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Original Research Article

Maxillary Expansion in Orthodontics - A Brief Overview

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Abstract

Transverse maxillary discrepancies are the most common. The narrowed upper arch is the most prevalent problem an orthodontist encounter while treating adolescent and adult patients. Maxillary expansion is a technique used to increase the upper arch's transverse dimension to apply forces to widen the upper arch. For young children, a narrow maxillary arch has to be corrected using orthopedic and orthodontic treatments. In an orthodontic treatment plan, it is crucial to update transverse maxillary defeat. There are various clinical manifestations associated with a transverse maxillary deficiency which include a narrow palate, crossbite mainly seen in posteriors (unilateral or bilateral), severe crowding in anterior teeth, and cone-shaped hypertrophy can be seen. Some frequently used therapies for constricted upper arch include slow maxillary expansion, rapid maxillary expansion, and surgically assisted rapid maxillary expansion. Slow maxillary expansion requires light and constant force, whereas rapid maxillary expansion needs heavy pressure for activation.

Keywords: Expansion, Maxillary Expansion, Rapid maxillary expansion, Slow Expansion, SARPE, MARPE and DOME.

Introduction

For over a century, maxillary transverse deficiencies have been corrected with maxillary expansion therapy. Angell [1] first proposed the theory of maxillary extension in 1860, and Hass [2] later popularized it in 1961.

Although the work was criticized at the time, orthodontic therapy using this technique is now widely recognized as being quite a simple and predictable treatment procedure. In order to correct transverse discrepancies, the palate must often be expanded using a mix of orthodontic and orthopaedic tooth movements. These days, three expansion treatment techniques have been used:

1. Slow maxillary expansion (SME).
2. Rapid maxillary expansion (RME).
3. Surgically assisted maxillary expansion.

There is debate over which treatment technique should be used because each has its own advantages and disadvantages. In addition to considering the patient's age and malocclusion, practitioners also choose treatment appliances based on their own experiences [3]. By the age of six, normal palatal growth is almost complete and following puberty, separation of mid-palatal suture becomes more challenging to accomplish due to sutures interdigitation. [4] Transverse forces tilt the buccal segments laterally during treatment. The clinical conditions indicating maxillary expansion include crossbites, functional appliance treatment and surgical cases for instance arch coordination, to aid maxillary protraction and mild crowding [5]. This article aims to review the maxillary expansion and commonly used appliances.

Anatomy

The hard palate is composed of the palatal process of the maxilla and the horizontal process of the palatine bones [6]. It articulates anteriorly with maxilla through transverse palatal sutures and posteriorly through pterygoid process of the sphenoid bone.

The interpalatine suture joins the paired palatine bones at their horizontal plates and continues as an intermaxillary suture. Theoretically, these sutures form the junction of the three opposing pairs of bones: the premaxillae, the maxilla and the palatine. Practically, they are treated as a single

entity- the mid-palatine suture (MPS) [6]. The sphenoid and zygomatic bones have a buttressing effect resisting mid-palatal suture opening [6]. Melsen observed that the midpalatal suture is Y-shaped in infants, T-shaped in juveniles, and jigsaw puzzle-shaped in adolescents (Figure 1).

Melsen performed a histological microradiographic study in a human autopsy, which revealed that osteoblasts become inactive after age of 15 years in girls and 17 years in boys.

These studies indicated that the shape of the midpalatal suture was not constant and that the difficulty of opening the midpalatal suture increased with age [6].

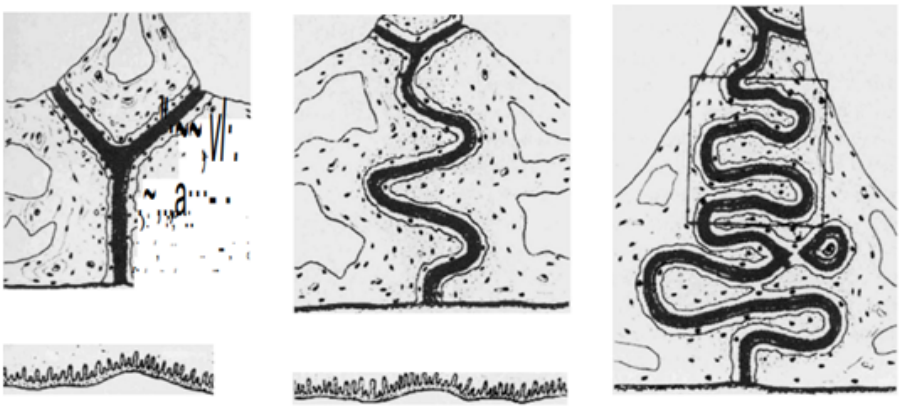

Figure 1

Indications for RME[6]

1. Posterior cross bite associated with a relatively narrow maxilla compared to the mandible.
2. Elimination of inter-arch transverse discrepancies prior to orthopedic intervention in class II malocclusions.
3. In Class III malocclusion for the correction of posterior crossbites.
4. SARPE (surgically assisted rapid palatal expansion). It is used in adult skeletal posterior crossbites along with surgery.
5. Constricted maxillary arch, involving airway impairment or mouth-breathing tendencies.
6. Cleft palate patients with collapsed maxillary arch.
7. RME is used along with face mask in maxillary sagittal deficiency cases.
8. TSALD (tooth size arch length discrepancies): Increase of arch perimeter to accommodate teeth in patients with tooth size-arch size discrepancies.
9. Gray and Brogans medical indications for rapid maxillary expansion include nasal stenosis, poor nasal airway, septal deformities and as a preliminary to septoplasty, recurrent ear and nasal infection, allergic rhinitis, deviated nasal septum (DNS), etc.

Contraindications of RME[6]

Absolute contraindications

1. Patients who have skeletal asymmetry of the maxilla or mandible.
2. Adults with severe anteroposterior and vertical skeletal discrepancies are not good candidates for RME.
3. Patients who have single tooth cross bite probably do not need RME.
4. Patients with already existing anterior open bite.
5. Patients with steep mandibular plane and convex profiles with vertical growth pattern are generally not suited for RME.
6. RME is contraindicated in patients who are not cooperative with the clinician as the appliance requires frequent activations.

Relative contraindications

1. Rapid maxillary expansion is not carried out after ossification of the mid-palatal suture is completed. In such cases, it is accomplished by adjunctive surgical procedures.
2. The procedure is not indicated in periodontally weakened molars.
3. Normal buccal occlusion with good interdigitation of cusps and fossa.

Diagnostic AIDS: General diagnostic aids include the patient's medical history, a physical exam, study models, and radiograph such a maxillary occlusal or a panoramic anteroposterior cephalograms [7]. Since reproducibility of 2D radiographs is problematic, and overlapping images are difficult to assess. More recent approaches include 3-dimensional (3D) imaging, Cone beam computed tomography (CBCT) were considered to be more accurate and reproducible imaging for assessing all craniofacial skeletal structures, including the circummaxillary sutures [8,9].

Fernanda Angelieri presented a novel classification method for individual assessment of midpalatal suture morphology [10].

Slow Maxillary Expansion:

Expansion of the arch is a tempting means of gaining space with the added advantage of being a conservative procedure that does not require extraction of teeth as an actual part of therapy [11].

Slow maxillary appliances can be broadly classified as follows:

Removable appliances:

1. Coffin spring
2. Y plate
3. Shwartz appliance
4. Active plate

Fixed appliances:

1. W arch
2. Quad helix
3. Spring jet
4. Niti palatal expander
5. Spring-loaded expander
6. Magnets

Removable Appliances:

Coffin Spring:

Figure 2: Coffin spring

Given by Walter Coffin–1875. It is activated by pulling two asides apart manually (fig 2). The appliance is mainly indicated to bring about dentoalveolar changes in cases of unilateral or bilateral crossbite, cases where lateral expansion is indicated, cases requiring anteroposterior expansion, and when space requirement is less than 3 mm. Some amount of skeletal changes can also be brought about in mixed dentition period if proper retention protocol is maintained.

Y-Plate:

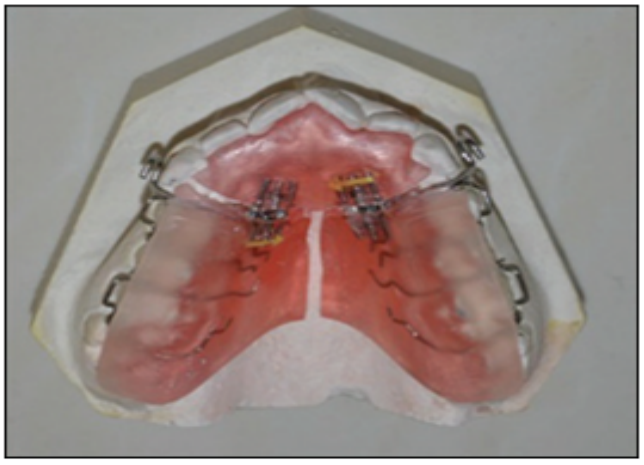

Figure 3: Y-plate

It is an active type of removable expansion appliance which is similar to that of the bite plate (fig 3).

The jackscrews on activation exert a distalizing force on the buccal segment teeth and a reciprocal force is delivered to the anterior palatal contour and maxillary incisors. The Y plate is indicated in patients with first premolars erupted, giving increased anchorage, upright incisors, and where no extensive bodily movement is required.

Shwartz Appliance:

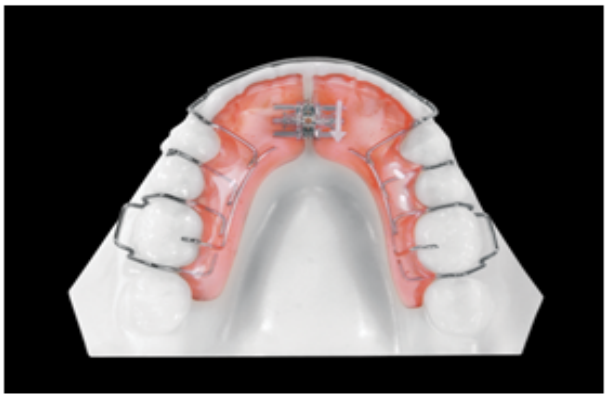

Figure 4: Shwartz appliance

The Shwartz appliance was introduced by Shwartz in 1966 (fig 4). The appliance is indicated during the mixed dentition phase.

The gradual expansion of Shwartz appliance produced by activation of midline screw simply tips the posterior teeth in a lateral direction. The appliance can be used in patients who have arch length deficiencies and/or posterior teeth that have an abnormal lingual inclination.

Active Plate:

Figure 5: Active plate

The concept of active plate was introduced by Pierre Robin in 1902 (fig 5). The expansion screws are the active components of this removable appliance. According to Profit, most screws open 1mm per complete revolution, so that a single quarter turn produces 0.25mm of tooth movement. The active plates are most useful when few millimetres of space is required (1.5-2mm per side) .

Fixed Appliances:

W ARCH:

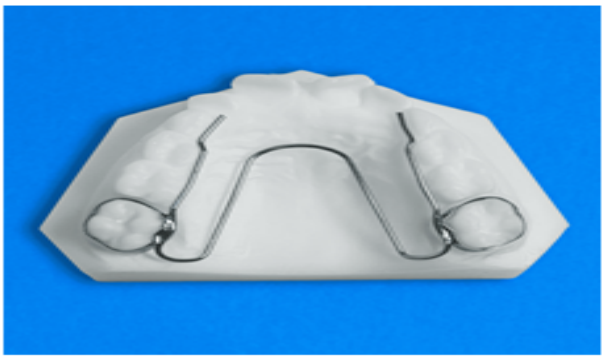

Figure 6: W- Arch

The "W" expansion appliance was originally used by Ricketts and his colleagues in the year 1975 to treat cleft palate patients (fig 6). It is activated simply by opening the apices of W-arch and is easily adjusted to provide more anterior than posterior expansion. Expansion should continue until the crossbite is slightly overcorrected.

QUAD HELIX:

Figure 7: Quadhelix

The quad-helix appliance (fig 7) is a modification of Coffin's W-spring and was described by Ricketts. The incorporation of four helices into the W-spring helped to increase the flexibility and range of activation. The length of the palatal arms of the appliance can be altered depending upon which teeth are in crossbite.

SPRING JET:

Figure 8: Spring jet

It is a prefabricated appliance that consists of a Niti coil spring (active component) (fig 8). Activation is done by moving the lock screw horizontally along the telescopic tube. The spring jet is activated by turning the lock screw by 90 degrees every two weeks to keep the spring compressed for slow palatal expansion.

NITI PALATAL EXPANDER:

Figure 9: Niti expander

The Nickel Titanium Palatal Expanders were introduced by Wendell V. The central component is made of a thermally activated NiTi alloy and rest of component is made of stainless steel (fig 9). The action of appliance is a consequence of nickel titanium's shape memory and transition temperature effects. The nickel-titanium component has a transition temperature of 94ºF.

SPRING LOADED EXPANDER:

Figure 10: Spring-loaded expander

The spring-loaded expander (SLE) was introduced by Leone in 2003 (fig 10).

The appliance is indicated in patients whose growth is completed. The device is activated on average, 4-8 activations (0, 4-0, 8 mm) every 6 weeks. However, by changing the activation pattern, rapid maxillary expansion can also be achieved using SLE.

Magnets:

Repulsive magnetic forces for maxillary expansion were first described by Vardemon et al 1987. Banded magnets produce more skeletal, versus overall expansion effects.

Disadvantage is that they tend to be oxidized in the oral environment due to the potential formation of corrosive products but this can overcome by coating magnets. The advantage is that they impart measured continuous force over a long period of time hence the risk of external root resorption is decreased.

Rapid Maxillary Expansion

Over the years, numerous types of RME appliances were designed ever since Angell introduced the first RME in 1860. They can be classified as [6]:

Will and Muhl

I) Removable expanders

Removable jackscrew appliances

II) Fixed jackscrew appliances

Banded RME

Tooth borne - Derichsweiller and Hass type

Tooth and tissue borne - Isaacson and Hyrax type

Bonded RME

Removable RME appliances: It consists of screw in the midline with retentive clasp on posterior teeth. The acrylic plate is split in the midline and activations of the screw forces the two halves apart

to result in the desired expansion. It is possible to bring about the skeletal expansion by opening the midline suture by using removable plates [6]:

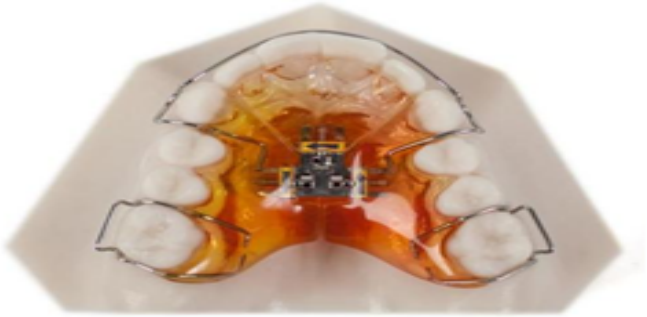

Figure 11: Removable RME

Fixed jacks crew appliances

Isaacson type

This is a tooth borne appliance without any acrylic palatal covering. A spring-loaded screw often called the MINNE expander (developed at the University of Minnesota, dental school) is soldered on the palatal extension of the metal framework. (Fig 12)The expander consists of a coil spring and a nut that compresses this spring on closing.[6]

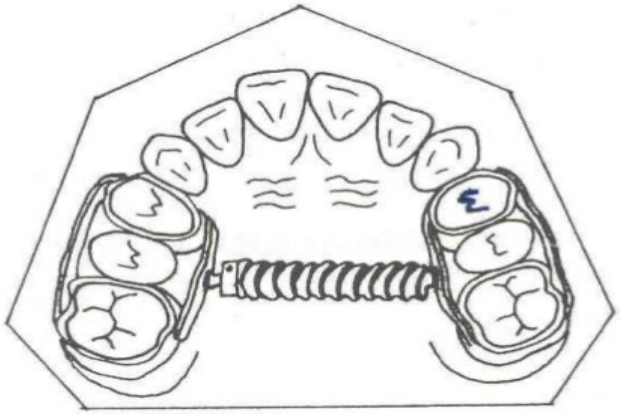

Figure 12: Isaacson

Biedermann type or Hyrax type

Bands are placed on the maxillary first molars and first premolars. The expansion screw is located in the palate in close proximity to the palatal contour. Buccal and lingual support wires also may be added for rigidity (Fig 13).

This type of appliance makes use of a special type of screw called HYRAX (acronym of Hygienic Rapid Expander). The screws have heavy gauge wire extensions, which can be adapted to follow the contour of the palate and are soldered to metal bands. Thus Hyrax can be used as both banded and bonded type. The banded Hyrax is Biedermann type. [6]

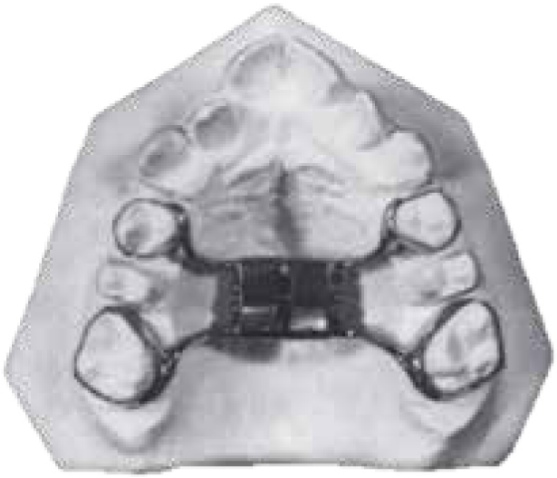

Figure 13:Hyrax

Derichsweiler type

This is both a tissue-and tooth-borne appliance. Molar and premolar bands are fabricated and fitted. Wire tags are soldered onto the palatal aspect of the bands. The tags do not directly contact the screw. These wire tags and the screw at the center is inserted into split palatal acrylic plates. (Fig 14) This appliance is a rigid appliance which not only transmits forces on to the teeth but also on to the palatal shelves directly. [6]

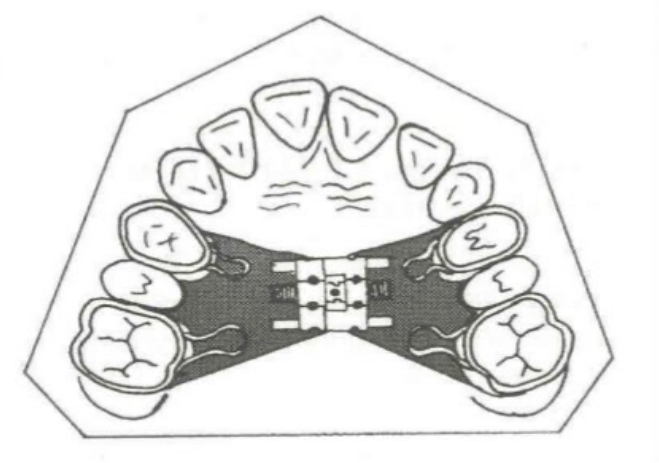

Figure 14: Derichsweiler

Haas type: A midline jackscrew is incorporated into the two acrylic pads that closely contact the palatal mucosa. Support wires also extend anteriorly from the molars along the buccal and lingual surfaces of the posterior teeth to add rigidity to the appliance (Fig 15). Haas states that more bodily movement and less dental tipping is produced when acrylic palatal coverage is added to support the appliance, thus permitting forces to be generated not only against the teeth but also against the underlying soft and hard palatal tissues. [6]

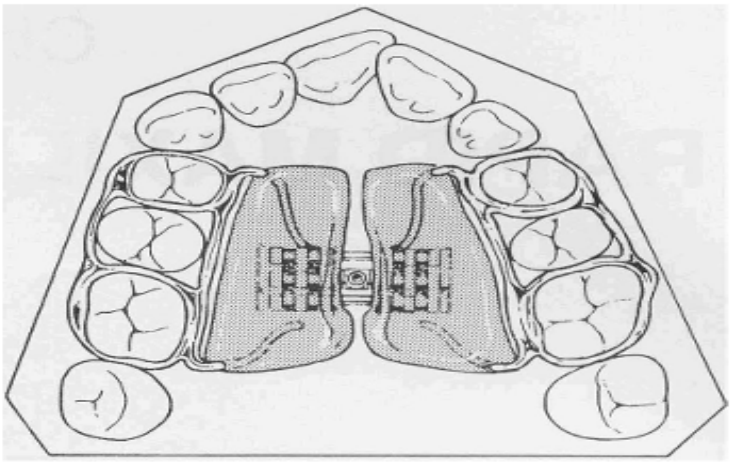

Figure 15: Haas

Bonded RME

The acrylic splint expander widens the maxilla by separating the midpalatal suture and activating the circummaxillary sutural systems(Fig 16).

In young patients, the effect of the appliance primarily is orthopedic in nature. The posterior occlusal coverage of the acrylic acts as a posterior bite block, inhibiting the eruption of the posterior teeth during treatment and making possible the use of this appliance in patients with long lower anterior facial heights. The acrylic occlusal coverage also opens the bite posteriorly, facilitating the correction of anterior crossbites.

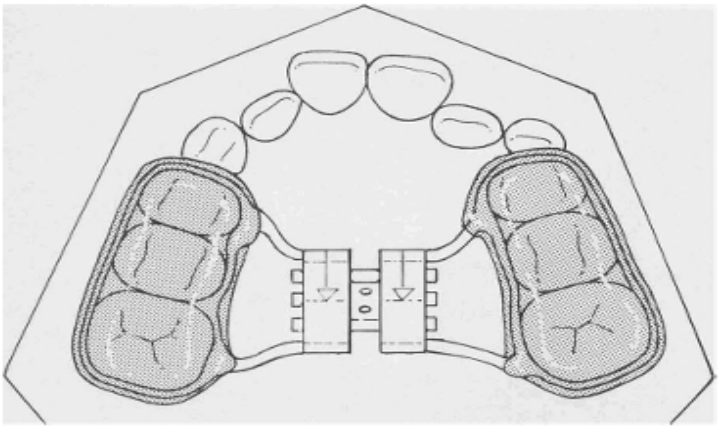

Figure 16: Bonded RME

SARPE

Surgically assisted rapid palatal expansion (SARPE) was introduced by Brown in 1938 and became a popular option since then for the treatment of transverse discrepancy in adults.

The main objective of SARPE approach is to reduce the resistance rendered by midpalatal sutures and lateral maxillary sutures so that a higher amount of skeletal expansion can be achieved.

After performing the surgical procedure, maxillary expansion is achieved with the help of tooth-anchored expansion appliances.

Adult patients in whom palatal suture is completely ossified and those who exhibit circum-maxillary resistance to separation of the palatine bones may require surgical intervention. Maxillary expansion in these patients can be brought by either of the methods described below[6].

1. Surgery alone- Segmental expansion by Lefort osteotomies. However these are unstable.
2. Surgically assisted rapid palatal expansion (SARPE)-

The surgical procedures usually carried out during the rapid palatal expansion:

a) Lee Fort I osteotomy
b) Mid palatal osteotomy
c) Lateral maxillary osteotomy
d) Anterior maxillary osteotomy

Transverse skeletal deficiency rarely occurs without coexisting vertical or sagittal discrepancies. When correction of a constricted maxilla is the only objective, distraction should be considered. Widening of the maxillary arch may also form part of a treatment plan requiring several other corrective orthognathic surgical procedures[13].

SARPE, which is usually indicated in the early stages of treatment, will be followed by a Le Fort I procedure as a definitive surgical procedure. This will subject the patient to 2 surgeries. A total bilateral maxillary osteotomy from the pyriform aperture to the pterygomaxillary fissure along with a midpalatal split from the anterior to the posterior nasal spines and also recommended sectioning all articulations and areas of resistance—anterior, lateral, posterior and median support of the maxillary arch (Fig-17) [13].

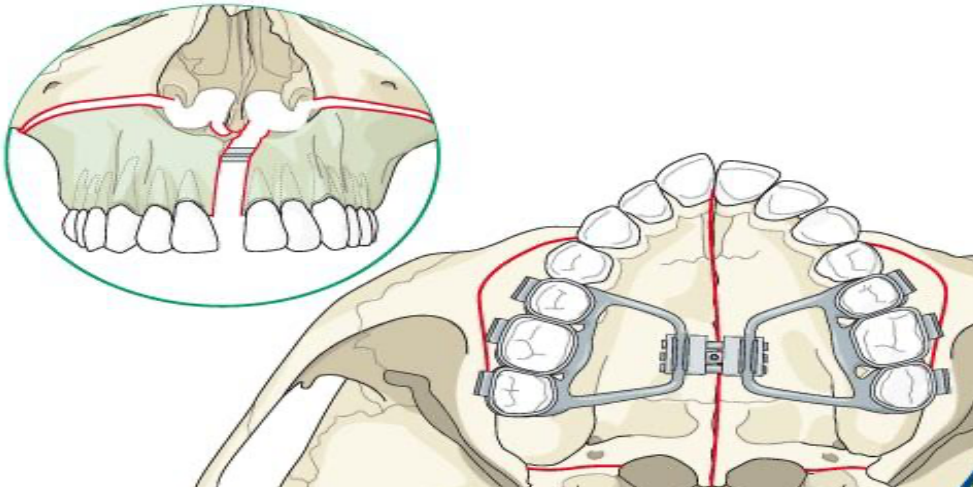

Figure 17

MARPE

To minimize side effects of conventional rapid maxillary expansion like alveolar bone dehiscence, buccal crown tipping, root resorption and marginal bone loss, orthopedic expansion of basal bone is essential in non-growing patients. To ensure the expansion of basal bone without surgical intervention and to maintain the separated bone in consolidation, Lee et al [14] introduced Mini-screw Assisted Rapid Palatal Expansion (MARPE) and reported successful expansion of the maxilla through the opening of the mid-palatal suture. Incorporation of mini-screws in a conventional rapid palatal expansion appliance transforms it into a mini-screw-assisted rapid palatal appliance [15]. The MARPE is a modification of a conventional RPE appliance that evolved in a quest for pure orthopaedic movement to maximize skeletal expansion and minimise dentoalveolar tipping. The prime difference is the incorporation of micro-implants into the palatal basal bone along with the expansion screw. Following are the different designs of expanders using micro-implants. [16]

Type 1: Bone-borne expander with micro-implants placed lateral to mid-palatal suture.

Type 2: Bone-borne expander with micro-implants placed at the palatal slope.

Type 3: Mini-screws as in type 1 but with additional conventional Hyrax arms.

Appliance design:

The appliance consists of a central expansion jack screw and four attached arms soldered to orthodontic bands on anchored teeth with 2-implant or 4-implant designs to facilitate placement of the appliance. Teeth on which bands are soldered aid in stabilization of the jack screw rather than anchorage of appliance as later is provided by the mini screws inserted into the palate. (fig.18)

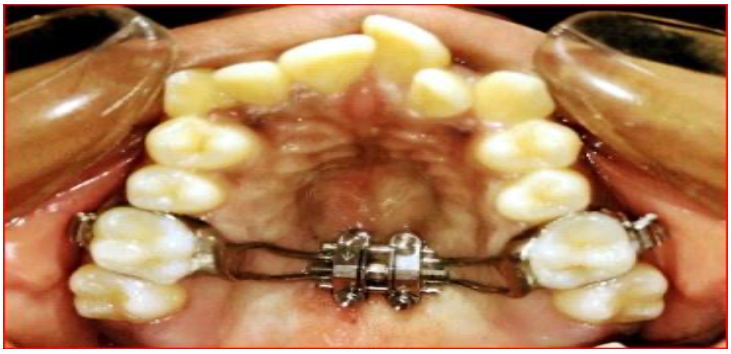

Figure 18: Design of appliance

Dimensions of mini screws as per the design of appliance i.e., 2-implant or 4-implant design. The length of implant chosen should consider height of insertion slot, space between the appliance and palate, thickness of palatal mucosa and a desired minimum of 5-7mm of bone engagement. The intention should be to achieve bi-cortical engagement aiding for better stability of mini screws [17].

Distraction Osteogenesis Maxillary Expansion (Dome)

The technique for DOME was first published in 2017 [18] .The protocol for DOME was developed at Stanford. It is indicated in adult OSA patients with narrow, high arched palate. It integrates minimally invasive osteotomy with mini-screw anchored RME. It alleviates nasal obstruction, decreases AHI, improves amount of REM sleep [19]. Using CBCT, custom designed bone & tooth borne distractors were fabricated individually for each patient. CBCT helps in mapping suture location and fusion density & thickness of palatal bone for optimal screw length & position. Miniscrews were placed with bicortical engagement of palatal roof as close to midpalatal suture as possible given that sufficient bone thickness is present [20].

DOME uses limited Lefort I osteotomy that doesn't require fracture of pterygoid plates. Piezo – electric saw and osteotomes are used from anterior maxillary approach to separate maxilla. As suture opens, a small gap occurs between maxillary central incisors. Expander screw is to validate integrity of screw threads with symmetric and easy separation of maxilla bilaterally. Patients with mild to moderate OSA can be discharged on the day of surgery, while individuals with severe OSA are monitored overnight. Septoplasty may be performed concur-rently in patients with severe posterior septal deviation at vomer region.

Expander device is activated 5 – 7 days post-surgery by activating an axial screw at a linear rate of 0.25 mm per day. On average 8-12mm of maxillary expansion is created. Once, expected expansion is complete, Orthodontic treatment is initiated using conventional fixed appliances or aligner therapy. Orthodontic treatment closes the space between dentition created by DOME and

restores normal occlusion. In general, consolidation phase is 3 months [21-23] for typical craniofacial distraction Osteogenesis, but to allow maximal bone fill and minimize relapse, expander is kept in place passively for additional 6 – 8 months.

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