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REVIEW ARTICLE **OPEN ACCESS**

Micro-Implant Assisted Rapid Palatal Expansion (MARPE): Expanding the Boundaries of Nonsurgical Maxillary Correction

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ABSTRACT
Mini screw, Rapid Palatal Expansion, (MARPE) is a consistent method of treating a constricted upper jaw in both adolescents and adults, when other forms of expansion fail due to the skeletal maturity. MARPE actively passes its forces to the base jaw bone via its micro temporary screws which generate real maxillary expansion whilst avoiding undesirable tooth movement. Some of the cases that will apply include a posterior crossbites; shallow upper arches as well as cases where the patient is on the verge of having to have an operation. There is significant skeletal widening and improvement in airways as shown in clinical results. Having selective case selection and retention being sufficient later, MARPE shows good stability over time and becomes less susceptible to relapse than having traditional tooth-supporting expanders.
Keywords: *MARPE; maxillary constriction; skeletal expansion; posterior crossbite; airway improvement; orthodontics; adult expansion; transverse deficiency; relapse stability*

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INTRODUCTION

Transversal maxillary deficiency is a common skeletal anomaly which may be clinically presented in the form of posterior crossbite, dental crowding, bulky buccal corridors and impaired nasal airway functions. It has been proven that early treatment with conventional Rapid Maxillary Expansion (RME) will provide consistent skeletal expansion in growing individuals [1]. Dislocation, however, with the increase of age and interdigitation of the midpalatal suture, the skeletal activity of tooth-borne expanders reduces and is usually accompanied by undesired dentoalveolar effects, such as buccal tipping, alveolar bending and possible periodontal compromise [2, 3].

Surgically Assisted Rapid Palatal Expansion (SARPE) was traditionally suggested to overcome the resistance provided by the circummaxillary and midpalatal suture in skeletally mature individuals [4]. Despite being successful, SARPE is associated with surgical morbidity, higher costs, and anxiety of the patient. To eliminate these shortcomings, Miniscrew-Assisted Rapid Palatal Expansion (MARPE) was suggested as an anchorage-supported modality that had the promise to apply expansion forces directly on the base of the maxillary bone with temporary anchorage devices (TADs) [5]. Through the integration of palatal miniscrews into the expansion system, MARPE adds synergetic effect to orthopedic outcome at the minimal dental morbidity. The clinical and radiographic reports have asserted the effective midpalatal suture distraction among the late adolescents and young adults, and the increase in maxillary width and airway size [6]. Consequently, MARPE has become an acceptable treatment of transverse dental discrepancy with a minimal invasiveness and reliability to use with patients who are well into the phase of growth. Considering its expanding clinical applications, there is the need to fully understand its indications, outcomes, and long-term stability in order to conduct orthodontics practice on an evidence-based basis.

HISTORICAL BACKGROUND

Maxillary expansion is a concept that had initially been characterized by Angell in 1860, and that the suture between the palates was exportable using a jackscrew appliance[6]. Even though greeted with skepticism, the concept of rapid maxillary expansion (RME) was subsequently popularized by Haas in the 1960s and depicted significant skeletal and nasal airway modifications in growing participants [7, 8]. However,

affecting skeletally mature patients, traditional tooth-borne expanders were observed to produce primarily dentoalveolar but not actual skeletal expansion. Among skeletally mature patients, it was noted that conventional tooth-borne expanders resulted in predominantly dentoalveolar, as opposed to actual skeletal expansion. Instead, in skeletally mature patients, the use of conventional tooth-borne expanders proved to result in primarily dentoalveolar alterations, but not a skeletal expansion. In skeletally mature patients, the expansioners of conventional tooth varieties were also reported to result in primarily dentoalveolar changes as opposed to actual skeletal expansion. On skeletally mature patients, conventional tooth-borne expander has been observed to induce predominantly dentoalveolar but not real skeletal expansion. When offered to skeletally mature patients, conventional tooth-based expanders proved to bring about primarily dentoalveolar and not real skeletal-based expansion. In skeletally immature patients, the conventional tooth-borne expanders were only observed to bring about changes in the dentoalveoli and not the actual skeletal expansion.

BIOLOGICAL RATIONAL AND BASIS.

MARPE addresses the resistance of the interdigitated intermaxillary sutures that is posed by interdigitated midpalatal and circummaxillary sutures by directing expansion forces to the basal maxillary bone using palatal miniscrews. In retention, skeletal anchorage decreases dentoalveolar tipping and enhances true sutural separation which is succeeded by the formation of new bone. It has been proven through clinical research that MARPE can be used as a reliable nonsurgical alternative to SARPE that successfully opens the sutures in late adolescents and young adults [8].

Midpaltalatal Suture's maturation and diagnosis.

One of the biggest determinants influencing the success of maxillary expansion is the extent to which the midpalatal suture is developed (mature) when it is dealt with. The midpalatal suture of young patients is largely straight and not highly interdigitated and that helps to produce effective skeletal expansion with the help of the traditional RME. With the growing of a person the suture becomes very much interdigitated and more and more quickly turns out to be ossified hence adding more and more resistance to separation. The authors (Angelieri et al) developed a classification scheme to explain the maturation of the midpalatal suture, when using CBCT as an imaging modality (Stages A through E) in order to allow orthodontists to more effectively design an individualized treatment plan to challenge maxillary expansion. At the more advanced stage (D and E) levels, there is a decrease in skeletal response, and MARPE or surgically assisted expansion [5, 6] may be needed. Clinical examination, growth assessment and CBCT imaging must therefore be used to diagnose the patient correctly in order to make the proper decision on the kind of expansion modality to be taken.

INDICATIONS OF MARPE

Skeletal Indications

MARPE is reported to occur in case of transverse maxillary deficiency, especially in patients who are in late adolescent and adults with little skeletal response in conventional RME chapter. It helps in posterior crossbite, narrow maxillary basal bone, and skeletal Class II/III malocclusions related to transverse discrepancy [2, 4]. MARPE can potentially be used as an alternate to SARPE where skeletal maturity is at the borderline cases.

Dental Indications

The dental signs consist of either bilateral or unilateral posterior crossbite, maxillary constriction with crowding, and requiring an arch perimeter gain with minimum dentoalveolar tipping [7]. MARPE has the benefit in patients with excessive buccal tipping due to expansion of the teeth need to be prevented .

Airway Indications

MARPE is recommended in those patients who have constricted nasal airways or impaired nasal breathing. Increased nasal cavity width and volume of airways have been linked to skeletal expansion with treatment [9].

Periodontal Withdrawals.

MARPE can also decrease the likelihood of dehiscence and fenestration in patients with thin buccal cortical plates, gingival recession, or less periodontal support by decreasing the number of dentoalveolar tipping forces and directing forces to skeletal structures [2, 3].

CONTRAINDICATIONS

MARPE cannot be universally recommended and a selective approach to the cases is necessary to be confident about expected results.

Advanced Skeletal Maturity

In patients with full closure of the midpalatal suture (late stages of maturation), skeletal separation might not occur and failure may follow, necessitating surgically assisted rapid palatal expansion (SARPE) [10].

Severe Osteo-articular Discrepancy.
Patients that have severe transverse discrepancies that needs deep skeletal correction can better be treated with a surgical protocol particularly when they have large vertical or sagittal skeletal discrepancies [11].
Absence of palatal bone thickness
One of the issues that may impinge stability of miniscrews is the absence of palatal bone thickness, inadequacy of bone density, or anatomy, which have the potential of elevating loosening or failure of screws [11].
Active Periodontal Disease
The patients that have uncontrolled periodontal conditions, gingival inflammation, or bad oral health are not the appropriate candidates due to the high risk of tissue irritation and infection [12].
Diseases that Challenge Bone Healing.
Bone remodelling and sutural responsiveness may be disrupted in patients presenting with osteoporosis, metabolic bone disease, or on persistent corticosteroid treatment [13].
Non-compliant Patients
Although MARPE reduces oral hygiene side effects attributed to dentoalveolar, there is a need to have cooperation with a patient in order to activate and maintain oral hygiene.

APPLIANCE DESIGN AND VARIATION
Bone-Borne MARPE
Palatal miniscrews are almost completely engaged in the support of the bone-borne MARPE appliances, and minimal or no dental anchorage is used. The growth forces act directly on the basal maxillary bone and provide a more positive skeletal response and minimise dentoalveolar tipping[7]. Four miniscrews are placed in the paramedian area of the palate in most cases to achieve an appropriate degree of stability [14]. This arrangement will be particularly desirable in adults and older adolescents in which sutural resistance is more pronounced and when expansion conventional employs tooth supported countermeasures which, primarily, have dental outcomes.
Hybrid MARPE
Hybrid MARPE is a method that integrates skeletal anchorage with miniscrews into tooth-borne anchorage which uses molar bands. This design prevents means of sharing forces between the teeth and palatal bone which in turn enhances the stability of appliances, with a meaningful skeletal expansion [12] at the same time. Hybrid types are also often chosen in relation to adolescents and young adults in cases when skeletal response is present to a certain degree but the extra support of a denture adds to efficiency [13].
MSE (Maxillary Skeletal Expander)
MSE design proposed by Moon et al. emphasizes bicortical involvement of miniscrews with extending anchorage into palatal and nasal cortical plates so as to enhance skeletal response. This would make the appliances stiffer and more likely to yield a more parallel pattern of suture opening which enhances orthopedic efficacy even when used later in adolescence or in adulthood. There are clinical outcomes that are positive in patients of higher skeletal resistance [14] yet the success depends on the bone thickness, screw stability, and the stage of maturation.
D. Customized / CAD-CAM MARPE
The most recent events are bespoke MARPE appliances, which are to be designed practically and 3D printed in CAD-CAM prototyping. These designs allow proper positioning of miniscrews according to the evaluation of CBCT to increase the biomechanical control decreasing the possible complications [15]. Individualization enables better adjustment to differences in palatines and enables more efficient force distribution, which leads to predictable skeletal growth. With the development of the digital methods, customized designing of the appliances becomes a more significant element of the modern MARPE therapy.
BIOMECHANICS OF MARPE
The biomechanics of MARPE are essentially anchored on the delivery of expansion forces to the basal maxillary bone with the use of palatal miniscrews, such that dentoalveolar compensation is minimized and skeletal response maximized [14].
Distribution of Forces and Application of Forces.
As compared to traditional tooth-based expanders where forces are exerted using the posterior teeth, MARPE employs temporary anchorage devices (TADs) located in the paramedian palate. When expansion screw is activated, lateral forces are conveyed to the midpalatal suture and the circummaxillary sutures, which cause skeletal separation instead of dental tipping [15]. Its force has transverse predominance, and low buccal tipping forces on the anchor teeth.

Sutural Response

Growth leads to mechanical distraction of the interdigitated midpalatal suture triggering a localized inflammatory response then osteogenesis. The division is usually in a pyramidal or parallel arrangement according to age, bone density and the appliance design [16]. Bicortical contact that is encouraged in other designs including MSE improves rigidity and a more parallel suture opening.

Rotational Effects at the Center of Resistance.

With the expansion, the maxilla develops rotational propensities because of the opposition by the other craniofacial sutures. MARPE minimizes the excessive dentoalveolar rotation by moving the center of force nearer to the skeletal center of resistance making it more orthopedically efficient [17].

Vertical and Anteroposterior Effects.

MARPE can result in secondary effects like minor displacement of the maxilla and auto-rotation of the mandible though it is a transverse modality. The changes are affected by the age of the patient, vertical growth pattern, and activation protocol 18]

EFFECTS OF MARPE

Skeletal Effects

Even in late adolescents and young adults, MARPE results in considerable transverse expansion of the skeleton by separating the midpalatal suture [16]. CBCT studies reveal that there is an augmentation of maxillary basal width, lateral movement of the nasal walls and parallel or pyramidal suture aperture based on skeletal maturity and appliance design 41. The MSE design provides bicortical anchorage, which improves the efficiency of orthopedics, decreases dental side effects [2, 4].

Dental Effects

Despite the fact that the action of MARPE is mainly skeletal, there is a minor transaction of anterior teeth at the dental tips that might appear[15]. MARPE greatly decreases buccal crown tipping, root resorption when compared with conventional RME because of skeleton anchorage support [17]. Better coordination of transverse arch often leads to the correction of posterior crossbite.

Dentoalveolar Effects

MARPE reduces bending of alveoli and dentoalveolar compensation that is usually seen with tooth-borne expanders[18]. A certain level of alveolar bone remodeling takes place as a result of skeletal expansion, which adds to perimeter of the arch and enhanced dental alignment.

Periodontal Effects

MARPE decreases the threat of the buccal cortical plate thinning, dehiscence, and gingival recession by diverting forces to skeletal, instead of tooth, structures[19]. When hygiene is maintained and good selection of cases is done, periodontal outcomes are usually positive.

Airway Effects

MARPE results in skeletal growth that results in high nasal cavity width and airway volume [9]. Research claims that nasal airflow resistance has improved and there is a possibility of benefit in mild sleep-disordered breathing patients [20]. These alterations of the airways are mainly credited to the lateral shift of the walls of the nose.

Soft Tissue Effects

The alterations in soft tissues involve the alar base enlargement, slight nasal width expansion and enhancement in midfacial fullness [21]. Some patients have such slight downward and forward movement of maxilla that it can affect the facial profile and the position of lips, depending on the pattern of growth and the time of treatment.

STABILITY OF MARPE

Short-Term Stability

MARPE stability is generally favorable in case there is enough retention of 3 to 6 months to help in closing the suture between the palates. CBCT researches have revealed that development of the skeleton continues to progress with minimum back-slipping in case of skeletal origin and little tooth origin development. Efficient bone retention solutions are highly essential in bone reorganizing and suture unification.

Long-Term Stability

Young adults and teenagers are promising because of the possibility of skeletal growth which offers them long term stability. It has been established that skeletal development that is produced by MARPE is more stable than that produced by the conventional tooth-borne RPE since this leads to reduction in dental tipping, and alveolar bending. Transverse relapse may, however, occur to some minor degree, growing attributes and retention conformity [22].

Factors Affecting Stability
• Age and sutural maturation stage
• Retention duration and protocol
• Vertical growth pattern
• Periodontal health

COMPARISON OF CONVENTIONAL RPE AND SARPE
MARPE offers better stability in the skeleton as it distributes force to the basal bone that allows better results compared to conventional expansion devices. Dental tipping and alveolar bending is more likely in traditional RPE to cause relapse. MARPE has the capability of attaining comparable skeletal outcomes to SARPE. It is least invasive and satisfactorily results are attained. SARPE is however more predictable in fully growing patients who have matured suture fusions and maturing.

CLINICAL PROTOCOL
Case Selection and Diagnosis
• The most important step towards large scale MARPE therapy is careful selection of the case. To ensure maxillary skeletal constriction, posterior crossbite, or transverse maxillary deficiency, the clinician must examine it and confirm it via radiographs. CBCT [23] is recommended to the patient to examine:
• Midpalatal suture maturation stage
• Palatal bone thickness
• Nasal floor anatomy
• Interradicular spaces
This orthopedic therapy is ideal for those in the late pubertal growth stage and at young adulthood with unfused suture.
APPLIANCE DESIGN SELECTION
the appliance may be of the following types based on the clinical case:
• Bone-borne
• Hybrid (tooth-bone supported)
• MSE design
• Customized CAD-CAM design
Four miniscrews are usually screwed in the paramedian region of the palatine bone in the maxilla to prevent damage to tooth roots and nearby vital anatomical structures.
Miniscrew Placement
• Local anesthesia is given.
• The paramedian location of palatal bone is filled with miniscrews that are about 1.5-2.0 mm in diameter and 9-11 mm in length.
Bicortical contact in the MSE designs is usually favored to improve stability.
• The appliance is secured and checked for a passive fit.
Activation Protocol
Common activation protocol:
• 0.2 to 0.25 mm per turn
• 1 to 2 turns per day (0.25 to 0.5 mm/day)
Activation continues until:
• overcorrection of maxillary teeth crossbite is achieved
Appearance of a midline space between the incisors as the palatal suture begins to open
In adults, the appliance should be activated slowly to limit discomfort and allow better adaptation.
Monitoring
The orthodontists are required to take a weekly review of patients as the expansion progresses and look forward to monitor:
Midline diastema present.
Screw stability
Tissue health
Patient discomfort
Follow-up visits are characterized by the taking of radiographs and analyzed in combination with clinical results.
Retention Phase
After expansion:
The appliance size will be passively held in the maxilla whether 3 to 6 months after expansion protocol. This allows ossification of the midpalatal suture.

• It helps prevent relapse

MANAGEMENT OF COMPLICATIONS

Possible complications include:

• Miniscrew loosening
• Soft tissue inflammation
• Asymmetric expansion
• Failure of suture opening

Although, adequate case planning and proper hygiene reinforcement by the clinician can reduce these risks.

COMPLICATIONS AND FAILURE

MARPE is not quite unpredictable; nevertheless, some complications can arise.

Suture opening may fail in patients whose skeletal maturity is too high and thus dentoalveolar tipping, rather than actual skeletal growth, occurs [24].

The poor bone support or over activation may lead to miniscrew loosening, which deteriorates the stability and symmetries.

Hygiene challenges may result in the development of soft tissue irritation and inflammation. Even in the hybrid designs, minor alveolar or dental tipping is possible.

Poor retention can result in an intermediate relapse and the issue of inappropriate consolidation is important.

EVIDENCE-BASED OUTCOMES

The existing body of literature endorses the use of MARPE as a successful modality in the format of realizing skeletal transverse expansion in late adolescents and young adults. The clinical and CBCT-based research is also consistent in the report of successful midpalatal suture separation, and an increased percentage of skeletal change than traditional tooth-borne rapid palatal expansion [25].

Evidence demonstrates:

- widening of the maxillary base.
- Minor or no labial tipping of lower anterior.
- Better perimeter and crowding relief of arches.
- Objective improvement in the width of the nasal cavity and volume of airways.

It should be noted that comparative analyses shows that MARPE provides more desirable skeletal to dental dimensional expansion ratio than traditional RPE, especially in borderline cases of skeletal maturity [26]. Moreover, the results indicate short- to medium-term stability, which is acceptable provided there are proper retention procedures.

Still, it is also believed that the successfulness of the treatment depends on age, the maturation stage of sutural borders, bone density, the design of the appliance, and the protocol according to which the appliance should be activated [27]. Although MARPE will lessen the need of a surgical intervention in most adults, totally fused sutures can still need surgical help.

In sum, based on evidence-based results, MARPE is an option that is predictable and minimally invasive enough in terms of transverse maxillary correction in the right patients.

COMPARISON AMONG EXPANSION TREATMENT OPTIONS

MARPE compared to the Traditional Rapid Palatal Expansion (RPE).

The traditional rapid palatal expander (RPE) is tooth-based to a large extent, and this expansive force is exerted through the posterior dentition leading to dentoalveolar tipping and alveolar aspect bending in skeletally fit persons [28]. On the other hand, the miniscrew-assisted rapid palatal expansion (MARPE) makes use of skeletal anchorage, and thus allows better orthopedic results and more effective separation of the midpalatal suture in late adolescents and young adults [29]. Comparative analysis shows that there is higher skeletal to dental expansion ratio with MARPE compared to conventional RPE [30].

MARPE verses Surgically Assisted Rapid Palatal Expansion (SARPE).

Surgically assisted rapid palatal expansion (SARPE) is considered to be the gold standard of adults with complete sutural fusion since it provides predictable skeletal expansion through surgically freed resistance sites [31]. Still, MARPE is a less invasive option to borderline adult cases, with reduced morbidity of surgery and a clinically significant skeletal growth. However, even in severe cases of transverse discrepancies, SARPE can potentially be more predictive.

MARPE OR Microimplant-Assisted Expansion of the Corticotomy.

In cases where skeletal resistance is increased, corticotomy-aided expansion has been supported to enhance skeletal response [32]. Such a process though effective requires surgery. MARPE, due to its ability

of bicorticol engagement, achieves similar orthopedic outcomes and corticotomy would not be required in the case of suitable patients.

FUTURE PERSPECTIVES

Recent scholarly evidence increasingly validates miniscrew-assisted rapid palatal expansion (MARPE) as a dependable, non-invasive technique for correcting transverse maxillary deficiency, particularly in adolescents and young adults where conventional expansion methods are often constrained by skeletal maturation. In contrast to traditional tooth-supported appliances, MARPE facilitates direct transmission of expansion forces to the maxillary basal bone, resulting in more pronounced skeletal changes while limiting unwanted dentoalveolar effects.

Technological progress has further strengthened its clinical outcomes, including the use of cone-beam computed tomography (CBCT) for accurate miniscrew positioning, the adoption of bicortical anchorage strategies to improve stability, and the introduction of digitally designed and manufactured expanders tailored to individual patient anatomy.

Moreover, growing clinical data suggest that MARPE contributes to increased airway volume and improved respiratory function, expanding its scope beyond conventional orthodontic applications. Nevertheless, additional high-quality longitudinal studies are necessary to confirm long-term treatment stability, define standardized activation regimens, and fully integrate digital workflows for personalized and efficient treatment planning.

CONCLUSION

Miniscrew-assisted rapid palatal expansion (MARPE) has emerged as a promising and minimally invasive approach for the correction of maxillary transverse deficiency, particularly in adolescents and young adults where conventional tooth-borne expansion often produces limited outcomes due to increased skeletal resistance. By utilizing temporary anchorage devices, MARPE effectively transmits expansion forces directly to the basal maxillary bone, thereby promoting true skeletal expansion while minimizing dentoalveolar side effects and preserving periodontal health.

Recent studies highlight its effectiveness in increasing maxillary width, enhancing airway dimensions, and improving occlusal stability. When implemented with appropriate case selection, precise biomechanical control, and adequate retention protocols, MARPE demonstrates favorable long-term stability with a reduced risk of relapse. Consequently, it serves as a viable alternative to surgically assisted expansion in borderline cases and continues to evolve with advancements in digital planning and biomechanical optimization.

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