

Miniscrew Assisted Rapid Palatal Expansion (Marpe) – Expanding Horizons To Achieve An Optimum In Transverse Dimension: A Review

Running title: MARPE- an optimum for transverse expansion

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ABSTRACT

In recent times, sleep disorders and associated breathing difficulties have received significant attention, leading to an increased interest in the study of various maxillary expansion protocols. MARPE has become progressively popular in the management of transverse discrepancies in comparison to traditional expansion methods, due to its augmented skeletal effects. Awareness of early prevention or methods to alleviate sleep-related breathing disorder symptoms by possibly increasing the airway dimensions has led to an interest in the study of various maxillary expansion protocols. Literature on MARPE, its effects and techniques are quite scarce. This article aims to review the appliance design, miniscrew placement, activation technique and post- expansion outcome parameters and latest advancement in the customized digital manufacturing process.

Key Words: Airway, Expansion effects, Miniscrew-assisted rapid palatal expansion

Abbreviations: MARPE-Mini-implant assisted rapid palatal expansion, RME-Rapid maxillary expansion, SARPE-Surgically assisted Rapid palatal expansion, MPS – Midpalatal suture, FEM –Finite element method, MI-Mini-implant.

1. INTRODUCTION

Treatment of the constricted maxillary arch mandates the application of orthopedic forces or a surgical intervention, for achieving expansion. Patients who have minimal or no growth remaining are often reluctant to undergo surgery, leading to attempts to correct these

deficiencies without subjecting them to surgery, which formed the basis for the development of MARPE. The MARPE appliance by Dr. Won Moon [8] et al is an innovative modification of the RME appliance and has evolved as a breakthrough in transverse malocclusion correction. Since this came into existence, it has proved to be a viable and efficient non-surgical option for young adults.

Preoperative Assessment

A thorough clinical evaluation forms the basis for accurate diagnosis of transverse discrepancies. Model assessment using McNamara [2] and the Andrews WALA ridge [19] method for assessing intermolar width and upper molar basal arch width respectively can be helpful in the identification of a true maxillary transverse deficiency when it is not obvious clinically. McNamara's method of assessment of transpalatal width includes measurement of the distance between the gingival margin of the lingual groove of 1st molar counterparts on both sides of the arches. The obtained values are compared with the norms based on the age to conclude if the maxilla is normal or expansion is required. Andrews WALA ridge focuses on the mandibular arch which templates the maxillary arch form. The distance between the mesiolingual cusp tips of right and left maxillary first molars should be equal to the distance between the mandibular right and left central fossa. Discrepancies in the values obtained evaluates the need for expansion. Using CBCT, Yonsei's index. [11] and Case western reserve university transverse analysis (CWRU) [12] for identification and demarcation of skeletal constriction and dental compensation can be performed. In Yonsei transverse index the average difference between the maxillary and the mandibular transverse width at the estimated center of resistance level was $-0.39\text{mm} \pm 1.87\text{mm}$. [11] In CWRU transverse analysis the measurement of buccolingual inclination of 1st molars and canines on the maxillary and mandibular arches are compared with the norms established. Deviations in the measurements from the norm values indicate transverse discrepancies.

Marpe Appliance Design

Dr Won Moon proposed the original MARPE design [8] which was placed at the centre of the palate banded to the molars. Later Dr KeeJoon Lee modified the design by banding the first premolars along with first molars. This provided good anchorage and adaptation based on the topography of the palate for effective separation of the midpalatal suture. Conventional Hyrax Rapid Palatal Expander was modified to derive the Maxillary Skeletal Expanders or miniscrew assisted rapid palatal expanders by incorporation of miniscrews in the design by Carlson et al. [8] They claimed that their design produced more of a parallel expansion of maxillary bone and negligible dental tipping. The changes suggested were Bi-cortical anchorage of the mini-screws implants, posterior placement of the implants, and reduction in the rigidity of the connecting wires. [6]

CLINICAL PRESENTATION OF MARPE APPLIANCE [Figure 1]

Based on Lee's studies, Mac Ginnis [6] et al developed the maxillary skeletal expander (MSE) with four miniscrews which were placed parallel to the midpalatal suture. The device had two

anterior screws of diameter-1.5-1.8mm, length-11-13mm which could be varied according to the anatomical thickness of the patient's palate and two posterior screws of length 9mm. [9]

Modified screw design in MSE— Hex head miniscrews(Medusa, FavAnchorTMSAS, India) are smooth and less bulky for a secure and precise insertion and are therefore more comfortable. They are available in 2 sizes - short (2X10mm) and long (2X12mm) based on requirements.

Two types of activation pin types are made available by Biomaterials Korea.inc,[24]

(1) MSE pintype with a cycle of 4 activation turns of 90° each providing 0.2mm separation per turn and (2) spanner type of activation key which provides six activation turns per cycle of 60° each and 0.33mmseparation.[24]

Based on the position of miniscrews and stress distribution various design types are classified.[Table1].

Insertion Factor Considerations

Appliance 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 bi-corticalpenetration.
- Posteriorly- immediately anterior to the soft palate, at the region of the first permanent molar. This results in an increased orthopaedic effect due tothe resistance offered by the pterygoidplates.

Appliance Insertion

Temporary Anchorage Device (TAD) placement is cumbersome 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 (L'il One, FavAnchorTMSAS,India) is favorable in maintaining the torque and angulation for precise insertion and placement of miniscrews. The clinical procedure that is recommended to be followed is mentioned in [Table2].

CLINICAL TIPS FOR INSERTION

Silicon-based impression material is preferred when impressions are made for obtaining accurate details which is essential during the digital workflow process. Miniscrews must be placed before curing the luting cement. A diagonal sequence of miniscrew insertion into the appliance should be followed. The root status of the supporting teeth on the OPG must be checked before band placement.

Appliance activation

The activation protocol varies based on the treatment objective and patient biotype.

Activation schedule guidelines [Table 4] should be followed for better treatment progress. On an average, 0.2mm of separation is achieved per turn. Activation is terminated when an edge to edge contact is achieved between the lingual cusps of maxillary first molars and the buccal cusps of the mandibular first molar [9].

Activation limits [9] – If the activations exceed the permissible limits, the expander loses rigidity and undergoes deformation.[Table3].

Recent advances

Ameliorated approach for better activation:-

Patients often require professional support when they are unable to perform expander activation in certain cases due to increased sutural resistance. This could be overcome by using an approach of corticopuncture^[17] before miniscrew and MARPE insertion.

- Shallow cortical bone is manually predrilled with 1.1mm diameter & 4mm bur and contra-angled screwdriver preferably set in 25 per min speed & 40 Ncm torque for corticopunctures, under greater palatine nerve block anesthesia.
- Eight corticopunctures of 5mm depth along midpalatine suture are made manually by inserting and removing a 9mm titanium alloy miniscrew (5mm double thread, 4mm neck of length & 1.8mm diameter.) The distance between 2 perforations should be kept at 2mm.
- After the procedure prescription of analgesics + 0.12% CHX mouthrinse for 7 days can be given.

Recent Advances In The Manufacturing Process Of The Appliance Digital workflow

Customization of the MSE appliances based on the patient-specific characteristics results in a more precise fit according to the palatal morphology. Virtual planning for the fabrication of MSE appliances with CBCT derived stereo-lithographic files (.stl files) obtained from intraoral or dental model scans are superimposed to identify the most suitable anteroposterior and vertical positioning of the appliance based on the extent and thickness of the palatal vault by evaluation of parameters in the sagittal, coronal and axial views. [22,23] Qualitative assessment of bone is not possible with CBCT derived

.stl file so a CBCT DICOM file can be used for qualitative and quantitative bone assessment for ensuring primary stability and reliable anchorage.

During superimposition, miniscrews are virtually inserted facilitated by tailored surgical guides (obtained from the patient directly if required) or direct virtual planning using specific reference planes of CBCT midfacial skeletal landmarks is done based on the most suitable angulation and precise directional positioning using appropriate CAD software. [22,23] A single consolidated .stl file representing the negative template of MSE palatal expander is created from which the final lab template is fabricated after subtraction from the 3d model designed using dolphin software. [10] A trial check for the fit of the MSE 3D model on the patient's palatal topography can then be done followed by designing of the final appliance by placing the MSE within the template on the printed model.

*Post expansion assessment**Skeletal and dental effects*

The total expansion achieved is a combination of skeletal (orthopedic) expansion and dentoalveolar (orthodontic) expansion which includes the alveolar bone bending and dental tipping.

In conventional hybrid bone-borne RPE appliances, center of rotation of maxilla is much higher than the miniscrew placement position, leading to torque generation in two maxillae resulting in alveolar bone bending.^[6] Though the relative position of anchored teeth was not changed dental tipping could be observed due to alveolar bone bending. By exerting the expansion forces pointing closer to the maxilla's center of resistance, a more lateral translation of the complex could be achieved with reduced dental tipping.

Since the greatest resistance against sutural opening is the pterygomaxillary complex, the body of MARPE should be positioned close to the junction of hard and soft palate.^[6]

If the forces are applied to the center of resistance of maxilla through appropriate microimplant positioning using customized MARPE appliances, the force system becomes more favorable which would practically eliminate the inclined forces due to homogenous force dissipation on the posterior teeth facilitating more parallel midpalatal sutural opening coronally. Pterygoid plate separation with MARPE results in a parallel expansion in comparison to SARPE which gives a "V" expansion, as there is an absence of pterygoid plate separation at the mid palatal suture.^[14] Bony resistance of maxillary expansion would be less in children and adolescents as their pterygomaxillary and zygomaticomaxillary sutures are less matured. In adult patients due to greater bony resistance offered, a substantial amount of orthopedic force will be experienced on the anchor teeth too resulting in dental tipping and alveolar bone bending.

The zygomatic bone shows a forward and lateral displacement. The forward displacement is minimal as a whole, whereas the lateral displacement is more near the zygomaticomaxillary suture and gradually decreases towards the temporal process of the zygomatic bone (zygomatic arch) and further decreases towards the frontozygomatic suture. Overall the zygoma rotates along with the zygomaticomaxillary complex with the frontozygomatic suture as the fulcrum. Cantarella et al ^[13,15,16] states that there could be almost no displacement that could be seen above the frontozygomatic suture and a possibility for asymmetric expansion due to differences in densities and morphology of bones especially the zygomatic buttress and pyramidal process which may not be identical on both sides. He suggested that the fulcrum of rotation of the maxilla to be more posterior and lateral in MARPE when compared to the tooth-borne appliance. Since the maxilla is located medially and anteriorly to this fulcrum of rotation, during expansion the maxilla tends to move laterally and anteriorly. This movement further helps in the disarticulation of pterygopalatine sutures. The pterygoid fossa and the infratemporal surface show almost no displacement.

Stress distribution as per FEM studies:-

Use of FEM to work out the strain distribution and displacement within the craniofacial complex in MARPE concluded that in contrast to standard expansion methods, MARPE showed less propagation of stress to the buttresses in comparison to adjacent locations within

the maxillary complex. [6] The maximum Von Misses stress was seen in the implant-supported region and it reduces along the connecting arms, almost disappearing as it reaches the outer end of the bands. Reducing the stress around the cervical region of the bone-implant interface by bi-cortical engagement will reduce the risk of implant failure.

Higher stress levels were witnessed within the canine and molar regions of the maxilla, lateral wall of the inferior nasal cavity, zygomatic, and nasal bones. The greatest stress concentration is observed at the pterygoid plates of the sphenoid bone near the cranial base. Some amount of buccal tipping is inevitable due to the usage of teeth as anchor units alongside MI in MARPE appliances but very much reduced in comparison to conventional appliances as reported by Greug and Garib et al. Due to increased density of the buccal cortical bone in the maxillary canine and premolar regions, greater buccal tipping of first molars occurs when compared to the first premolars. [6]

Jafari et al [3] found that the inferior part (the free ends) of the lateral pterygoid plates bent laterally and diminished in the regions which were closer to the cranial base. No displacements were evident on the rest of the sphenoid bone.

Respiratory Airway Effects

Studies explain that orthopedic expansion by resolving the nasomaxillary deficiency also alters the abnormal breathing pattern. [7] Post -MARPE patients incline more towards nasal breathing thereby probably altering the tongue posture and muscular dynamics, indirectly increasing the nasopharyngeal airway which further enhances expiratory peak flow. [14] Nasal inspiratory peak flow, an indicator for nasal and oral obstruction, can be increased immediately after expansion with stability maintained up to 5 months. [14] The zygomatic arch is expanded to a lesser extent than the nasal cavity which substantiates the increased nasal airflow creating a positive impact on respiratory function and muscle strength. The increase in airway volume was

greater than conventional RME. MARPE treatment with an efficient increase in the nasal cavity volume also improves the constricted airway and the upper airway resistance, thus aiding in the long-term stability of the corrected malocclusion. No implicit difference in oropharyngeal and hypopharyngeal airflow improvement was recorded in the literature. Separation is effected in the nasal area and causes a sudden improvement in the airflow by relieving the obstruction causing nasal air resistance, thus an aid in mouthbreathers.

Advantages of MARPE

Treatment duration is very less, one to four weeks of active expansion period, when compared to other conventional expansion, 2-6 months of period for expansion. MARPE independent of any anchor teeth units supports a simultaneous fixed orthodontic therapy and expansion as an added advantage. Maximal skeletal displacement can be achieved with minimal dental tipping effects. More stable on completion of treatment because the maxillary posterior teeth are not tipped buccally as much as in conventional expansion procedures.

Limitations of MARPE:-

- Forces applied from increased distance to the bone or implant interface leads to higher chances of MI deformation. [9]
- Chance of treatment success is hindered when MSE placement is attempted on a narrow high arched palate.
- Unpredictable variability in the pattern of MPS calcification and craniofacial architecture (higher resistance) are contributing factors for MARPE failure.
- Incorporation of Missing/compromised anchor units in classic design MARPE implementation is a hindrance.
- MARPE creates stress distribution around the anchor teeth and zygomaticomaxillary process extending along the external wall of the orbit, which can cause dizziness and tension around the bridge of the nose, eyes, and mostly throughout the face. Therefore in individuals who have very heavy sutural inter-digitation and bone density expansion must resort to surgically assisted expansion.
- In case of multiple congenitally missing teeth and often associated with craniofacial anomalies sutural expansion is difficult due to loss of anchorage. The use of endosseous implants as abutments for sutural expansion would eliminate unwanted tooth movement and may allow non-surgical treatment in cases with a compromised dentition.

Indications for MARPE

MARPE has effects on respiration and as well as on the occlusion. The separate assessment of both respiration and occlusion in majority of patients show that both were mutually supporting one another e.g. buccal cross bite are associated with increase in nasal resistance and mouth breathing.

Based on Occlusion

- Maxillary deficiency is Class III Cases: MARPE is of value in the Class III malocclusions with maxillary deficiency and also with flattened profile in the middle third of the face, crowding of maxillary arch and cross bite which may be either unilateral or bilateral and the teeth are often inclined buccally.
- Bilateral or severe unilateral expansion in class I cases: Conventional forms of orthodontic treatment takes a long period for correction and relapse following treatment. Rapid expansion with MARPE corrects the relationship of the buccal segments within 3 weeks without fitting the teeth in to an unfavourable relationship. There may be a forward movement of the upper incisors in these and teeth should not be included in the appliances. This allows them to relapse back into correct relationship with the lower teeth during the period of stabilization.
- Certain Class 2 div 1 malocclusion cases in which there is an extreme narrowing of the upper arch associated with a unilateral or bilateral crossbite.
- Selected arch length discrepancy cases: Borderline case with good facial patterns.
- True maxillary deficiency case: Cases in which mandible is normal with under developed maxilla with a straight profile in a midface region and are also associated with crossbite.
- Relative Maxillary deficiency case: A case in which a larger size of mandible with a

normalmaxilla.

- Asymmetries of condylar position: Skeletal response during MARPE redirectsthe developing posterior teeth into normal occlusion and corrects asymmetries of condylar functional shifts and possible temporomandibular jointdysfunction.
- Class II cases with mouth breathing : A narrow nasal aperture literally filled by concha, with deviated nasal septum ,is often seen in these patientsincreasing the internasal capacity to facilitate nasalrespiration

Medical Indications:

- As a preliminary to septoplasty
- Nocturnal enuresis: Sleep laboratory confirms the etiology of nocturnal enuresis due to disturbed sleep patterns by obstruction, which is usually caused by an adenoidal hypertrophy or less commonly, an anterior nasal stenosis. Considering MARPE as a most successful procedure in early adult dentition,maxillary expansion in nocturnal enuresis cases of young adults can reduce the adenoids in a fewmonths.

Contraindications of MARPE:

- A person who shows soft tissue pathology in pressure bearingareas.
- Patient with severe tendency to gingival enlargement as in Dilantoinhyperplasia.
- Patient with cover bite(maxillary teeth completely outside themandible)
- Patient with normal buccal occlusion in lateralaspect.
- Patients who cannot co-operate with theclinician.
- Patients with severe anteroposterior and vertical skeletaldiscrepancies.
- Patient with single teeth cross bite, anterior open bite, steep mandibularplanes and convexprofiles.
- Patient with skeletal asymmetry of maxilla ormandible.

2. CONCLUSION:-

MARPE has proved to be an effective and viable procedure for the correction of transverse maxillary deficiency offering a significant success rate and stability.MARPE is claimed to be more efficacious than conventional RPE and had also subjugated SARPE as an acceptable and cost-effective alternative in suitable cases.

TABLE 1: MSE Design types (Bone -borne)

DESIGN TYPE	MINISCREW PLACEMENT	STRESS DISTRIBUTION
TYPE 1	Lateral to midpalatal suture	Concentratedaround miniscrews andMPS
TYPE 2	At the palatal slope	Low stresses evenly around the implants

TYPE 3	As in type 1 with additional conventional Hyrax arms	Largely on the MPS and around micro-implants and anchor teeth roots.
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TABLE 2: Clinical procedure:-

VISIT	CLINICALPROCEDURE [9]	LABORATORY PROCEDURE
1st	Separator placement on maxillary permanent 1 st molars	
2 nd	1) Separators are removed followed by band placement on 1 st molars after prophylaxis. 3) After the replacement of separators orthodontic accessories can be	2) Alginate impression is made and poured with regular plaster. 4) Selected MSE is soldered to bands according to curvature of the palate with 2mm separation from the palate.

	<p>soldered to the bands at this stage.</p>	<p>5) Reverse traction screws are soldered (optional) on the buccal aspect of molar bands followed by finishing and polishing.</p>
<p>3rd</p>	<p>Separators are removed and expander proof is placed after prophylaxis. Appliance cementation is done under topical anesthesia after vertical positional assessment. Self -drilling mini- implants are placed under local infiltrative anesthesia. Immediate expander activation is done using the appropriate digital key. Hygiene and activation instructions with optional analgesic drug prescription for</p>	

	<p>2 days should be given. Antibiotic coverage for good general health may not be required.</p>	
Follow up	<p>MI stability is checked with tweezers regularly. The distance of the expander from mucosa is checked at all visits. If the mobility of MI is witnessed, treatment can still be continued carefully with one proper MI on each side.</p>	
Removal	<p>Removal is done by counterclockwise rotation of jackscrew with the digital key Hydrogen peroxide dipped cotton pellet on MI removed site to promote asepsis. Oral Prophylaxis before removal is attempted to prevent Plaque accumulation</p>	<p>Removed MI should be discarded without sterilization and reuse</p>

on MI head hinders
MI gripping.

TABLE 3: ACTIVATION LIMITS

MSE size	MAXIMUM NUMBER OF ACTIVATIONS
8mm	40
10mm	50
12mm	60

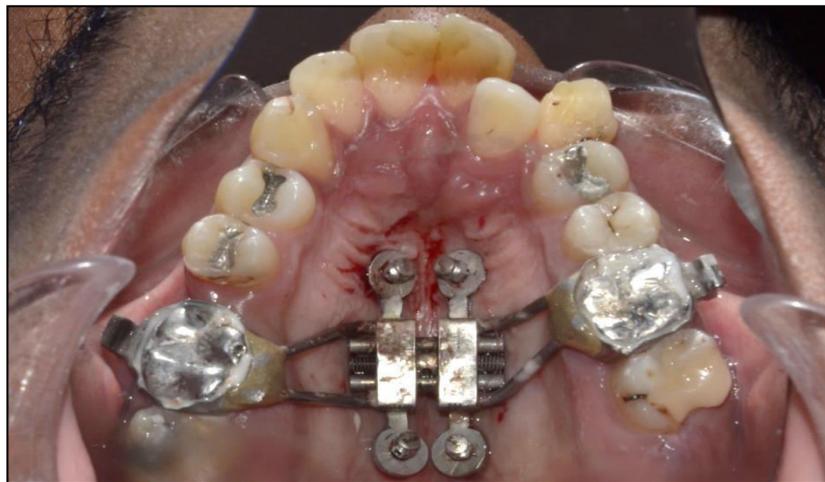
TABLE:4 ACTIVATION SCHEDULE [9]

AGE GROUP	INITIAL EXPANSION RATE	EXPANSION AFTER OPENING MPS (DIASTEMA FORMATION)
Beginning of adolescence(13- 16 years)	3-4 turns /week	3 turns/week

End of adolescence(16- 19 years)	1 turn / day	1 turn/ day
Young adults(19-25 years)	2 turns per day	1 turn/ day
Adults(Older than 25 years)	2 or more turns per day	1 turn/ day

(ADOPTED [9])

Figure



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