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MARPE: A Literature Review on Various Designs for Clinical Orthodontics

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Abstract

Background: Maxillary arch constriction has been a major issue attributing to occlusal effects, a narrow nasal cavity: the deficit can cause major pulmonary issues, dental crowding, an excessive buccal corridor, and non-carious cervical wear. Forceful separation of mid palatine suture using expanders are desired for transverse correction. Incorporation of miniscrews in RME appliance to take the advantage of the bone support for parallel disarticulation of sutures in individuals. Various designs have been recommended by authors around the globe; exclusively bone borne, teeth-bone borne and tissue-bone borne with two/ four mini screws in the assembly. This work aims to provide an overview of the history of MARPE, suture morphology, and a detailed analysis of the design and application of the procedure for treating transverse discrepancy.

Keywords: Expansion, MARPE, Midpalate suture, Growth, Appliance design

Introduction

From primary to permanent dentition, maxillary transverse deficit is a relatively widespread malocclusion that affects all age groups. Depending on the demographic sampled, posterior cross-bite in the primary dentition has a documented prevalence ranging from 1% to 16%, with Caucasian populations typically showing a greater prevalence compared to populations in Africa and Asia.[1-2]A maxillary transverse deficiency is typically accompanied by an anterior and/or posterior crossbite attributing to occlusal effects, a narrow nasal cavity:the deficit can cause major pulmonary issues, dental crowding, an excessive buccal corridor, and non-carious cervical wear which may be caused by increased non-axial loading and stress concentration in the cervical region.[3] Depending on the suture turgor, transverse constriction can be addressed using various slow and rapid expansion modalities. Ideal age for Rapid maxillary expansion is

10-13 years when sutures will be responsive to expansion owing about 38% of skeletal changes and 49% of dental tipping and alveolar bone bending.[4] By the age of 14-17 years mixed responses to RME are due to the mid palatal suture's gradual ossification and the increased interdigitation of the craniofacial sutures, which have negative consequences like root resorption, undesirable tooth movement, unhealthy periodontal condition, and minimal skeletal effect.[5] Despite the availability of surgical alternatives(SARME), many patients are unwilling to have invasive surgery done and to risk complications like as gingival recession, inadvertent root injuries, and post-operative haemorrhages.[6-8] Transverse disparity can now be treated with minimal invasiveness thanks to advancements in CBCT and TADS. This work aims to provide an overview of the history of MARPE, suture morphology, and a detailed analysis of the design and application of the procedure for treating transverse discrepancy.

History

Emerson Colon Angell[9] created the first palatal expansion apparatus in 1860 and published in Dental Cosmos but did not gain popularity as it was believed to have some ill effects on nasal process. The procedure was revived by European orthodontists in the later years, drawing from the works of Derichweiler in 1953 and Korkhaus in 1960. American Orthodontics developed an interest in it after Haas,[10] performed the technique on pigs in 1961 and demonstrated the result along with microscopic evidence.

The original expansion appliance consisting of a screw embedded into acrylic on the palatal mucosa. Since then, several appliance designs have been developed with the goal of correcting transverse discrepancy while producing better results. The force exerted due to gradual opening of the screw lead to expansion of plate. This force is than dissipated to the adjacent tooth roots which lead to decrease blood flow and the teeth might undergo root resorption which is the case for all tooth and tissue borne expansion devices.

Many innovations were being carried out to improve the palatal expansion process and make it useful for skeletally adult individuals. In 2010, Lee et al. treated a 20-year-old patient who had substantial transverse discrepancy and mandibular prognathism.[11] The patient used an expansion device called a Mini screw-assisted rapid palatal expander, or MARPE, which was affixed to the palate before orthognathic surgery. Clinical evidence revealed steady results after expansion was accomplished with no harm to the periodontium and teeth. Based on research by Lee, Park, and Hwang, Moon[12] and MacGinnis et. al, developed the maxillary skeletal expander (MSE, Biomaterial Korea, Seoul, South Korea) recently which has four Mini screws inserted into the expansion screw body, one for each of the midpalate suture and one for the expansion screw itself.

Midpalatine Suture Ossification:

Ossification of the suture starts at the posterior region by means of mineralized bridges formed from posteriorly to anteriorly, varying according to the chronological age at which they form.[13-15]

Sequence of ossification[16]: The palatal maturation starts with the incisive suture, which is followed by the transverse palatine suture and the posterior part of the midpalate suture. Next is the midpalate suture's core region.

In human beings, ossification of the midpalate suture occurs within the period from adulthood to the elderly stages in life. Average age for suture ossification in males is 13-15 years and in females up to 12-13 years.[17] It is best to carry out RME before CVMI 4 (Hassel and Farman 1995) or MP3 H (Rajagopal

and Kansal 2002) stage but MARPE is usually done after the suture fusion is completed.[18]Also as MPDS increases with skeletal maturity, the skeletal effects of RME might decrese.[19]

Pattern of suture opening: In MARPE the suture disarticulation is seen to be relatively parallel and the suture opening angle (SOA) was very close to 0° (0.57°) even though suture interdigitation becomes more complex after the adolescent stage of development[20] it is because of the rotation of zygomaticomaxillary complex of the midface in the axial plane with its fulcrum near the TMJ.[21]

Design: MARPE designs can be classified based on:

(I) Type of anchorage:

1. Bone anchored
2. Tooth Bone Anchored

Bone anchored appliances – It was first introduced by Winsauer et. al[22] and called it MICRO 'mini-implant collar-retained orthodontic expander with four or six miniscrews (2–2.5mm in diameter, 10–14mm long) inserted exactly perpendicular to the anterior palate in the paramedian area. The MICRO-4 was mainly used in adolescents, and the MICRO-6 Hyrax, was recommended for use in adults. After expansion, it was advocated that expanders remain in situ for 6 and 12 months, respectively, for retention. (Figure 1 - MICRO-4 Hyrax expander.)

Figure 1: The MICRO 4 appliance (a): laser-welded to miniscrew collars on plaster cast (b): Dual-Top Jet miniscrew. (c):collars (d):collar extractor with central bolt and tempered stainless steel finger, securely held in place with needle holder

Kim et. al.[23] demonstrated bone-borne appliances, with and without palatal acrylic resin coverage. Four Mini screws (1.6mm × 10mm in the anterior and 1.6mm × 8mm in the posterior regions) with stainless-steel arms extending to the lingual surfaces of the upper premolars and first molars were inserted para-medially in the premolar areas. Acrylic resin was occasionally added over the expander and secured to the palatal Mini screws. It was suggested that, in patients with extremely narrow or high-vaulted palates, the use of an acrylic RPE was beneficial because it produced less gingival impingement and inflammation compared with the wire type. (Figure 2)

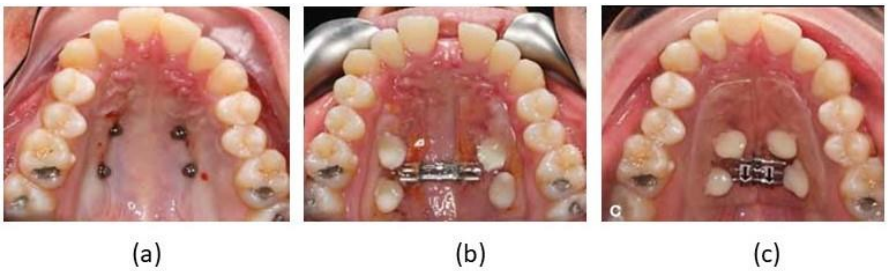

Figure 2: Kim's Bone borne appliance

Lee also introduced a purely bone borne MARPE appliance (figure 3).

Figure 3: Lee's bone borne appliance design

Tooth-bone-anchored (hybrid) appliances- Lee et al.[24,25] introduced a combined Hyrax RPE with four extension arms comprising helical hooks soldered under the body of a jackscrew to accommodate the Mini screws. Lateral arms from the body of the Hyrax expander were soldered to bands on the first premolars and first molars, respectively. Two anterior hooks were positioned in the rugae area and the other two were placed posteriorly in the parasagittal area. It was recommended that orthodontic miniscrews (1.8mm collar diameter, 7-mm length) be placed in the centre of the helical hooks. Patients were advised to activate the expansion mechanism once a day (0.2mm/turn) following placement (Figure: 4).

Figure 4: Lee's tooth-bone anchored appliance design

Montigny[26] proposed a Hyrax expansion device supported by two molar bands and two anterior palatal mini-implants. The mini-implants were 1.8–2.2mm in diameter, 7–9mm in length and inserted into the paramedian area aligned with the premolar region. The anterior arms of the appliance delivered a force via the mini-implants to the anterior palate, whereas the posterior arms delivered a force via the molars to the posterior segments. It was believed that placing the anchorage directly on the palate, i.e. closer to hemi-maxillary resistance centre, would allow better skeletal maxillary expansion (Figure:5).

Figure 5: Montigny's appliance, Hybrid disjunctor with dental and bone joint supports.

Garib et al.[27] suggested using a Hyrax expander supported by the permanent first molars and palatal implants placed bilaterally between the first and second premolars. The advice was to place the implants obliquely and lingually to avoid contact with important anatomical structures (nasal cavity, maxillary sinuses, dental roots), and to resist transverse expansion forces.[28,29] (Figure:6)

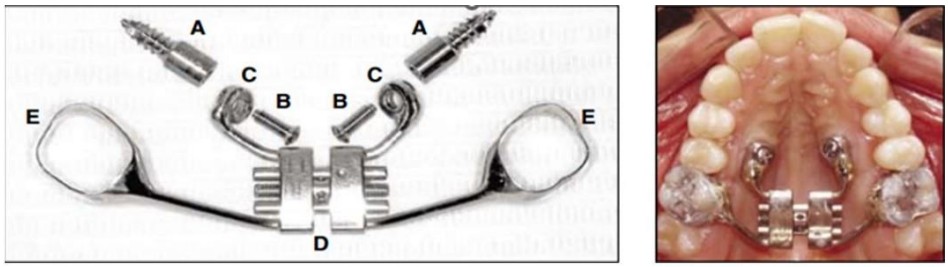

Figure 6: Garib's hyrax expander (a): A. Titanium implants (3mm ∠ 7mm). B. Fixation screws. C. Stainless steel rings. D. Hyrax expander. E. Orthodontic bands. (b) Palatal expander in place at start of treatment.

Nojima et al.[30] gave a design like Lee et al.[24,25] Bicortical engagement of the miniscrews was recommended for the internal cortices of the hard palate and nasal fossa, and it was believed that this was fundamental to support anchorage during expansion and to overcome the resistance of the maxillary bone (Figure:7).

Figure 7: Nojima appliance

Moon et. al.[31] developed a MARPE device named the Maxillary Skeletal Expander (MSE), The main body of the appliance contained an expansion screw with four parallel holes sited at the corners of the expander. Each hole was sized 1.8mm in internal diameter and 2mm in thickness and acted as a guide for the placement of the micro-implants. In addition, the holes prevented tipping of the implants during insertion and activation. Four lateral arms extended from the main body and were soldered to the molar bands. Moon et al. urged that force application should be delivered more posteriorly and so the expander was placed at the level of the first molar to overcome initial resistance. It was believed that, in this position, a lateral force could be exerted directly against the pterygomaxillary buttress and promote a parallel opening on the midpalate suture.[32,33] After cementation of the MSE, micro-implants were placed through the parallel holes with a manual driver. The inserted micro-implant was 1.8mm in diameter, and either of 9mm, 11mm, or 13mm in length according to the thickness of palate measured from the CBCT image. The length of the screw should provide at least 5–6mm of bone engagement and ensure Bicortical penetration (Figure 8- Maxillary Skeletal Expander: Jack screw body with four holes {1.8 mm in diameter and 2 mm deep} and four soft supporting arms, soldered to first molar bands).

Figure 8: Moon's appliance (a): MSE screw (b):Expanded MSE screw with visible midline diastema of 4mm

The activation protocol recommended by Moon:

Table I. Activation protocol suggested by Moon et al.

Age range	Suggested activation protocol
Beginning of adolescent	3~4 turns/week
End of adolescent	1 turn/day
Young adults	2 turns/day
Older than 25 years old	2 turns or more/day

Figure 9: Activation protocol

(II)Based on design:

1. No Tooth Attachment Design, a clinical advancement in MARPE concept:

In this system the laboratory work is minimized significantly in addition to all the anatomic advantages of miniscrew placement. The square-shaped expansion screw consists of a screw and four mini holes to accommodate the insertion of miniscrew (Figure:11- A). There is no need to weld or solder any other pieces to the expansion screw. The mini holes on each corner of the expansion screw are compatible with guiding tubes, predrilling burs, and the miniscrew that are used to fix the appliance on the palatal bone. Before the appliance insertion process, minimal laboratory preparation is needed. The clinician decides on the exact positioning of the appliance using the rugae anatomy and considering the position of maxillary incisor roots. (Figure:10) The expansion screw should be positioned slightly distal to the third rugae and parallel to the palate's anterior incline. Three-dimensional digital or plaster dental models can be used to arrange the position of the expander and fabricate a transfer template (Figure:11-B) using thermoplastic materials or 3D printing. After the expansion device is positioned parallel to the curvature in the anterior palate during the laboratory preparation, the mini holes are used to tighten the guiding tubes on the expander. Guiding tubes are used (Figure:11-C) during the predrilling stage, and their purpose is to ascertain a perpendicular insertion into the cortical bone in that area. After the pilot holes are drilled, guiding tubes can be removed, and miniscrew can be inserted. [34]

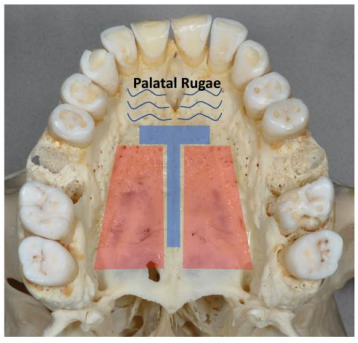

Figure 10: The "T zone": redrawn from Wilmes et al

The anterior palate offers an outstanding amount and quality of bone, particularly an area distal to the third rugae extending medially toward the bicuspids and over the Midpalatine suture posteriorly.

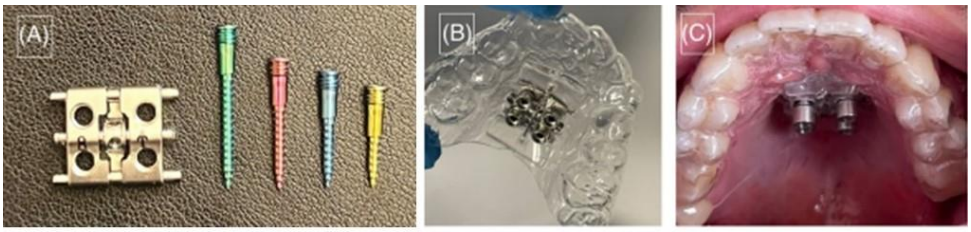

Figure 11-A: Bone expander screw and miniscrews B: Transfer template made out of thermoplastic material C: Transfer template seated in the mouth with guiding tubes installed for predrilling.

2. Supporting Wires Design:

Four or two miniscrew implant places were marked on a plaster cast, which was used to build a Hyrax expander. The expander screw was laser-welded to four metal rings. To stop palatal tilting, stainless steel wires were extended to the lingual surfaces of the maxillary premolars and first molars. In both palatal slopes, four miniscrew implants were placed using a vacuum-forming plastic template (Fig. 12). The supporting wire on the same side of the miniscrew implant may become trapped in the soft tissue as the expansion continues if one side is positioned more gingivally than the other which can irritate the soft tissue. [35,36,37,38]

Figure 12: Supporting wire design

3. Acrylic-Type Design:

The palatal bone thickness ranges between 4 and 7 mm on average, located 2-4 mm from the midline. The palate was paramedically implanted with four miniscrew implants initially. Palatal acrylic was used to create an imprint for the RPE, and flowable composite was used to fasten it to the miniscrews. To avoid irritating the sensitive tissues underlying the acrylic, a tiny bit of relief is needed. To improve mechanical retention, higher-profile miniscrew implants or cross-slot head designs are preferred. To prevent the acrylic from meeting the palatal tissue, small occlusal rests are required on the premolars. Following the curing of the flowable composite, the wires for occlusal rest can be removed. [39,40]

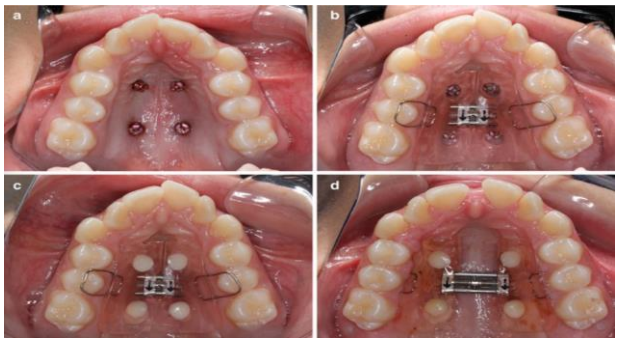

Figure 13: Acrylic type design

4.Hybrid Design: Adding a trans palatal bar inevitably transforms the appliance design into a combination of a tooth- and bone-borne expander. It is feasible to use tooth anchorage and bone anchorage simultaneously for RPE. Hybrid RPE can be utilised when teeth that are typically used for anchoring are lacking. The hybrid RPE appliance may be able to reduce several of the periodontal adverse effects connected to the tooth-anchored RPE, according to finite element calculations.[41]

Figure 14: Hybrid appliance

SIDE EFFECTS OF MARPE: In the traditional MARPE technique the activation of the expander leads to a notable stress concentration in the palatal fibro mucosa due to the tension produced from the appliance itself.

Dental side effects: Five studies reporting dental side effects[42,43,44,45,46]. gives an overview of the dental tipping of the upper first molars. There was a wide variation in the mean amount of dental tipping, ranging from −5.5° to 8.01°

Periodontal side effects: Decrease in the mean buccal bone thickness up to −0.36 mm to −0.60 mm, and a decrease in buccal alveolar height/crest level ranging from 0.74 mm to 1.7 mm has been mentioned in several studies[47,48,49]

According to the examinations by Ngan et al[50], directly loaded titanium mini-implants with a diameter of 1.5 mm under these circumstances will undergo major deformations with the risk of breakage. According to this study, hybrid expanders with dental anchorage and the assistance of 2 to 4 mini-implants should be used only in adolescent patients, not in adults. In a study of 33 adults with pure BAME, 90% of the patients between 23 and 33 years (n = 11) had successful palatal widening without SARPE and no dental side effects.

Conclusion:

Expansion has become an invaluable tool to correct transverse malocclusion. Expansion achieved by use of MARPE are majority skeletal expansion which separates the Midpalatine suture into two straight halves with minute side-effects. The groups showing highest success are in late teens to mid-twenties. Intervention with appropriate appliance in special situation can change an extraction protocol to non-extraction and even a surgical requirement to non-surgical comprehensive treatment.

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