively). On the other hand, each age group behaved differently from the time of appliance removal to the end of retention. The group under 12 years of age had a further increase in intermolar width of approximately 16%, the 12 to 18 years group had a relapse of approximately 10%, and the over 18 years group had a relapse of approximately 63%.

The optimal age for expansion is, therefore, before 13 to 15 years of age. Although it may be possible to accomplish expansion in older patients, the results are neither as predictable nor as stable.

Zafer sari and Tuncan et al (AJO2003) compared the skeletal effects of modified acrylic-bonded rapid maxillary expansion device when it is used in the mixed and permanent dentitions.

The study group consisted of 2 groups patients. Mixed dentition group consisted of 34 subjects (19 girls and 15 boys) mean age of 9.2±1.3years, and permanent dentition group two consisted of 17 subjects (7girls and 10 boys) with mean age of 12.7±1.2 years who underwent RME treatment. Lateral, frontal cephalograms and upper dental casts were collected before and after treatment, and after retention.

Results in both groups after RME, the maxilla move forward; mandible rotated posteriorly; facial height increased; nasal, maxillary, and maxillary intercanine and first molar widths increased; and the upper molars tipped buccally. All most all these significant changes were stable as follow up.

However when the relapse tendencies between the two groups evaluated, the mixed dentition group showed more reduction of the intercanine and intermolar widths than did the permanent dentition group. This indicates that expansion in the earlier period of development is not more stable.

Authors suggested that orthopedic effects of RME are not as great as expected at early ages, and it might be better to delay RME to early permanent dentition.

Baccetti and Franchi et al (ANGLE 2001) evaluate the short-term and long-term treatment effects of rapid maxillary expansion in 2 groups of subjects treated with the Haas appliance. Treatment outcomes were evaluated before and after the peak in skeletal maturation, as assessed by the cervical vertebral maturation method, in a sample of 42 patients compared to a control sample of 20 subjects.

Posteroanterior cephalograms were analyzed for the treated subjects at (pretreatment), (immediate post-expansion) and (long-term observation), and for the controls. Following expansion and retention (2 months on average), fixed standard edgewise appliances were placed. The study included transverse measurements on dentoalveolar structures, maxillary and mandibular bases and other craniofacial regions (nasal, zygomatic, orbital, and cranial).

Author’s concluded that application of the Cervical Vertebral Maturation method for the assessment of differences in the outcome of RME therapy in relation to treatment timing revealed that RME therapy with the Haas expander induces clinically significant and reproducible transverse changes at the dentoalveolar level in patients treated before or after the peak in skeletal growth velocity.

Patients treated before the pubertal peak exhibit significant and more effective long-term changes at the skeletal level in both maxillary and circummaxillary structures. When RME treatment is performed after the pubertal growth spurt, maxillary adaptations to expansion therapy shift from the skeletal level to the dentoalveolar level.

Handelman (ANGLE 2001) studied the efficacy of nonsurgical RME, and to determine the incidence of complications such as relapse of the expansion, pain and tissue swelling, tipping of the molars, and opening rotation of the mandible and gingival recession.

Rapid maxillary expansion using a Haas expander was examined in 47 adults and 47 children. A control group of 52 adult orthodontic patients who did not require RME was also studied.

Rapid maxillary expansion in adults flared the molars buccally only 38 per side. The mandibular plane and lower facial height were unchanged. The adults achieved 18% of their transmolar expansion at the height of the palate and the remainder with buccal displacement of the alveolus.

The children achieved 56% of their expansion by an increase at the height of the palate with the remainder due to displacement of the alveolus. There was some buccal attachment loss (0.6 ± 0.5 mm) seen in the female subjects associated with RME, but the extent was clinically acceptable.

This resulted in significantly longer clinical crowns, but rarely caused exposure of buccal root cementum. Complications were infrequently observed or of minimal consequence. The results indicate that nonsurgical RME in adults is a clinically successful and safe method for correcting transverse maxillary arch deficiency.

SURGICAL MIDPALATAL SPLITTING

The decision to use a surgical adjunct for the correction of the transverse skeletal discrepancy

To achieve greater dental and skeletal stability in the adult retreatment case.

To prevent periodontal problems.

To improve dentofacial esthetics by eliminating or improving lateral negative spaces, which accompanies maxillary transverse deficiency.

Rapid maxillary expansion has been used frequently for younger patients. However, if applied to adult patients, the possibility of successful palatal expansion is decreased because the sutures show a more interdigitated form and greater resistance to mechanical forces. For such cases, a surgically assisted rapid maxillary expansion would produce a better treatment result.

Palatal expansion can be accomplished by surgically moving the maxillae or by surgically undermining the maxillae to facilitate expansion using an RME appliance.

The surgical approaches are either corticotomies of the buccal surfaces of the maxillae or more extensive surgery involving the separation of the maxillae from the pterygoid plates. With true unilateral skeletal maxillary constriction, surgical expansion of the collapsed side offers a distinct advantage, particularly when bilateral expansion of the two halves is not indicated.

When the clinician considers moving the maxillary segments laterally during a surgical procedure, it should be remembered that this instantaneous expansion of the maxilla is limited in part by the amount the palatal mucoperiosteum can be stretched.

Northway and Meade (ANGLE 1997) evaluated the dental tipping effects resulting from SARPE and a full course of edgewise-orthodontic treatment. They reported nearly 5 degrees of buccal tipping at the first premolars and 3 degrees of lingual tipping at the first molars in the buccal corticotomy with mid-palatal split group. However, they also stressed that much of the tipping from SARPE may be eliminated or reduced as a result of the following edgewise orthodontics.

Jeffrey Berger and Valmy et al (AJO 1998) examine and compare the dental and skeletal changes over time for both orthopedic maxillary expansion and surgically assisted palatal expansion.

The study was divided into two groups. Group one was orthopedically expanded and consisted of 14 males and 10females. The ages ranged from 6 years to 12 years with a mean of 8.5 years. Group two received surgically assisted rapid palatal expansion and consisted of 12 males and 16 females with ages ranging from 13years to 35 years and a mean age of 19.25 years.

Dental models and posterior anterior cephalograms were obtained immediately before and after expansion, at removal of the expansion device, and 1 year after removal of the appliance. The surgical and nonsurgical techniques displayed similar trends over time although the surgical group contained a greater quantity of expansion.

Both the orthopedic and the surgical groups showed stable results.

Chun chung and Andrew woo et al (AJO 2001) investigated the sagittal and vertical effects on the maxilla induced by surgically assisted rapid palatal expansion.

Twenty patients (average age, 25.6 years) who required a surgically assisted rapid palatal expansion procedure were available for this study. Each patient was banded with a Haas-type palatal expander, maxillary surgery was performed, and the expander was activated. Presurgical and postexpansion lateral cephalograms were taken for each patient.

Author concluded that,

1. There was a slight maxillary forward displacement after the surgically assisted RPE. These changes are small in magnitude and may not be clinically significant.

2. There was a slight retroclination of the maxillary incisors after the surgically assisted RPE

3. There was no significant maxillary vertical displacement after the surgically assisted RPE.

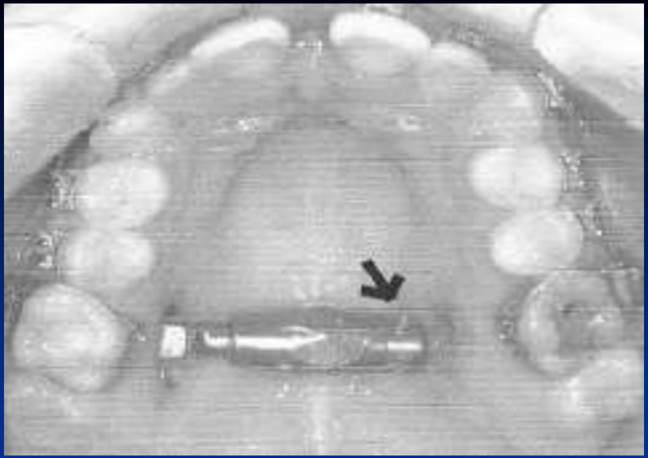
Chun Chung and Adena et al (EJO 2003) evaluated the effects of dental tipping and rotation immediately after surgically assisted rapid palatal expansion (SARPE).

Fourteen patients (10 females, 4 males; mean age 25.6 years) who required a SARPE procedure were available for this study. A palatal expander appliance was cemented on four abutment teeth (first premolars and first molars) of each patient 1 week prior to surgery.

Maxillary study models were taken before surgery and 2–3 weeks after full expansion (7 mm). Each model was trimmed to have the base parallel to its occlusal plane. From an occlusal view, measurements were made to determine if the abutment teeth underwent rotation from SARPE. From a postero-anterior view, the abutment teeth were examined for any tipping effect due to SARPE.

The results showed that from pre- to post-expansion, SARPE induced a slight mesiobuccal rotation and significant buccal tipping of the first premolars and the first molars. Some overexpansion is suggested to counteract the relapse effect of buccal tipping of the posterior teeth that takes place during SARPE.

TRANSPALATAL DISTRACTOR



The transpalatal distractor (TPD) allows for maxillary expansion according to the concepts of distraction osteogenesis. Unlike tooth-borne, surgically assisted rapid palatal expansion devices, the bone-borne TPD is designed to avoid periodontal ligament compression, buccal root resorption, fenestration, tooth tipping, and orthodontic relapse during and after the expansion.

When the distractor is placed on the palate at the level of the second premolar and pterygomaxillary disjunction is not performed, more expansion occurs in the anterior part of the maxilla than it does in the posterior.

Claudio and Maurice et al (AJO 2001) investigated the hypothesis that pterygomaxillary disjunction and placement of the TPD on the palate at the level of the first molars result in more parallel expansion of the maxillary segments.

Twenty consecutive patients were included in a prospective way, and their predistraction and postdistraction models were electronically analyzed. The change in resistance and force application resulted, on average, in parallel segment expansion.

The results showed that pterygomaxillary disjunction and posterior placement of the TPD are indicated for patients having transverse maxillary deficiency with lateroposterior crossbite.

EFFECTS OF RME ON PALATAL MUCOPERIOSTEUM, PERIODONTAL TISSUES AND ROOT RESORPTION

Cotton (AJO 1978) suggested that the postexpansion angular changes of the maxillary first molars may be related to the stretched fibers of the attached palatal mucosa. He found that all maxillary molars in his animal study demonstrated an average 10° decrease in angulation after active expansion and this decrease occurred regardless of whether an actual increase in molar angulation had occurred during the treatment period.

Maguerza and Shapiro (AJO 1980) attempted to relieve the stretch of the mucoperiosteum after "slow" expansion by making incisions along the palate down to the cortical bone, 3 mm away from the teeth. The incisions did not effectively reduce the relapse tendency. Whether such incisions might be effective with RME expansion or whether the incision wound itself causes contraction is yet to be determined.

Greenbaum and Zachrisson(AJO 1982) evaluated the effects of orthodontic treatment alone, RME (tissue-borne fixed appliance), and slow (quad-helix) palatal expansion on the periodontal supporting structures located at the buccal aspects of the maxillary first permanent molars. They found that the differences among the groups were not significant and were clinically of small magnitude.

James et al (JCO 1968) in order to ascertain whether lateral resorption has occurred on the buccal root surfaces during expansion, histological examination of teeth and alveoli extracted from arches which had previously been expanded was undertaken. Examination of the histological material revealed microscopic areas of resorption, which had partially or totally repaired with osteodentin (Fig). Very little cellular activity was present except at the sites of repair. The periodontal membrane and alveolar bone appeared normal.

Barber (AJO 1981) and Langford (AJO 82) reported marked buccal root resorption of the anchor teeth during RME and fixed retention. These defects tended to gradually repair.

Moss and Timms et al have histologically examined anchor teeth removed from human patients following RME and retention of varying periods. A common finding was root resorption. In addition, repair was also described in the material examined, although attachment of the principal periodontal fibers was not discussed.

Barber and Sims et al (AJO 1981) investigated the effects of rapid maxillary expansion on the external root structure of thirteen appliance-attached and five unattached maxillary first premolars from nine patients with the scanning electron microscope (SEM).

Topographic features of` cementum and dentine resorption, as well as initial and subsequent remineralization changes, were observed.. All anchor premolars exhibited root resorption, which was mostly confined to the buccal surface.

Active resorption was the dominant process in anchor premolars extracted almost immediately after rapid expansion. Subsequently, repair became the predominant process, but continuing resorption was apparent even after 9 months of retention.

Repair of root defects occurred by the deposition of cellular cementum which revealed little evidence of principal periodontal fiber reattachment within the advancing mineral front. The resorption pattern identified in the scanning electron microscope was not detected by in viva radiographic examination.

Langfurd et al (AJO 1982) investigated human repair and reattachment of principal periodontal fibers in areas of resorption on anchor premolar root surfaces following rapid maxillary expansion. Maxillary first premolar teeth were obtained from patients requiring rapid maxillary expansion.

Extraction of the teeth was scheduled after periods of retention varying between 14 and 53 weeks. The roots of the teeth were examined via light microscopy and scanning electron microscopy. Extensive root resorption characterized the buccal surfaces of anchor premolars.

Repair of the resorptive defects was found to occur exclusively with cellular cementum. Anchor teeth retained for longer periods, up to the maximum of 53 weeks of retention in this study, generally demonstrated more advanced repair.

Topographically, Sharpey fiber holes indicative of principal periodontal fiber insertion were found in repair cementum.

However, these depressions were neither numerous nor consistent in their presence and location. In human teeth, periodontal attachment to resorbed and repairing surfaces was shown to be present. SEM studies of histologic sections revealed that periodontal fibers and fiber bundles inserted directly into the repair cellular cementum matrix, irrespective of the site of the lesion on the root.

Odenrick et al (EJO 1991) compared the Haas (tissue borne) and the Hyrax (all wire framework) appliances with respect to root resorption. They concluded that tissue borne appliances were more successful in minimizing the incidence of root resorption.

Nejat and Nazan (AJO 1994) investigated to compare Haas and Cast Cap Splint devices from the point of root resorption. The material comprised thirty-eight upper and twelve lower premolar teeth derived from nineteen patients who required RME and subsequent removal of the first premolars as part of their full banded orthodontic treatment. Root resorption and repair areas were observed on the buccal surfaces of premolars. Repair tissue was cellular cementum in both groups. There was no significant difference between these two techniques from the point of root resorption amount.

Fulya and Nazan et al (AJO 2000) investigated the effects of the heavy forces exerted by the rapid palatal expansion (RPE) appliance on the pulpal tissue of anchor premolar teeth and to evaluate these effects by histologic and histomorphometric methods.

Materials consisted of 34 sound upper premolars, extractions of which were required as part of orthodontic treatment. Twenty-three teeth were extracted after RPE; the remaining 11 teeth, which had not undergone any orthodontic force, were taken as controls. After extraction, the teeth were prepared for histologic examination under light microscopy. Histomorphometric measurements were performed using image analysis.

Of the parameters evaluated, vessel area and minimum and maximum vessel diameters showed significant differences among the groups. Especially the difference between the control and 3-month groups had marked statistical significance.

In conclusion, forces applied by RPE appliances caused an adaptive vascular tissue response, as well as fibrotic changes, in the "affected" upper premolars.

RETENTION AND RELAPSE OF RME

Expansion through maxillary suture widening by rapid maxillary expanders has been claimed to promote stability after retention. Stability has been attributed to the skeletal component of arch enlargement obtained by the expansion appliance as opposed to dental expansion as a result of edgewise appliance mechanotherapy.

The causes of Relapse were summarized in the literature as follows: -

High stress accumulated between the articulations of the craniofacial complex.

Tension produced in the palatal mucosa.

Imbalance between the buccal and lingual pressures, which is created as a result of maxillary expansion

Thorne (AJO 1960) noted that cases retained less than 2 months demonstrated considerable collapse. No retention resulted in complete relapse, while cases held over 2 months manifested complete stability.

The implant studies by **Krebs (1964)** during a 7-year observation period found a substantial reduction in dental arch width after discontinuation of retention which continued for as long as 4 to 5 years.

Skieller (1964) carried out scientific study where he inserted metal implants into thirteen girls and seven boys, using an expansion appliance. This was opened at the rate of 0.5 mm. per week for 7 months and then maintained for 12 months. He found that both the teeth and the vault widened and that the vault continued to widen both during retention and thereafter.

The teeth, however, commenced to relapse at the end of the expansion and continued to do so out of retention, with the relapse amounting on average to about 25 percent of the total opening. Skieller's, reportes show that the dental relapse was less for the patients under 9 years old and noticeably higher for those over 12 years of age.

Zimring and Isaacson (Angle 1965) studied the forces produced by RME and found that the facial skeleton and maxillary articulations are the main resistance to expansion, not the mid-palatal suture.

In their study the maximum loads on the patients ranged from 16.6 pounds (7.53kg) and 34.8 pounds (15.8kg) during treatment, and these forces were gradually dissipated almost to zero during the retention period of six weeks. They demonstrated that forces tending to collapse the maxillary expansion exist for approximately 6weeks.

Stockfish (1969) found 50% of relapse within 3 to 5 years after retention after rapid palatal expansion.

Hicks (AJO 1978) observed that the amount of relapse is related to the method of retention after expansion. With no retention, the relapse can amount to 45% as compared with 10% to 23% with fixed retention and 22% to 25% with removable retention.

Linder-Aronson and Lindgren (1979) performed a 5-year posttreatment study and noted that only 45% of the initially achieved rapid palatal expansion was maintained. They also found a residual expansion of 38% and 59% for intercanine and intermolar widths, respectively, over a period of observation.

Bell (AJO 1982) concluded that slow expansion is less disruptive to the sutural systems. Slow expansion that maintains tissue integrity apparently needs 1 to 3 months of retention, which is significantly shorter than the 3 to 6 months recommended15 for rapid expansion. Mew advocates a total retention period of 1½ to 4 years, depending on the extent of expansion.

Mew in (AJO 1983) studied twenty-five patients (10 boys, 15 girls) who were consecutively treated with maxillary expansion. The cases were overexpanded 2 to 4 mm. The expansion was measured 2 or 3 months out of retention to allow the overexpansion to settle. Measurements were made again 2½ years out of retention. The net expansion had been 3.5 mm., and this had subsequently not relapsed.

Herold (BJO 1989) reported that the increase in intercanine and intermolar widths observed during treatment with palatal expansion was followed by relapse, with a residual increase of 2.1 mm (62.5%) and 3.1 mm (56.4%), respectively.

Jeffrey L. Berger in (AJO 1998) examined and compared the stability of orthopedic and surgically assisted rapid palatal expansion over time. Orthopedic expansion group consisted of 14 males and 10 females with ages ranged from 6 years to 12 years and Surgically assisted rapid palatal expansion group consisted of 12 males and 16 females with ages ranging from 13 years to 35 years. Dental models and PA cephalograms were obtained immediately before and after expansion, at removal of the expansion device, and 1 year after removal of the appliance.

From the study he concluded that,
Clinically, there is no difference in the stability of surgically assisted rapid palatal expansion and nonsurgical orthopedic expansion.

The length of time after appliance removal was a year or slightly longer. These patients were kept in retention during the 1-year period thus demonstrating the importance of retainers to control perioral forces and maintain stability. Both the orthopedic and the surgical groups showed stable result

Halozonetis et al (EJO 1994) recorded the cheek pressure after RME and found that during the three-months to four-months period of stabilization of the appliance, the pressure remained at the postexpansion levels, and no adaptation of the soft tissue occurred. Because the expansion appliance was not removed during the measurements, the tongue pressure were not examined in this study

Nazan et al (Angle 2003) investigated the changes in pressures that are exerted to maxilla by the tongue, lip, and cheek before and after expansion and during the retention period. Twelve patents (5males and 5 females) with maxillary transverse deficiencies were randomly selected. Pressure measurements were made using a diaphragm pressure transducer.

The first pressure measurements were made before expansion and second measurement were made after the maxillary expansion procedure, which lasted about 20 days. The expansion devices were replaced with retention devices, and measurements were made at the end of the first, second and third months of retention.

Pressure values on the buccal side of the upper first molar and incisor increased significantly right after expansion but started decreasing during retention. The values at the end of the third month of retention were similar to the pre-expansion values.

Tongue pressure on the lingual side of the upper molar and upper incisor decreased significantly with expansion but started increasing after the expansion procedure. Even at the end of the third month of the retention period, the values were not similar to the pre-expansion values.

Author concluded these values showed that the cheeks and lips almost adapt to the new position of dental arches at the end of the third month, whereas tongue adaptation took comparatively longer.