Review Article

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Rapid Maxillary Expansion in Trasverse Maxillary Deficiency: A Review

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ABSTRACT

Background: Early correction of transverse maxillary discrepancy can be achieved using a unique treatment modality, Rapid maxillary expansion. The treatment goal is achieved by the separation of mid palatal suture using an expansion device. The maturity of circum maxillary sutures determine the time and success rate of the treatment with RME. Maximum treatment effect would be achieved if the expansion is done before the pubertal peak. Orthopaedic correction using facemask combined with RME is a valuable treatment option in growing children with maxillary deficiency. Alternate expansion and contraction is a recent development by which the maxillary sutures can be disarticulated to facilitate orthodontic protraction. For skeletally mature individuals, assisted surgery to separate the sutures can be considered.

Keywords: Maxillary deficiency, Rapid maxillary Expansion, Expansion protocols.

INTRODUCTION

The narrow maxillary arch compared to mandibular arch usually results in transverse discrepancy of posterior teeth characterized by unilateral or bilateral crossbite. According to a recent epidemiologic study by da Silva et al[1], approximately 21% of children have some form of transverse skeletal discrepancy involving the dental arches. The etiology of maxillary constriction has been shown to be genetic, environmental or multifactorial. There is no significant difference in the prevalence of maxillary constriction between gender or ethnicity groups.

The early correction of posterior crossbite requiring maxillary expansion has been advocated to redirect the maxillary teeth in to more normal positions, eliminate untoward mandibular joint positions and mandibular closure patterns and make beneficial dentoskeletal changes during growth periods that would reduce the complexity of further treatment[2].

Rapid maxillary expansion (RME) is the most common orthopaedic procedures used to correct a maxilla with a transverse discrepancy. Heavy orthopaedic forces are used to separate the two halves of the maxilla at the midpalatal suture. The earliest commonly cited report on rapid maxillary expansion is that of E.C. Angell published in the Dental Cosmos in 1860[3].He described an appliance that succeeded in seperating two halves of maxilla. The early 1900s were commonly known as the maxillary expansion years by many orthodontists and as well as rhinologists. Brown, a noted rhinologist, used palatal expansion for the purpose of increasing nasal airflow. Eventually this technique lost its popularity; but was reintroduced by Korkhaus and Haas in mid-twentieth century.

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Since White and Angell's first appliances, there have been continuous efforts to modify and improve Rapid Maxillary Expansion (RME) appliances. In 1958, Haas introduced what is now referred to as the Haas appliance. This is a fixed appliance with orthodontic bands on the maxillary first premolars and first molars which are then connected to a jackscrew located in the center of the appliance; two acrylic plates cover the soft tissue of the palate. While it has been stated that the tooth and tissue-borne Haas appliance results in a more parallel expansion of the alveolar ridges, there is great potential for soft tissue irritation with this appliance. In 1968, William Biederman created an alternative design to the Haas appliance that was initially called the Biederman or Hygienic appliance, but later became known as the Hyrax. This appliance consisted of bands on the maxillary first premolars and first molars which were then soldered onto steel arms connected to a jackscrew.

ANATOMY

The paired maxillae unite with palatine bone to form complete hard palate (or) floor of nose and greater part of lateral wall of nasal cavity. The palatine bone articulates anteriorly with maxilla through transverse palatal sutures and posteriorly through pterygoid process of the sphenoid bone. The interpalatine suture joins the two palatine bones at their horizontal plates and continuous as inter maxillary sutures. These sutures form the junction of three opposing pairs of bones: the premaxillae, maxilla, and the palatine. The entire forms mid-palatal suture.

SUTUTRES

The midpalatal suture plays a key role in RME. Melson (1975) describing the morphology of midpalatal suture divided its postnatal development in to three stages[4].

1. Infantile – broad and Y shaped suture
2. Juvenile – more wavy suture (T shaped)
3. Adolescent –tortuous nature (jigsaw puzzle)

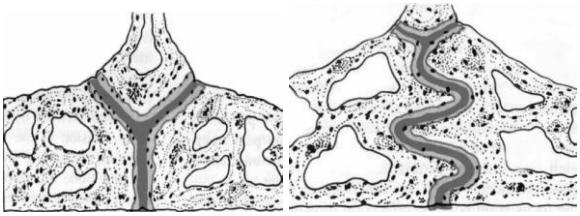

Fig 1a: Suture at infancy(adopted)[32]. 1b: Suture at adolescence(adopted)[32]

It is believed that growth at midpalatal suture continues until around the ages of 13-15 years and then is followed by continuation of apposition until the age of 18 years. If 5% midpalatal suture closure is set as a limit for splitting the intermaxillary suture, this 5% will not have been reached in most patients younger than 25 years of age[5]. Greater degree of obliteration occurs posteriorly than anteriorly.

Along with the opening of the midpalatal suture RME has an effect on the entire maxillary complex. According to Starnbach, palatal expansion doesn't only separate the midpalatal suture, but the circumzygomatic and circummaxillary sutural systems as well. In palatal splitting with rapid expansion devices, it has been shown by Issacson and Ingram(1964) and Wertz(1970) that most of the resistance to separation is due to circummaxillary structures.

RATIONALE

The rationale behind rapid force is that with rapid force application to the posterior teeth there would not be enough time for tooth movement, the force would be transferred to the suture and the suture would open up while the teeth moved only minimally relative to their supporting bone.

INDICATIONS OF RME

Haas (1980) lists six primary indications for RME

1. Cases of real/relative maxillary deficiency
2. Cases of nasal stenosis.
3. All types of class III malocclusion.
4. The mature cleft palate patient.
5. Antero-posterior maxillary deficiency cases.
6. Selected arch length problems.

As a general rule, RME is indicated in cases with a transverse discrepancy equal to or greater than 4mm, and where the maxillary molars are already buccally inclined to compensate for the transverse skeletal discrepancy[6].

CONTRAINDICATIONS

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.

HAZARDS OF RME [Timms (1981)]

1. Oral hygiene problems.
2. The length of fixed retention being upto 4 months.
3. Dislodgement and breakage.
4. Infection due to invasion of microorganisms.
5. Failure of suture to open.

BIOMECHANICAL BASIS OF OPENING THE PALATAL SUTURE

Three main designs for the rapid expansion appliances in current use today. Main component is the screw, which provides the force to separate the suture. In the conventional design, anchorage is derived from bands that are usually placed on the maxillary first molars and first premolars. An alternative design, typically called a Haas type expander, adds acrylic coverage of the palatal vault to increase anchorage. A third design recently developed is a jackscrew attached to the palatal vault by orthodontic temporary anchorage devices.

Thus rapid maxillary expansion can be of two types:

Tooth and Tissue borne – Haas type expander, Derichsweiler type

Tooth borne - Banded – Hyrax or Biedermann type

Bonded maxillary expansion

Minne Expander or Isaacson type.

Two point rapid palatal expander.

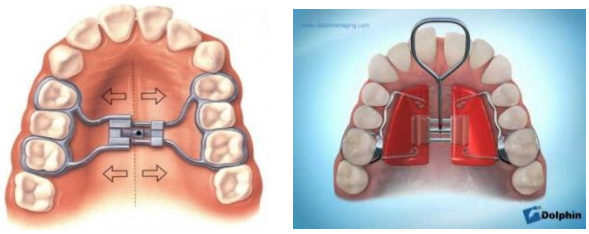

Fig 2a: Banded Hyrax expander. 2b: Haas expander (google images)

TIMING OF TREATMENT

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[7].Midpalatal suture opening can be achieved in both children and adults, but as the skeletal components mature, the rigidity of the bony inter digitation becomes so heavy that it is not possible to separate the two halves of the maxilla unless assisted by surgical fracturing of the maxilla.

FORCE OF EXPANSION

According to Isaacson, forces for palatal expansion often can reach 2–10 pounds to achieve the desired orthopaedic effect[8].A single activation of either a Haas or Hyrax appliance produces 2-10 pounds of force with a rapid initial decay followed by a slower decay curve[9].According to Zimring and Issacson, the maximum load produced by any single activation occurred immediately at the time of appliance activation and began to dissipate soon after[10]. Residual load level increases with progressive activations if load is not dissipated. Younger patients dissipate load faster than adults. Sander et al, in his study found that forces that occur during RME can go up to 120 N, but as soon as the suture ruptures, the force drops dramatically to about 25 N[11].

Major resistance to expansion forces was not the midpalatal suture, but other articulations in the maxilla, such as the zygomatic and sphenoidal sutures. Using photoelastic visualization of a model of a human skull, Chaconas and Caputo stated thatadditional stresses generated by RME were concentrated at the anterior portion of the palate

and then radiate superiorly along the perpendicular plates of the palatine, lacrimal, nasal and zygomatic bones to the pterygoid plates of the sphenoid[9].

From a clinical perspective, placement of the jackscrew should be as close to the centre of resistance as possible to effect a more translatory movement of the maxillary halves as well as the teeth.In the primary dentition, the centre would be in the middle of the palate between the embrasures of the primary first and second molar. In the mixed and permanent dentition, this location moves posteriorly to the embrasure between the second premolar or the second primary molar and the first permanent molar.

On activating the screw, resulting rotational force creates equivalent moments at the centre of resistance of each maxilla. As a result, there are two centres of rotation. The first is located at the frontonasal suture, which is seen from a frontal view. The other is at the posterior of the midpalatal suture in the third molar area, when viewed from the occlusal.

EFFECTS OF RME

SKELETAL EFFECTS OF RAPID MAXILLARY EXPANSION

RME increases the transverse dimensions of the maxillary arch primarily by separating the two maxillae (orthopedic effect) followed by buccal movement of the posterior teeth and alveolar processes (orthodontic effect). Expansion occurs when the force applied exceeds the limits of orthodontic tooth movement. This acts as an orthopaedic force that opens the midpalatal suture.

When the appliance is first activated, compression of the periodontal ligament occurs, followed by the bending of alveolar process and tipping of anchor teeth. The final result is a distraction force on the midpalatal suture. According to Starnbach et al., palatal expansion doesn't only separate the midpalatal suture, but the circumzygomatic and circummaxillarysutural systems as well[12]. The opening of the midpalatalsuture is pyramidal in shape from both frontal and occlusal views with the widest opening occurring at the alveolar bone between the central incisors, and narrowing as the suture goes superiorly and posteriorly.

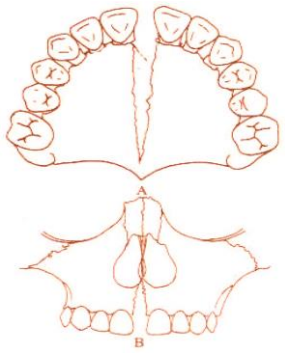

Fig 3: Effects of RME on the midpalatine suture(adopted)[32]

Inevitably, there are side effects with rapidmaxillary expansion. An increase in vertical dimension is one such effect. This is evident when the mandibular plane angle and the lower anterior facial heights increase during rapid maxillary expansion. These may not be beneficial in cases with existing open bites or large vertical dimensions.

DENTAL EFFECTS OF RAPID MAXILLARY EXPANSION

Most common change accompanying RME is the opening of a diastema between the maxillary central incisors. It is estimated that during active suture opening, the incisors separate approximately half the distance the expansion screw has been opened. Following this separation, the incisor crowns converge and establish proximal contact. The mesial tipping of the crowns is due to the elastic recoil of the trans-septal fibers of periodontal ligament. Once the crowns of incisors contact, the continued pull of the fibers causes the roots to converge toward their original axial inclinations. This takes about 4 months.

One of the main dental effects seen with rapid maxillary expansion is a tipping and extrusion of the teeth that anchor the appliance.To counteract this dental tipping a very rigid appliance should be used.As a result, it is believed that the center of rotation will move superiorly from a frontal perspective and more posteriorly from an occlusal perspective with a more rigid appliance. This will result in a more linear separation of the bones.

A more linear opening can also be achieved from the occlusal perspective by locating the Hyrax mechanism more posteriorly. But while doing this, patient comfort and ability to activation should be taken in to consideration. Braun also commented that the Haas type expander with the acrylic pads lacks the appropriate stiffness and may produce more tipping[13]. The vertical effects of rapid maxillary expansion come from both the dental and skeletal changes.The most obvious cause of the increase in vertical dimension is the change in the posterior occlusion.The application of the force from the expander is coronal to the center of rotation of the attachment points of the appliance to the maxillary posterior teeth. This causes the teeth to tip and extrude slightly, also causing an increase in the vertical dimension through increased cuspalinterferences[14].This RME phase is followed by fixed orthodontic treatment during which the uprighting of molars can be achieved.

As the maxillary arch width increases, the mandibular posterior teeth tend to upright and tip buccally. Haas (1961) theorized that the change in orientation of the mandibular posterior teeth is due to the tongue being forced downwards by the palatal appliance. In addition the buccinators muscle,due to buccal movement of the maxillary teeth would have less of a confinement effect on mandibular molars[15].

ASSESSMENT OF RAPID MAXILLARY EXPANSION

Clinically, the most common way of assessing the results of rapid maxillary expansion is through a visual examination of the patient. In addition, rapid maxillary expansion has been analyzed using two-dimensional posteroanterior (PA) cephalograms, occlusal radiographs and/or dental study models. Unfortunately, photographs and dental casts are only able to document what is visible clinically during expansion.The actual separation of the sutures is not visible clinically or radiographically, with the exception of the occlusal radiograph, which can document the midpalatal suture opening.

ACTIVATION OF THE APPLIANCE

Haas(1961) states that most of the screws are calibrated to give 0.8-1 mm expansion for each full turn, being constructed so that they are turned a quarter turn at a time. At the time of insertion, Haas recommends a full turn over 15 minutes, last quarter turn made by the parent. The parent is then instructed to make quarter turn twice daily. The patient is reviewed at 7,10,14,18, 21 days intervals and screw manipulation discontinued when overexpansion is achieved[15].

Timms(1981)[16] stresses the importance of patient instructions. The instructions should be carefully explained to the parent as their co-operation is required for the activation.Timms divides his activation schedule in to three age categories:

Upto 15 years of age : turn two turns morning and evening to make a full turn per day.

15 -20 years of age : increasing resistance to expansion may cause higher force build up and pain results. So Timms changed the activation schedule in to 4 quarter turns spread evenly throughout the day.

Over 20 yearsof age : not more than 2 turns per day. Over 25 years of age, suture is opened surgically and may not be necessary to reduce the activations. A return visit should be organised after 1 week in younger age group and 3-4 days in older age group. Dipaolo(1970) states that severe symptoms may appear such as blurring of vision, dizziness, headaches, nose bleeds, or pain in the zygomatic area and bridge of the nose. At the first sign of pain, re evaluate the treatment; stop activation for a period of time and determine the suture is opening. Werz(1970) also suggests this and adds that reduction of the activation schedule has proved most successful in providing time for cellular adjustments to occur at the activation sites[17]. Issacson and Ingram(1964) suggested that more than two activations per day cause significant force build up. They recommended, in younger patients twice daily activations for 4-5 days, then once daily for the remainder of the treatment. In older patients, twice daily for the first two days, then once daily for 5-7 days, then one every other day until the completion of treatment[8].

HOW MUCH TO EXPAND?

Krebs(1964), Stockfish(1969), Timms(1976) and Linder Aronson and Lindgren(1979) show that

between a third and a half of the expansion achieved will be lost before stability is achieved. So the clinician must consider the possibility of relapse and allow for it by overexpansion during the treatment. Timms(1980) felt that a convenient guideline to stop expansion is when the maxillary palatal cusps are in line with the mandibular buccal cusps.

Haas(1965) recommended that expansion should be continued till the maxillary arch completely encloses the mandibular arch. This overexpansion is needed because the increment of arch width gained by alveolar bending, periodontal membrane compression and extrusive tooth movement is almost certain to be lost.

MAXILLARY EXPANSION WITH FACEMASK THERAPY

The orthopaedic facemask combined with rapid maxillary expansion has been a valuable treatment option for children with class III malocclusion associated with maxillary retrusion. Effective maxillary advancement has been observed when treatment is performed at an early age, the time of greater responsiveness of the circummaxillary sutures. Baccetti et al[18] (1998) assessed two different age groups using maxillary expanders and facemasks and noticed a significantly greater advance of maxillary structures in the younger group. Besides correcting the posterior crossbite, this expansion causes partial disarticulation of the maxillary sutures, stimulating cellular activity in these areas and improving the orthopaedic action of maxillary protraction forces. Furthermore, this expansion prior to facemask prevented anterior maxillary constriction, which might take place during maxillary protraction[19].Even in absence of maxillary constriction, rapid palatal expander is activated for 7-10 days with different daily activations(Turley 1996, Baccetti et al 1998, Ngan et al 1998, Saadia & Torres 2000) prior to facemask therapy.

Although treatment goal is to displace maxilla forward by applying force to circum maxillary sutures, both skeletal and dental changes occurs with forward displacement of maxilla(1-3mm), flaring of maxillary incisors, downward and backward mandibular rotation and lingual inclination of mandibular incisors. The orthopaedic alteration are responsible for 75% of the correction with maxillary advancement representing 75% of the skeletal correction and 25% due to downward and backward mandibular rotation[20].

There are controversial results regarding the advantages of rapid palatal expansion before maxillary protraction. Baik reported statistically significant difference in treatment outcomes when RME was used in combination with maxillary protraction. Large forward (1mm) and downward(0.5mm) movement of point A was observed, indicating that maxillary growth has been achieved.. In a meta analysis, Jager et al[21] described a greater success in the treatment when RME/FM was used. However Vaughn et al[22] found no statistically significant differences between the groups treated with FM and with/without RME. Similar results were reported in a recent investigation by Tortop et al[23].

Masucci et al[24] evaluated the long term stability of RME and facemask therapy after active circum pulpal growth; in the long term, approximately 73% of the class III patients achieved successful outcomes. Also Westwood et al[25] described a success rate of about 76% at a follow up observation 5 years after treatment. Renato Rodrigues de ALMEIDA et al stated that this approach is highly recommended for patients in their mixed and primary dentitions and showed to be stable 15 years post treatment[19].

Correction of class III malocclusion occurs by a combination of skeletal and dental movements that occurs not only in the antero-posterior dimension, but also in the vertical plane of space. Majority of correction occurs by orthopaedic movement, with most of the change in the maxilla. Profile become more convex, with midface approximately 3.5mm farther forward than at the start of treatment and chin displaced a similar amount vertically[26].

ALTERNATE RAPID MAXILLARY EXPANSION AND CONTRACTION

A repetitive weekly protocol of alternate rapid maxillary expansion and constriction (Alt-RAMEC) was presented by Liou (2005) to disarticulate the circum-maxillary sutures for the growth of hypoplastic maxilla in growing cleft lip

and palate patients. But this protocol is effective in patients without cleft lip and palate also. With this protocol, the maxilla is expanded 1 mm/day for 1 week, then constricted 1 mm/day for the next week with a rapid maxillary expander. This procedure can be repeated for 7-9 weeks to disarticulate the maxilla. This rationale is similar to that of simple tooth extraction. Like a tooth that is rocked buccally and lingually within the socket until it is loosened, the maxilla is disarticulated without being overexpanded[27].

The total treatment period is 6 months, including 3 steps in sequence:

1) 7 weeks of Alt-RAMEC to loosen the maxilla.
2) 1 to 2 months of active maxillary protraction.
3) 2 to 3 months of maintenance.

An average anterior movement of point A of 5.8mm was observed with 9 weeks of Alt-RAMEC in cleft patients where as 2.6mm anterior movement was reported with RPE for 1 week. This difference was attributed to the Alt-RAMEC, which opens up circum maxillary sutures more extensively than one week of RPE[27]. Liou & Tsai(2005) reported that maxillay advancement in Alt-RAMEC group was two or three times greater than that in RPE/FM. This was supported by Wang et al(2009)[28], who concluded from his experimental study that Alt-RAMEC opened the sagittally and coronally running circum maxillary sutures quantitatively more than RPE.

SURGICALLY ASSISTED RAPID PALATAL EXPANSION(SARPE)

Surgically assisted expansion techniques can be considered in skeletally mature individuals with significant transverse discrepancies. Median palatal split with or without pterygoid osteotomy, after which a maxillary expander is cemented and activated on the upper arch for a couple of weeks for overcorrection.The retention period usually lasts for 3-6 months. SARPE is indicated to loosen the circummaxillary sutural resistance therefore to restrict unwanted tooth movement from dentoalveolar expansion[29].

ROLE OF LITHIUM

Effect of Lithium has also been studied related to RME by Tang GH et al, they found out lithium increased β-catenin expression and cell proliferation in expanding sutures. β-catenin regulates proliferation of osteoprogenitors and maturation of osteoblasts during midpalatal suture expansion osteogenesis, and that lithium enhances bone regeneration by elevating β-catenin expression. Lithium treatment could be a pharmaceutical aid to improve the stability of orthodontic treatment like rapid palatal expansion[30].

RETENTION AND RELAPSE

The space created in between the sutures is initially filled by tissue fluids and hemorrhage which makes the expansion highly unstable. Therefore the expansion device must be stabilized and left in place for 3-4 months after expansion. By then new bone will fill the space at the suture and skeletal expansion becomes stable. During retention, a wire ligature can be tied around the expansion screw to prevent it turning inadvertently.

CONCLUSION

Rapid maxillary expansion results in significant displacement of the bones of the circummaxillary sutures in growing children. The displacement of the midpalatal suture is significantly correlated to the displacement of the frontonasal and zygomaticomaxillary sutures. Along with an increase in the transverse dimension, the overall movement of the maxilla is downward and forward. The maturity of the circummaxillary structures determine the time and success rate of the treatment with RME. Maximum treatment effect would be achieved if the orthodontic expansion is done before pubertal peak. For patients that have passed the growth spurt assisted surgery to separate the midpalatal suture can be considered.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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