Review Article

Miniscrew-Assisted Rapid Palatal Expander - A Review Article

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Abstract

Maxillary transverse deficiency is a widespread malocclusion present in all age groups, from primary to permanent dentition. If untreated on time, it can aggravate and progress to a more complex malocclusion which will further interfere with facial growth and development. Apart from the occlusal importance, the deficiency can cause serious respiratory problems due to associated consequent nasal constriction. In growing patients, this condition can be easily treated with a conventional rapid palatal expansion. However, mature patients are frequently treated with a more invasive procedure such as surgically-assisted rapid palatal expansion. Recently, researches have demonstrated that it is possible to expand the maxilla in grown patients without performing osteotomies using microimplants. This novel technique is called Microimplant Assisted Rapid Palatal Expansion (MARPE). MARPE technique was developed by Dr. Won Moon and colleagues at University of California – Los Angeles. In this appliance, four miniscrew positioned in the anterior and posterior part of the palate with bicortical engagement. MARPE produce even stress distribution, decreased the stress on the buccal plate of the anchor teeth, and reduced tipping of the anchor teeth. Thus, MARPE may perform as an effective modality for the nonsurgical treatment of transverse maxillary deficiency in young adults. The aim of the present article is to describe the appliance designs, indications, contraindications, clinical aspects, activation schedule and miniscrew configuration, skeletal, and dental effects.

Keywords: Microimplant-assisted rapid palatal expansion, Maxillary expansion, Miniscrew, Micro-implant, Dental effects, Skeletal effects, Midpalatal suture.

Introduction

The first use of orthopedic expansion to correct a transverse discrepancy was by Angell in 1860. He used a jackscrew which is placed between the maxillary premolars in a 14-year-old girl.[1]After 2 weeks of turning the jackscrew, he observed widening of the maxilla and spacing between the maxillary central incisors and concluded that he was successful separated the two halves of the maxillary bone. From then on, many types of expansion devices have been designed and used and research on the effects of expansion to correct a transverse discrepancy has been carried out.

The incidence of a maxillary transverse discrepancy ranges between 8 and 18% in the deciduous and mixed dentition, presenting as a unilateral or bilateral crossbite.[2] When Maxillary transverse discrepancy in a young child or early teen occurs, conventional palatal expansion is most often employed. Palatal expansion in a younger age group results in mainly skeletal expansion with opening of the mid-palatal suture and a small amount of bone bending and dental tipping.[3,4] Patients in their peak growth or late in their teens or early 20s are usually treated with surgically assisted palatal expansion which is also known as surgically-assisted rapid palatal expansion.[2] Studies using rapid palatal expansion in older patients have shown skeletal suture opening but more dentoalveolar effects and rarely successful cases are reported.[3,4]

With the introduction of mini-implants into the orthodontic armamentarium in the 1980's, the ability of orthodontist is to correct skeletal and dental discrepancies without surgical intervention and has greatly improvised. The use of mini-implants for palatal expansion has reduced the need for surgically assisted expansion in some clinical cases. New technology in orthodontics has allowed us to push the envelope in treating more difficult orthodontic cases and gain more insight into the true effects of orthodontic procedures.[4]

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This novel technique is called Micro-implant Assisted Rapid Palatal Expansion (MARPE). MARPE technique was developed by Dr. Won Moon and colleagues at University of California – Los Angeles. The appliance consist four micro implants which is positioned in the anterior and posterior part of the palate with bicortical engagement. MARPE expands the basal bone without surgery in young adults.[2] Compared with the other appliances, MARPE produce relatively even stress distribution, decreased the stress on the buccal plate as well as reduced tipping of the anchor teeth. Thus, MARPE may perform as an effective modality for the nonsurgical treatment of transverse maxillary deficiency in young adults.[5,6]

Anatomy of maxilla

The mean transverse growth of maxilla ranges approximately about 6.5 mm between the age group of 6 and 17 years. Palatine bone and the vomer bone fuses with maxillary bone to form complete hard palate and larger part of lateral wall of nasal cavity. The mid-palatine suture forms the junction of the premaxillae, maxilla, and the palatine bone (Figure 1). The mid palatine suture is referred as an end-to-end type of suture with its characteristic change in morphology during growth. Ossification of the suture starts at the posterior region by means of mineralized bridges formed from posteriorly to anteriorly which vary according to the chronological age. This anatomical reason causes the expansion to occur more anteriorly than posteriors.[7] The mid-palatine suture morphology was classified into stages by Angelieri *et al.* (Table 1 and Figure 2).[8] The ideal time of MARPE is indicated in Stages C, D, and E. The amount of rapid maxillary expansion depends on the patency of the mid-palatine suture. Suture closes by 5% at the age of 25 years. Ossification comes very late anterior to incisive foramen which is important when planning for surgical freeing of RME.

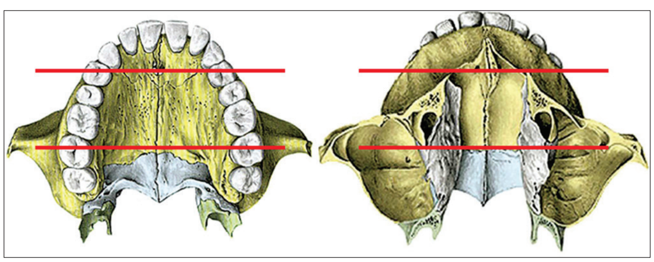

Figure 1: Mid-palatine Suture and its Three segments (anterior, middle and posterior)

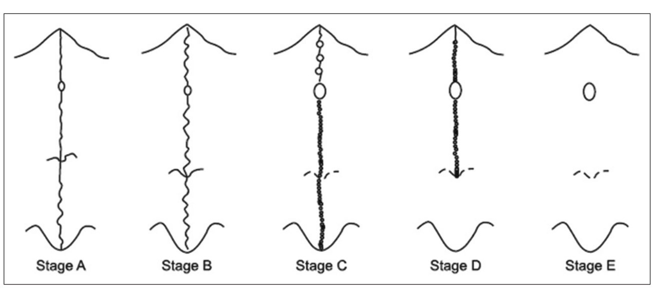

Figure 2: Schematic drawing of the maturation stages observed in the midpalatal suture

Indications

- Posterior crossbite
- Bilateral or severe unilateral expansion in Class I cases
- Class III malocclusion
- Selected arch length discrepancy
- True maxillary deficiency cases in which mandible are normal with under developed maxilla with crossbite and straight profile in a midface region.
- Relative maxillary deficiency case in which normal maxilla is with a larger size of mandible.
- Asymmetric condylar position
- Mouth breathing in Class II patients
- Medical indication such as nasal stenosis, poor nasal airway, and septal deformity.[2,4,9,10]

Contraindications

- Single tooth crossbite, anterior open bite, steep mandibular planes, and convex profiles.
- Uncooperative patients
- Growing patients[2,4,10]
- Soft tissue pathology
- Patient with cover bite (maxillary teeth completely outside the mandible)
- Normal buccal occlusion in lateral aspect
- Severe anteroposterior and vertical skeletal discrepancies
- Skeletal asymmetry of maxilla or mandible.

Appliance Design

Various MARPE designs have been recommended as shown in Table 2 and Figure 3. Type 2 is the most efficient bone-anchored maxillary expander because it distributes even and

Table 1: Classification of Mid-palatine suture

Stage A	Straight high-density line of a midpalatal suture with no or little interdigitation
Stage B	scalloped high-density line of suture
Stage C	Two Parallel, scalloped, high density lines both in the maxillary and palatine bones
Stage D	Fusion of midpalatal suture in the palatine bone
Stage E	Midpalatal suture is not seen even in maxillary portion

Table 2: MARPE designs

Design type	Miniscrew placement	Stress distribution
Type I	Lateral to midpalatal suture	Concentrated around miniscrew and mid-palatine suture.
Type II	At the palatal slope	Low stresses evenly distributed around the implants
Type III	Similar as type 1 with additional conventional Hyrax arms	Largely on the mid-palatine suture and around micro-implants and anchor teeth roots.

MARPE: Miniscrew-assisted rapid palatal expander low stress around implants. They can be prefabricated or can be made in the laboratory (commercially available like MSE, etc.).[9,20]

Screw design

Headless screws (Medusa, FavAnchor TMSAS, India) are preferred for palatal insertions as they are less bulky and comfortable for the patient (Figure 4). They are available in two sizes, namely; short (2 × 10 mm) and long (2 × 12 mm). The hex head of the screw is small enough to have a smooth feel for the tongue (in MARPE cases) and big enough to fit in the driver for a secured insertion.[5,9]

Location of miniscrew

Paramedian area (3 mm lateral to the suture in 1st Premolar region) is the most suitable site for placement of mini screws because of low risk of damage to the surrounding anatomical structures, good quality of cortical bone and thin mucosa of palate.[9,10]

Miniscrew configuration

The lengths of screw are based on height of insertion slot, space between the appliance and the palate, thickness of the palatal mucosa, and more of bone engagement (5–7 mm). Bicortical Engagement is essential which aids better stability of the mini screws. The length of miniscrew is selected by the below formula.[9]

Total miniscrew length (MI) = o + m + a + d + (1 or 2)

Where,

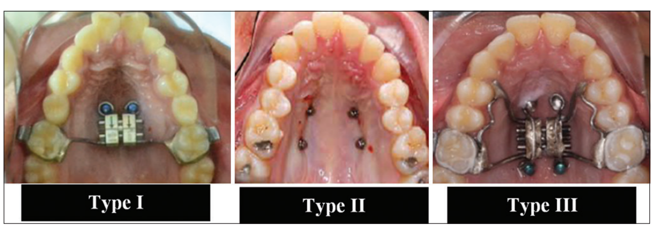

Figure 3: Different designs of miniscrew-assisted rapid palatal expander

Figure 4: Medusa Screw

o - Bone thickness adding 1.0–2.0 mm (necessary for the miniscrew tip to surpass the cortical plate of the nasal fossa)

m - Soft tissue thickness

a - Fixation ring thickness

d - Distance from the ring to the palatal surface

Insertion technique

Temporary Anchorage Device placement is unmanageable sometimes due to lack of torque and directional control to drive the implant into hard palatal bone with an engine mounted or a conventional straight driver. A uniquely designed palatal driver is favorable in maintaining the torque and angulation for precise insertion and placement of mini-screws (FavAnchor TMSAS, India).[9]

Clinical and Laboratory Procedure

The clinical procedure that is recommended to be followed is mentioned in Table 3.

Activation protocol/schedule

Activation initially is done for 2 turns/day till development of diastema, followed by 1 turn/day till sufficient expansion has been achieved.[9,16] Activation schedule is shown in Table 4.

Retention of MARPE

An acrylic plate may be used as a retainer to maintain transverse dimensions. Period of 3–6 months of passive stabilization after active expansion is recommended to allow bone formation in the separated palatal suture which will produce stable result.

Post-expansion assessment

Post-expansion transverse measurements of frontonasal area, zygomatic arch, and nasal cavity should be recorded and compared to the pre-treatment values to evaluate and compare the skeletal change. Maximum expansion is usually associated in the nasal cavity followed by zygomatic arch and frontonasal area.[9,13,21]

Effects of MARPE

Conventional Rapid Palatal Expander (RPE) and MARPE are both effective in widening dental arch form, although the main target is age of patient different. However, the extent of skeletal and the dental arch-form widening is different (Figure 5).

Skeletal Changes

A retrospective study by Cantarella *et al.*[11] showed midpalatal suture opening efficiency (ratio of expansion screw opening to suture separation) for MARPE was 71% and 63% in the anterior and posterior, respectively. Park *et al.*[5] reported that maxillary skeletal expansion accounted for 37%, whereas alveolar expansion is 22% of total expansion gained by MARPE. These ratios are higher than those of the conventional RPE, which indicates that MARPE promotes skeletal changes.

Table 3: Clinical and Laboratory procedure of insertion of MARPE appliance

Visit	Clinical and Laboratory procedure
First visit:	1. Thorough explanation of procedures with all details and limitations to the patient 2. Placement of separator elastics on the permanent maxillary first molars.
Second visit:	1. Removal of separators 2. prophylaxis and band placement on first molars 3. conventional alginate transfer impression 4. regular plaster pouring 5. separators elastics placed again on molars 6. orthodontic accessories (tubes and brackets) may be soldered to the bands at this stage Laboratory procedures: 1. Selection of 8, 10, or 12 mm MSE, according to palate width. 2. Bending wires to reach the bands following palate curvature, at a separation of at least 2 mm along all their extension 3. Wire soldering to the bands followed by finishing and polishing 4. Reverse traction hooks may be soldered to the buccal aspect of bands at this stage[21]
Third visit	1. Removal of separators, prophylaxis and expander. 2. Application of topical anesthetics to the palate. 3. Appliance cementing and checking the vertical position in relation to palate. 4. Local infiltrative anesthesia and self-drilling micro-implant placement using appropriate instrument. 5. Immediate expander activation about 2–3 turns and instructions about hygiene and activation should be given 6. Prescription of analgesic drug of choice for 2 days (optional)
Follow-up:	1. The patient should be seen more often than in conventional expansion. 2. In some cases, the patient is not able to activate the expander at home due to increased resistance, professional support is necessary. 3. Distance of the expander from the mucosa should be checked. 4. The stability of all miniscrew should be checked regularly using tweezers and in case any mobility is found, MI should be removed[19]
Removal:	1. For removal, the same connector coupled with the digital key used for placement should be slowly turned counterclockwise. 2. Careful previous cleaning of the site is required as plaque accumulation can occur. 3. Miniscrew tipping may occur due to the forces applied and complicate the gripping. 4. Immediately after each MI is removed, a cotton pellet soaked in hydrogen peroxide should be applied to the site to promote asepsis but no additional care is required. 5. Mucosa wounds usually heal in 2–3 days after removal. 6. MI should be discarded after removal and should never be sterilized or reused[21]

The mode of mid palatal suture separation was different from that of conventional RPE. A parallel separation of the suture was seen with 90% of anteroposterior ratio in contrast to conventional RPE, which shows more opening in the anterior and less opening in the posterior part.[11]

Table 4: Activation schedule

Age of the patient	Initial expansion	Expansion rate after opening of rate the diastema
13–16 years	3 turns/week	3 turns/week
16–19 years	1 turn/day	1 turn/day
19–30 years	2 turns/day	1 turn/day
Older patients (>30 years)	> 2 turns/day	1 turn/day

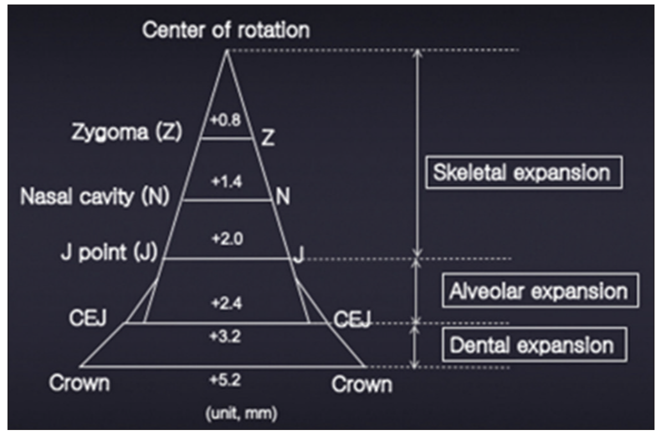

Figure 5: Schematic diagram of changes in the transverse dimension miniscrew-assisted rapid palatal expander

Extended skeletal effects of MARPE have been reported. In a retrospective study with young adults, patients with MARPE reported separation of the midpalatal suture and widening of the maxillary bone up to zygomatic arch levels with a decrease in the amount of expansion as it goes up (pyramidal pattern).[5]

Dental Changes

MARPE exhibited minor buccal tipping of the maxillary molars and less amount of periodontal effect (i.e. decrease in buccal alveolar bone thickness and loss of crestal bone) are expected when compared with conventional RPE.[12-14]

Soft tissues

Studies regarding soft tissue changes with MARPE are scarce. A retrospective study on young adults using facial scanners investigated nasal soft tissue change after MARPE showed a tendency for lateral, protrusive and inferior movement but these are the immediate effect.[15] The retrospective study by Abedini *et al.*[16] using adult patients which examined more extensive areas of the face and provided longer follow-up data (1 year after expansion) showed that paranasal area and the medial side of the cheek exhibited most changes and presented with forward and outward movements. These soft-tissue changes can be connected with reported changes in maxillary position after palatal expansion.[17]

Stability of Changes Acquired with MARPE

Long-term stability reports were difficult to find. In an article presenting 30.2 + 13.2 months of follow-up results, the skeletal and dental expansion was stable with <0.5-mm change, and maxillary clinical crown heights did not change significantly, indicating favorable periodontal conditions.[6] Another study with 1-year post-expansion reported similar stable skeletal and dental changes.[4] Both reports showed good stability of the maxillary expansion by MARPE without significant periodontal side effects. However, there have been few longer follow-up results, especially with post-retention data. Moreover, various retention protocols after MARPE have been reported, pointing towards necessity for well-established retention protocols.

Airway Issues

The expansion of palate can widen the nasal cavity and thereby improve breathing (Figures 6 and 7).[18] MARPE has been proven to expand bony maxilla more efficiently than the conventional RPE, it is expected to have better efficiency in widening the airway. Widening of the bony maxilla can cause changes in tension, shape and form of soft tissue in the nasal cavity and nasopharynx, which might have influence on the adjacent soft tissues of the oropharynx and laryngopharynx that are physically and functionally connected. This effect can be immediate or delayed due to the latent period for adaptation.

CBCT studies showed an increase of the volume in the nasal cavity and nasopharynx after MARPE (Figure 7).[19,22]

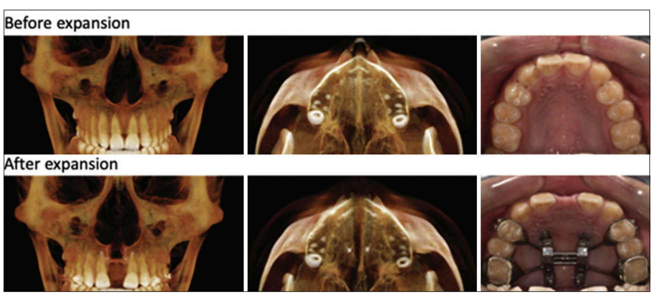

Figure 6: Expansion of Maxilla and related nasal airway after miniscrew-assisted rapid palatal expander

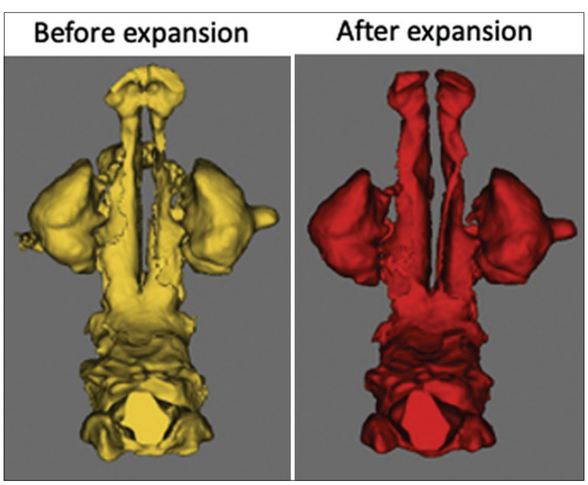

Figure 7: Axial view of the nasal airway from the nostril (top) to the oropharynx before (left, yellow) and after maxillary expansion (right, red)

Interestingly, an additional increase in nasal cavity volume was detected at 1 year after expansion, which could be explained as a result of nasal wall adaptation.[19] The study by Storto *et al.* showed there was an increase in maximum expiratory and inspiratory pressure immediately and 5 months after expansion, respectively using analog manometer.[22] However, more studies with direct subjective and objective measures for airway function are required to predict MARPE effects on patients with breathing problems and determine and differentiate who can be benefitted.[23-28]

3D Digital MARPE

The morphology of palate is not uniform as it varies from person to person. However, due to this there is few limitations noted with the use of prefabricated MARPE designs such as adaption to the palate or miniscrew fit in high arched palate cases. To overcome limitations of prefabricated MARPE appliance, 3D printing in combination with computer-aided design-computer-aided manufacturing can be used to fabricate and bring about greater precision in their outcome. The future lies in the acceptance of advanced technology for successful clinical outcome as well as greater comfort to the patients such as elimination of impression and reduces chair side time.[29-32]

Conclusion

MARPE can deliver expansion force directly to the palatal bone through miniscrew, which are placed near the target - midpalatal suture. These directiveness and close force application points are considered to be the reason for more effective/extensive skeletal changes and applicability to older patients compared to the conventional RPE.

MARPE is characterized by decrease in the excessive load performed by conventional appliances on the buccal and periodontal ligament of teeth to which they are anchored. There is also a considerable decrease in accidental movement of anchoring teeth as it provides bony support for palatal expansion.

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