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Miniscrew-assisted Rapid Palatal Expander – Non-surgical Method for Maxillary Expansion in Young Adults Based on Histological Review

Aarthi Vadivel*, D. Muralidharan, R. Thirunavukkarasu, C. Nirupama, J. Tamizhmani, C. Prasanth

Abstract

Expansion is one of the most effectual orthopedic procedures for the treatment of maxillary constriction. Slow and rapid palatal expansion (RPE) are two reliable and commonly used procedures to correct transverse maxillary deficiencies. RPE produces good adaptation at skeletal level in children and adolescents. By late adolescence, the mid-palatal suture allows only limited skeletal expansion and may produce undesirable dental effects. Miniscrew-assisted RPE (MARPE) extended not only skeletal effects with fewer dental changes but also the age limit of nonsurgical maxillary expansion treatment. This review article evaluates the role of MARPE in widening the scope of non-surgical orthodontic treatment from various aspects with a focus on recent studies.

Keywords: Mini-implants, Orthopedic procedures, Palatal expansion technique, Sutures, Young adults

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Introduction

Transverse maxillary deficiency is one of the common orthodontic problems usually accompanied by unilateral or bilateral posterior crossbite, narrow nasal cavity, and dental crowding.[1] Its multifactorial etiology includes myofunctional disorders of the stomatognathic system, usually associated with deleterious habits such as thumb sucking. Genetic and hereditary factors also influence the development of maxillary transverse deficiencies.[2]

If not properly managed within appropriate time, they may result in different degrees of occlusal disharmony; changes in tongue posture; damage to periodontal structures; functional shift of the mandible due to incorrect buccolingual tipping of posteriors; asymmetric mandibular position in growing patients; joint disorders, muscle function disturbances; and space deficiency in the arch for adequate dental alignment.[2,3] Most serious consequence might be narrowing of the nasal cavity, which increases nasal air resistance and may be an etiological factor of obstructive sleep apnea.[3] Transverse maxillary deficiency affects 8–23% adolescent patients and in adults, only <10% were reported.[4] Early intervention is vital because growth in the transverse dimension typically precedes anteroposterior or vertical growth.[5]

In 1978, Hicks used a fitted split acrylic plate to expand the maxillary arch and proved the effectiveness of slow maxillary expansion.[6] In 1860, Angell first introduced rapid palatal expansion (RPE) which was then reintroduced by Haas in 1959 to correct transverse problems for adolescent patients.[7] Before pubertal growth peak, RPE would contribute to a more significant adaptation to expansion therapy at skeletal level in both maxillary and circummaxillary structures. In adult patients, it is rarely successful because the mid-palatal suture and adjacent articulations begin to fuse by late adolescence and become more rigid with age.[8]

Histologic studies by Melsen in 1975 stated that transverse growth of mid-palatal suture continues up to age 16 in girls and 18 in boys. After this age, the suture interdigitation becomes so heavy that a separation of two halves of the maxilla would not be possible without fracturing the interdigitating process.[9] Later, Persson and Thilander quoted that, whenever the ossification of mid-palatal suture is <5%, transverse expansion by conventional RPE can be done. Most of the patients till 25 years of age does not attain this 5% ossification of mid-palatal suture.[10] This was supported by Knaup *et al*. in 2004 who also noted the obliteration of mid palatal suture <5% in 100% of the individuals aged ≤25 years.[11]

Potential limitations and side effects of RPE in adults are limited skeletal expansion, instability of results, pain, buccal crown tipping, tissue swelling, root resorption, gingival recession, and ulceration.[12] Surgically assisted RPE (SARPE) has been used to overcome the limitations through surgical release of the closed sutures that resist expansion forces in adults.[13] However, patients tend to be reluctant to undergo multiple surgical procedures and the demand for non-surgical treatment has been increasing.

Recently, a non-surgical maxillary expansion treatment using miniscrew-assisted RPE (MARPE) extended the skeletal effects with fewer dental changes in young adult patients. MARPE shows success rate of 86.9% and stable results after 30-month follow-up.[2] In this review article, indications, contraindications, design, and clinical effects of MARPE are discussed.

Department of Orthodontics and Dentofacial Orthopedics, Karpaga Vinayaga Institute of Dental Sciences, Chengalpet, Tamil Nadu, India

***Corresponding Author:** Dr. Aarthi Vadivel, Department of Orthodontics and Dentofacial Orthopedics, Karpaga Vinayaga Institute of Dental Sciences, Chengalpet, Tamil Nadu, India. E-mail: aarthivadivel97@gmail.com

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Marpe

MARPE transmits expansion forces directly to the palatal bone by means of miniscrews, contributing to more skeletal movement rather than bending the maxillary alveolar shelves. This may allow for more physiologic sutural expansion, reducing undesirable dental effects, and contribute more toward efficient mechanics.[2]

Indications

- Bilateral or severe unilateral expansion in Class I and Class II div1 cases
- Class III malocclusions with maxillary deficiency, flattened profile in the middle third of the face, crowding, and crossbite
- Borderline case with good facial patterns
- True or relative maxillary deficiency
- Asymmetries of condylar position
- Mouth breathing cases
- Septoplasty and nocturnal enuresis.

Contraindications

- Soft-tissue pathology in pressure bearing areas
- Severe gingival enlargement as in dilantin hyperplasia
- Cover bite (maxillary teeth completely outside the mandible)
- Normal buccal occlusion in lateral aspect
- Severe vertical and anteroposterior skeletal discrepancies
- Single teeth crossbite, anterior open bite, steep mandibular planes, and convex profiles
- Skeletal asymmetry of maxilla or mandible.

Appliance Design

In 2010, Lee *et al*. introduced MARPE to treat maxillary transverse discrepancy. According to Lee *et al*., MARPE is a simple modification of the conventional RPE with the incorporation of miniscrews placed at the center of the palate and extensions banded to the molars and premolars providing both skeletal and dental anchorages (hybrid Hyrax) [Figure 1].[14]

Based on Lee's *et al*. studies, Park and Hwang (2010), Moon *et al*. (2013), and Mac Ginnis *et al*. (2014) developed the maxillary skeletal expander [Figure 2] with four miniscrews installed into the expansion screw body, parallel to the mid-palatal suture and to itself.[15]

In 2016, Carlson *et al*. published the standardized design or expansion protocol [Figure 3] with four miniscrews installed into the expansion screw body, parallel to mid-palatal suture to maximize the effects of MARPE.[16]

Asymmetric Expansion

Bilateral expansion in patient with unilateral posterior crossbite may cause overexpansion and iatrogenic creation of crossbite on normal side which may result in increased treatment time and discomfort. It can be avoided by unilateral expansion to correct the affected side only.[17]

Conventional RPE with an acrylic plate having locked mechanics on the side without crossbite can produce increased expansion on the crossbite side and relatively less expansion on the normal side. Appliances such as an asymmetric maxillary expander (AMEX) [Figure 4] also produce unilateral expansion. However, the activation is done extraorally requiring removal and recementation of the appliance, thereby increasing the chairside time. Undesirable dental effects on the side without crossbite seen because they are used as anchorage units.[17,18]

A modified design U-MARPE [Figure 5] facilitates better control over force distribution than a regular expander and more efficient correction of the unilateral posterior crossbite. The expansion force was felt by the TADs on the side without crossbite and the molars and premolars on the crossbite side. This enabled us to expand the molars and premolars on the crossbite side without affecting the normal side. Activation of the screw was done intraorally and does not use mandibular teeth as an anchor unit. However, AMEX can be used as an alternative in patients who do not wish to use TADs.[17]

Ideal Position

Anteriorly – distal to the 3rd rugae along the anterior palate increases the primary stability due to thick palatal bone, propagating the forces to the nasomaxillary complex.

Middle – on the flat palatal but thinner bone surface of second premolar region. This promotes a close contact area with the jackscrew but significantly increases the risk for bicortical penetration.

Posteriorly – immediately anterior to the soft palate, at the region of the first permanent molar. This results in an increased orthopedic effect due to the resistance offered by the pterygoid plates.

Bone Density

In 2010, Moon *et al*. evaluated bone density in Hounsfield units (HU) at 80 coordinates at regular anteroposterior and mediolateral intervals along the mid-palatal suture [Figure 6].

Bone densities ranged from 805 to 1247 HU and decreased toward lateral and posterior regions. The results suggested that orthodontic anchorage may be effectively accomplished when mini-implants are placed 1–5 mm to the paramedian side and 3 mm posterior to the incisive foramen. The bone density varied among different subjects and site selection for implant placement should be adjusted according to bone density measurements.[19]

In 2016, Suzuki *et al*. quoted that in the lateral palatal region, at the canine heights, there are plexus of nerves and blood vessels coming from the incisive and palatine foramina. There is an increase in the risk of perforating such vessels and nerves, when miniscrews are placed in that region. The posterior hard palate in continuity with the soft palate has number of small salivary glands. Miniscrews placed too posterior might affect such glands, provoking mucus-retention phenomena similar to mucocele or necrotizing sialometaplasia.[15]

Lyu *et al*. in 2020 measured the palatal hard and soft-tissue thickness at coronal planes of the 1st premolars, 2nd premolars, 1st molars, and 2nd molars. The hard tissue was thickest at the 1st premolar, followed by 2nd premolar, 1st and 2nd molar and soft-tissue thickness was similar among all the planes. The thick cortical bone offers enough bone quality and quantity to support and stabilize the mini-implants.[20]

Clinical Effects

In 2016, Park *et al*. reported 37% skeletal expansion at J point (junction between maxillary tuberosity and zygomatic process) and 22%

Figure 1: Hybrid Hyrax

Figure 2: Maxillary skeletal expander expansion appliance developed by Dr. Won Moon

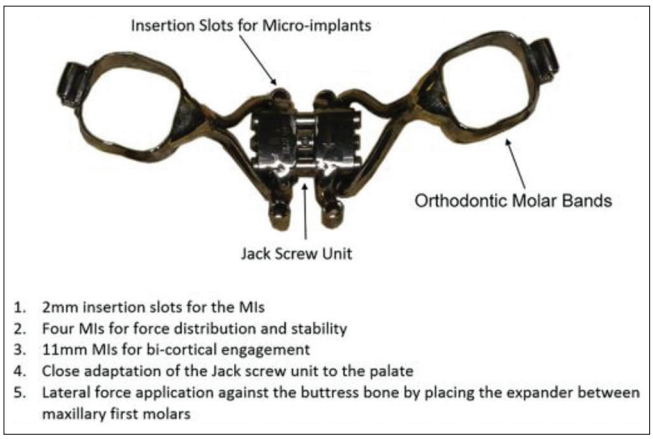

Figure 3: Miniscrew-assisted rapid palatal expansion appliance design

alveolar expansion at cementoenamel junction following MARPE therapy. These ratios are more than conventional RPE. The amount of separation decreased with superior positioning of anatomical structures, indicating a pyramidal pattern of expansion [Figure 7]. The increase in the width of basal bone was greater than nasal cavity.[21]

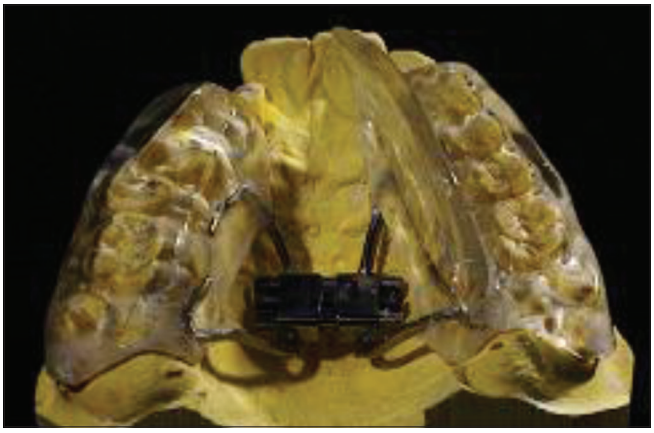

Figure 4: Asymmetric rapid maxillary expander

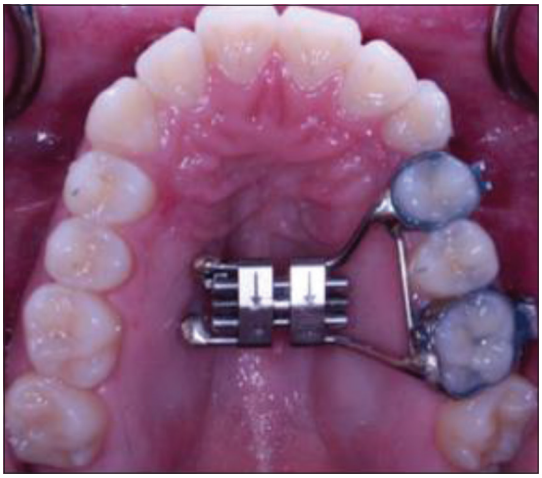

Figure 5: U-miniscrew-assisted rapid palatal expansion appliance applied with two mini-implants and bands on the maxillary first premolar and maxillary first molar[17]

Cantarella *et al*. in 2017 found that MARPE efficiently splits the mid palatal suture in late adolescents, and separation at posterior nasal spine was 90% of that of anterior nasal spine resulting in a parallel separation of suture in the sagittal direction in contrast to conventional RPE which shows more opening in the anterior and less opening in the posterior region.[22]

MARPE has shown to expand bony maxilla more efficiently than conventional RPE which makes it more effective in widening the airway. Widening of the bony maxilla can cause changes in shape, tension, and form of soft tissue in the nasal cavity and nasopharynx [Figure 8], thereby influencing adjacent soft tissues of the oropharynx and laryngopharynx that are structurally and functionally connected. The increase in nasal airway volume can occur immediately or delayed depending on the duration of soft-tissue adaptation. CBCT studies showed an elevation of the volume of the nasal cavity and nasopharynx after MARPE with an additional increase in volume during the 1-year retention period.[23,24]

Advantages

- Reduced dental tipping and more skeletal expansion compared to conventional RPE

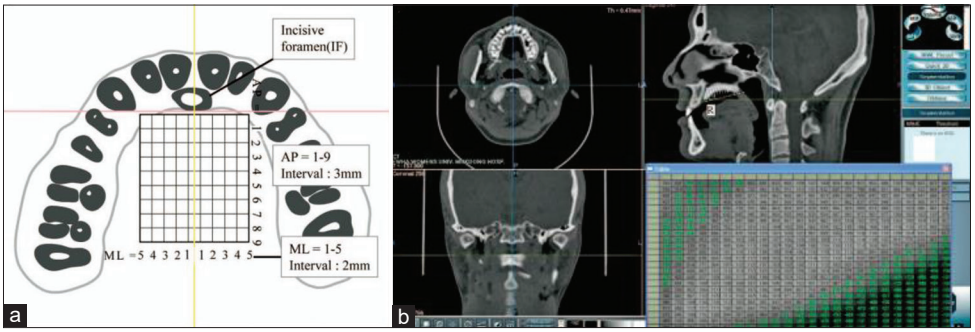

Figure 6: (a) Measurement points, (b) bone density was measured at 9 points with intervals of 3 mm, perpendicular to reference line (r) through the incisive foramen and the posterior nasal spine

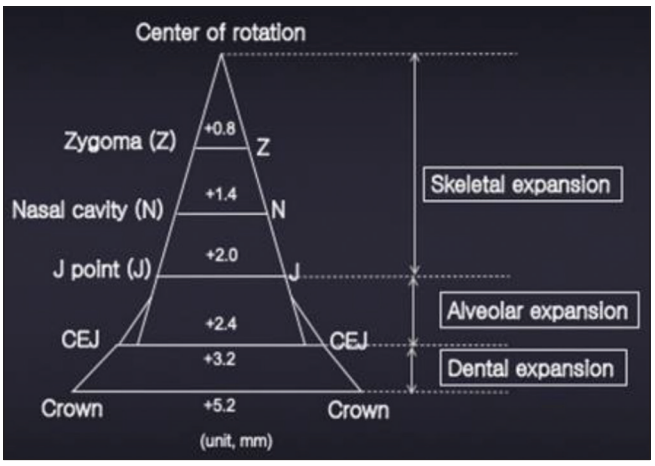

Figure 7: Schematic diagram of changes in the transverse dimension after miniscrew-assisted rapid palatal expansion

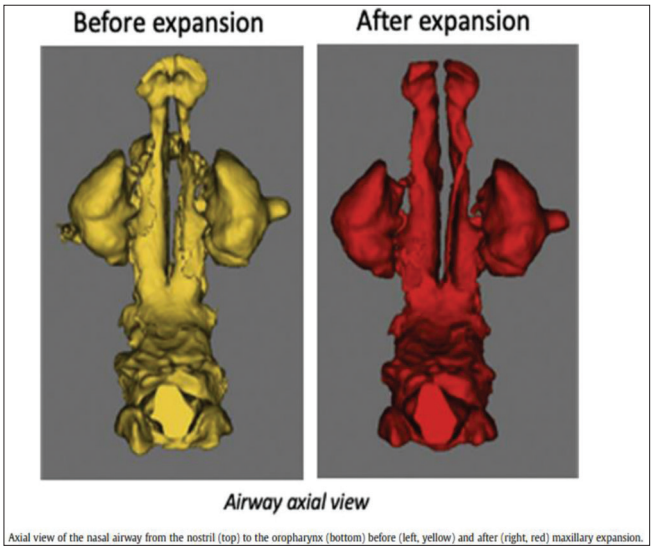

Figure 8: Axial view of the nasal airway from the nostril (top) to the oropharynx (bottom)

- Ability to expand even when the teeth normally used for anchorage are missing
- Both banding and bonding carried out in teeth with expander in place so that leveling and alignment can be started during expansion or retention.

Limitations

- Narrow high-arched palate may reduce chances of treatment success and increased chances of mini-implant deformation
- Unpredictable variability in the pattern of mid-palatal suture calcification and craniofacial architecture
- Incorporation of compromised or missing anchor units is a hindrance
- Stress distribution around the anchor teeth and zygomaticomaxillary process extending along the external wall of the orbit causes dizziness and tension around the eyes, bridge of the nose, and mostly throughout the face. Therefore, in patients who have very heavy sutural interdigitation and bone density, expansion must resort to SARPE.

Conclusion

The development of MARPE has created new possibilities for accomplishing skeletal expansion of maxilla with minimum dental effects. MARPE provides increased success rate in separation of mid-palatal suture and improved force delivery system in young adults between 17 and 25 years of age, whereas using conventional RPE in such patients may lead to fracture of suture interdigitated processes resulting in expansion failure.

In addition, MARPE also treats growing patients with anteroposterior and transverse maxillary deficiency and is recommended in maxillary protraction cases. MARPE also has an important impact on reduction of upper airway resistance.

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