

Miniscrew-Assisted Rapid Palatal Expansion (MARPE) in Late Adolescents and Skeletally Mature Adults: A Comprehensive Review of Current Evidence, Clinical Applications, and Treatment Outcomes

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ABSTRACT

Transverse maxillary deficiency represents a common clinical concern in orthodontic practice; however, as skeletal maturation progresses and resistance of the midpalatal suture increases, the predictability of conventional rapid palatal expansion diminishes. With the routine adoption of temporary anchorage devices, miniscrew-assisted rapid palatal expansion (MARPE) has emerged as a conservative option for selected late adolescent and adult patients who would otherwise require surgical interventions. The fundamental rationale underlying this approach is that applying force at a location closer to the maxillary basal bone increases the skeletal component of expansion while limiting dentoalveolar side effects such as molar tipping and extrusion. This review synthesizes current evidence on MARPE, addressing appliance design characteristics, case selection and indications, activation and retention protocols, dentoskeletal and adjunctive treatment effects, stability, and principal limitations of the existing literature. The objective is to support evidence-based clinical decision-making in the management of transverse maxillary deficiency.

KEYWORDS: MARPE; miniscrew-assisted rapid palatal expansion; transverse maxillary deficiency; skeletal expansion; temporary anchorage devices

INTRODUCTION

Maxillary expansion has occupied a central position in the orthodontic agenda since the nineteenth century, when Angell first described a mechanical method for alleviating transverse maxillary constriction (1). Contemporary rapid palatal expansion (RPE) protocols aim to generate transverse forces of sufficient magnitude to separate the midpalatal suture and thereby correct transverse maxillary deficiency. During the growth period, when sutural maturation and mineralization remain incomplete, RPE yields the most reliable outcomes typically in children and adolescents (2). Conversely, in late adolescence and adulthood, increasing resistance to sutural separation frequently diminishes the predictability of tooth-borne mechanics and may necessitate adjunctive or surgical interventions in certain cases.

As knowledge of craniofacial growth and biomechanics has deepened, alternative expansion strategies suited to skeletally mature individuals have been developed. Within this context, MARPE has emerged as a clinically meaningful option when conventional expansion is unlikely to achieve treatment goals (3). While surgically-assisted rapid palatal expansion (SARPE) continues to serve as an established alternative in adults, concerns regarding morbidity, healing duration, and operative complications have heightened interest in less invasive protocols where applicable (4).

MARPE rests on the principle that skeletal anchorage provided by miniscrews redirects the line of action of expansion forces toward the maxillary basal bone, thereby limiting the load transmitted to the teeth (5). Consequently, the dentoalveolar effects that frequently accompany conventional RPE—particularly buccal tipping and extrusion of posterior teeth—may be ameliorated, yielding a more controlled expansion pattern (6). Published reports demonstrate that clinically significant skeletal expansion can be achieved even in adults with advanced sutural maturation, and evidence suggests that with appropriate case selection, MARPE may substitute for surgically-assisted expansion (7).

Discussion of MARPE has extended beyond transverse correction to encompass Class III camouflage or adjunctive protocols (18) and consideration of effects on obstructive sleep apnea (8). Concurrently, the incorporation of three-dimensional imaging, CAD/CAM workflows, and digital fabrication has enhanced the precision and reproducibility of appliance planning and manufacture (9). When comparative evidence is evaluated in aggregate, skeletal anchorage via miniscrews appears to increase the skeletal component of correction relative to conventional techniques and to limit dentoalveolar effects, thereby providing clinically meaningful transverse gain with reduced posterior tipping and extrusion (10,11).

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The capacity of the midpalatal suture to separate under miniscrew support has been documented in early clinical reports. Lee and colleagues (2010) documented successful sutural separation and minimal buccal tipping in a 14-year-old patient using bilateral miniscrews (12). Subsequent clinical observations in young adults have reported high rates of sutural separation and clinically significant transverse gain, accompanied by increases in nasal cavity width and interolar distance; these findings reflect both skeletal and dental components of expansion (13). Collectively, these data suggest that MARPE may be an effective method in skeletally mature individuals when case selection and treatment planning are individualized (14).

Despite widespread clinical adoption of MARPE, evidence regarding long-term stability, potential age-related variations in treatment response, and effects relative to craniofacial patterns remains limited. Therefore, this review consolidates the MARPE literature to support clinicians in selecting and adapting expansion strategies according to patient-specific clinical characteristics.

MARPE DESIGN CHARACTERISTICS

One early hybrid MARPE configuration was described by Lee and colleagues, who combined orthodontic miniscrews with a Hyrax-type expansion screw to provide skeletal anchorage (12). In this protocol, anchorage was provided by four miniscrews—two positioned anteriorly on the palate near the rugae, and two placed more posteriorly in parasagittal locations. The screw was activated once daily by a quarter-turn (≈ 0.2 mm) for approximately 40 days, after which the appliance remained passive for a three-month retention period. The authors reported successful correction of marked transverse discrepancy in a 20-year-old patient (12).

From a biomechanical perspective, the placement of posterior miniscrews carries clinical significance, as it determines how expansion forces are transmitted through the maxillary complex. Cunha and colleagues noted that optimizing miniscrew placement toward a more posterior position may facilitate a more uniform separation pattern along the midpalatal suture and is consistent with Type I disjunction configuration (15).

Evidence exists that the response to MARPE extends beyond the maxilla alone. MacGinnis and colleagues, using finite element method (FEM) analysis, described measurable effects on neighboring nasomaxillary structures, including a rotational tendency with the center of rotation located near the frontonasal suture, accompanied by buccal displacement of maxillary segments (17). This same analysis underscored the importance of screw-unit positioning. Positioning of the expansion screw closer to the estimated resistance center of the maxilla was associated with greater horizontal translation and reduced buccal tipping of the teeth; moreover, MARPE appeared to apply lower stress to adjacent maxillary buttresses compared to conventional rapid palatal expansion (17).

THE MAXILLARY SKELETAL EXPANDER (MSE)

The Maxillary Skeletal Expander (MSE), developed by Won Moon, represents a distinct MARPE configuration designed to extend the effects of expansion beyond the palatal vault to the broader midface complex (18). Clinical reports indicate that combined use of MSE with facemask therapy may be beneficial in selected adult patients, particularly in augmenting maxillary advancement while limiting excessive vertical effects and dentoalveolar compensation (18). This combined protocol has been conceptualized as producing an orthopedic response analogous to distraction, and on this basis has been proposed as a non-surgical option for carefully selected adult Class III cases (18).

Biomechanically, successful MSE performance is attributed to posterosuperior placement of palatal miniscrews and the use of four long implants designed to achieve bicortical engagement. This anchoring strategy is believed to overcome the resistance of load-bearing anatomic regions—particularly the zygomatic buttress and pterygopalatine sutures—and may contribute to a more parallel maxillary expansion pattern (18,27).

SCREW SELECTION AND ACTIVATION PROTOCOL

Carlson and colleagues emphasized that MSE activation should not adhere to a single fixed regimen; rather, it should be adapted according to the patient's age and expected resistance from the midpalatal suture (19). Their clinical protocol recommends that late adolescents, adults, and individuals over 30 years initiate expansion during the initial phase with two daily activations. After interincisal diastema appears, activation frequency is reduced to once daily (Table 1) (19). The purpose of this graduated adjustment is to overcome initial resistance and facilitate diastema formation while allowing subsequent skeletal expansion to progress in a more controlled manner (19).

Regarding screw selection, Carlson and colleagues noted that jackscrew dimensions should be determined based on the largest size the patient's palatal vault can accommodate. The appliance should be designed to maintain close adaptation to the palatal mucosal surface at approximately the level of the maxillary first molars (19). The purpose of this close adaptation is to optimize the direction and effectiveness of force transmission to the pterygomaxillary resistance zones. The activation schedule described by the authors derives from Moon's reported clinical experience (Table 1) (19).

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MINISCREW SELECTION AND PLACEMENT ZONE

Nojima and colleagues proposed a systematic planning framework for miniscrew length selection in MARPE and emphasized that this decision must be individualized according to each patient's anatomy (20). Their graduated protocols are based on CBCT measurements encompassing available palatal bone height, palatal soft tissue thickness, and dimensions of the appliance fixation components contacting the miniscrews (20). A principal element of the algorithm is ensuring bicortical engagement—penetration beyond the nasal cortical plate—to strengthen primary stability and increase resistance to forces generated during expansion (20). By integrating patient-specific measurements with appliance-related variables, the method aims to render miniscrew length selection safer and more predictable, reducing risks such as inadequate anchoring, screw deformation, and inadvertent damage to neighboring anatomic structures (20). From this perspective, individualized miniscrew planning—particularly in skeletally mature patients—is emphasized as an important determinant of biomechanical performance and overall clinical success (20).

In concordance with this approach, Lee and colleagues reported that bicortical engagement provides greater stability than monocortical placement, reduces the likelihood of screw deformation or fracture, and contributes to a more parallel expansion pattern in the coronal plane (21).

Regarding placement zone selection, Wilmes and colleagues identified a relatively favorable and safe area located immediately behind the palatal rugae in the paramedian region, which they designated the "T-Zone" for palatal miniscrew application (22). Supporting mechanical feasibility, FEM analysis by Lombardo and colleagues demonstrated that a palatal miniscrew 2 mm in diameter and 11 mm in length can tolerate loads of 240–480 gf even in the absence of osseointegration (23).

SURGICAL GUIDE USE IN MARPE

Incorporation of surgical guides into the MARPE workflow can enhance the accuracy of miniscrew placement and reduce the discrepancy between virtual planning and clinical application. Minervino and colleagues identified two principal components of MARPE planning: (i) CBCT evaluation of the midpalatal suture and (ii) three-dimensional optimization of both the expander position and miniscrew trajectories (9). Integration of intraoral surface scans with CBCT data further enhances planning precision and permits virtual positioning of the appliance within specialized planning software prior to clinical application (9).

Maino and colleagues introduced the MAPA system (Method of Palatal Miniscrew Placement), which employs high-precision three-dimensional surgical templates to support parallel placement and depth control. In this approach, CBCT-guided planning is particularly recommended for patients with impacted canines, displaced lateral incisors, narrow maxillae, or clinically significant anatomic variations (24). In general, guided placement is recognized as supporting safe and reproducible application while reducing the likelihood of iatrogenic damage to adjacent structures (24).

CLINICAL SIGNIFICANCE

MARPE has gained clinical significance because it offers a more skeletal approach to transverse maxillary correction in patients where conventional tooth-borne expansion has low predictability. By transferring the load-bearing component of expansion to skeletal anchorage, MARPE can extend the scope of non-surgical options for carefully selected late adolescent and adult patients, with effects that may extend to structures beyond the dentoalveolar unit.

ADVANTAGES OF MARPE

The primary advantage of MARPE lies in the application of expansion forces at a location closer to palatal bone, which may support a more parallel and reproducible opening pattern at the midpalatal suture and extend effects to neighboring craniofacial regions including the zygomatic and nasal bones (17). When compared to conventional rapid palatal expansion (RPE), MARPE is associated with a greater skeletal contribution to transverse correction; however, reductions are reported in adverse dentoalveolar responses such as molar tipping, vertical alveolar bone loss, and alveolar buckling (17).

Skeletal anchorage also appears to reduce the biomechanical load transmitted to the periodontal ligament, which may in part explain the relatively favorable adverse effect profile reported for MARPE (17,25). Improved vertical control is frequently emphasized as a benefit and may be of particular importance in dolichofacial patients where extrusion and clockwise rotation of the mandible are undesirable (17). In large adult series, craniofacial skeletal patterns have been shown to correlate with obstructive sleep apnea (OSA) and associated respiratory and sleep parameters (26). On this basis, MARPE—because it addresses maxillary constriction through a more skeletal approach—has been associated with nasal cavity expansion and improvements in nasal and oral airflow in selected patients (36,37).

Conducting expansion concurrently with comprehensive fixed orthodontic therapy has been proposed to shorten overall treatment duration, though this depends on case selection and sequencing. In selected adult Class III patients, MSE combined with facemask therapy has been described as a non-surgical orthopedic pathway to maxillary protrusion (18). Finally, current clinical reports demonstrate acceptable stability with relatively modest relapse; Choi and colleagues and Park and colleagues reported success rates of 86.96% and 84.2%, respectively (13,28).

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LIMITATIONS OF MARPE

Despite offering significant clinical advantages, MARPE presents various practical and biological limitations that warrant consideration in treatment planning. The most frequently reported complication is soft tissue irritation around the miniscrews, typically manifesting as mucosal inflammation and/or hyperplastic tissue changes around the screw heads (29). In hybrid (tooth and bone-borne) designs, residual dental tipping may still occur; this has been attributed to the rigidity and cross-sectional volume of connecting rods extending from the expansion unit to the molar attachments, which may transmit a portion of the activation load to the teeth (30).

Asymmetry management constitutes another limitation. Because standard MARPE designs do not ordinarily permit true unilateral expansion, modifications to the appliance are necessary when the clinical objective includes asymmetric transverse correction (31). Applicability is also influenced by anatomic conditions: inadequate palatal bone thickness may compromise miniscrew stability and may constitute a contraindication in certain patients (9,20). Additionally, severe maxillary atresia or significant palatal asymmetry may compromise appliance fit, reduce predictability, and limit the overall applicability of MARPE in such cases (30).

Finally, patient-related systemic and lifestyle factors warrant careful evaluation. Conditions such as type 2 diabetes and habits such as tobacco use may negatively influence miniscrew stability and peri-implant soft tissue adaptation, and these factors should be addressed within the context of case selection and risk counseling.

INDICATIONS FOR MARPE

Transverse Maxillary Deficiency with Unilateral or Bilateral Posterior Crossbite in Skeletally Mature Individuals

When transverse maxillary constriction occurs in late adolescence and adulthood, ongoing midpalatal suture maturation and interdigitation may limit the efficacy of conventional expansion approaches (19). Clinically, transverse maxillomandibular relationships are examined through combined assessment of the working models, occlusal examination, and radiographic evaluation; since posterior crossbite may reflect either true skeletal discrepancy or dentoalveolar compensation, and these scenarios demand different therapeutic decisions, careful interpretation is required (32). In this regard, examination on the working model serves as a preliminary screening phase, with comparison of maxillary and mandibular transverse dimensions at the first molar level, and discrepancies are interpreted in light of the buccolingual inclinations of the posterior teeth (32).

For quantitative assessment, a posteroanterior cephalometric method derived from the Ricketts Rocky Mountain analysis has been defined (32,33). In this approach, a transverse discrepancy exceeding the reference Ricketts value of 19.6 mm may signal a need for skeletal maxillary expansion (32,33). Furthermore, to permit more precise evaluation of skeletal transverse discrepancy, a CT-based diagnostic criterion—the Yonsei transverse index—has been proposed (34). When estimated resistance centers near the furcation regions of the maxillary and mandibular first molars are used as reference points, CT-based assessment more closely reflects basal bone relationships compared to conventional cephalometric analysis; notably, greater transverse discrepancies have been reported in Class III skeletal cases compared to Class I individuals (34).

Combined Use of MARPE and Facemask Therapy in Managing Class III Skeletal Patterns at Different Growth Stages

Application of facemask therapy in conjunction with MARPE has been proposed as an approach to advance the maxilla in the anteroposterior direction across various stages of skeletal development in Class III patients (18). This protocol has been reported to reduce the need for dentoalveolar compensation; improvements in the control of adverse dentoalveolar responses—particularly buccal inclination and vertical displacement of maxillary molars—have been noted (18). Because enhanced vertical control during protraction may limit unwanted backward rotation of the mandible in susceptible patients, this approach may provide additional benefit (18).

In this context, Wilmes and colleagues reported that combining tooth and bone-supported rapid palatal expansion with facemask therapy achieved maxillary protraction in growing patients, with reduced unfavorable effects associated with mesial movement of the anterior teeth (35). By contrast, in skeletally mature patients, facemask protrusion generally proceeds more slowly, and greater orthopedic forces may be necessary to achieve clinically meaningful change (18). Moon applied approximately 1 kg of protractive force per side in an adult case, 24 years of age, and described a midface advancement pattern analogous to distraction (18). Nevertheless, well-designed additional clinical studies are needed to elucidate the magnitude and nature of skeletal and dental changes accompanying this approach (6).

Transverse Maxillary Deficiency in Patients with Obstructive Sleep Apnea

Accumulating evidence suggests that MARPE may be associated with nasal cavity expansion and resultant increases in upper airway dimensions following transverse expansion (11,29,36,37). In one clinical report, comprehensive orthodontic treatment combined with MARPE was undertaken in a young adult with mild obstructive sleep apnea symptoms and maxillary constriction; post-treatment apnea-hypopnea index showed marked reduction and perceived sleep quality improved (29). Some investigators have extended their inquiry beyond anatomic changes to determine whether MARPE produces measurable alterations in respiratory function. In one study, respiratory muscle strength was evaluated concurrently with dentoskeletal outcomes, using objective

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pressure-based measures—maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP)—as indicators of ventilatory muscle performance (37).

In the same investigation, the authors proposed that MARPE may be accompanied not only by dentoskeletal changes in the nasomaxillary region but also by measurable improvements in respiratory muscle performance, potentially supporting respiratory function (37). In a related report, Garcez and colleagues described favorable changes in respiratory test results and improved athletic performance in a competitive swimmer with transverse maxillary constriction; notably, these gains were reported to persist for approximately one year following MARPE (36). Collectively, these observations suggest that MARPE may provide short-term benefit on parameters related to OSA; however, controlled clinical trials remain necessary to establish the magnitude, clinical significance, and temporal persistence of these effects (36).

Transverse Maxillary Deficiency in Patients with Reduced Periodontal Support or Limited Dental Anchorage

In a CBCT-based comparative analysis, tooth-borne expansion was compared with approaches combining dental and skeletal anchorage, with particular focus on periodontal, dentoalveolar, and skeletal outcomes. Findings suggested that when expansion relies solely on dental anchorage, buccal alveolar bone thickness tends to diminish, whereas when hybrid anchoring systems are employed, buccal bone levels are largely preserved. Accordingly, a tooth and bone-supported MARPE design may offer a more favorable risk profile in patients at high risk for buccal periodontal destruction during expansion, by reducing the periodontal load associated with purely tooth-borne mechanics (38).

MARPE has also been proposed as a feasible alternative when conventional dental anchorage proves insufficient. Situations such as limited anterior unit anchorage, premature loss of primary teeth, or incomplete development of premolar roots—conditions that may compromise the stability required by conventional expanders—may favor selection of bone-supported MARPE over traditional RPE (35,39).

STABILITY

Maintenance of midpalatal suture separation during the consolidation period is considered one of the principal determinants of favorable long-term outcomes following transverse expansion (16). Choi and colleagues, examining young adults treated with hybrid MARPE design, reported relapse of approximately 10% in intermolar width over an average retention period of 30 months (28). The degree of gingival recession observed during follow-up was not considered clinically significant (28). These authors noted that changes in mid-alveolar width varied by age and that changes in interpremolar width showed positive correlation with the amount of premolar expansion achieved; however, no significant relationship was found between interpremolar change and the amount of intermolar expansion.

In a separate study, the one-year stability of dentoskeletal changes following the same hybrid MARPE protocol was evaluated (16). During the post-expansion period, contributions were calculated as 39.1% skeletal, 7.1% alveolar, and 53.8% dental; by month 12, these proportions shifted to 43.2%, 15.0%, and 41.8%, respectively. This pattern was interpreted as evidence that the dental component is more prone to relapse than the skeletal component. Small decreases in nasal cavity and nasal base widths were reported during the one-year observation period (0.37 ± 0.36 mm and 0.64 ± 0.73 mm, respectively), corresponding to 23.0% and 29.1% of the initial expansion achieved; these values were deemed clinically insignificant. The authors also noted that subsequent orthodontic treatment may influence dental measurements and may to some degree mask MARPE-specific dental effects (16). Overall, current findings suggest that MARPE provides clinically acceptable and reasonably durable transverse expansion in young adults, with skeletal effects demonstrating more consistent stability compared to dental effects.

CONCLUSION

When aggregate evidence is evaluated comprehensively, miniscrew-assisted rapid palatal expansion (MARPE) appears capable of providing clinically acceptable transverse correction in late adolescents and young adults, and with appropriate case selection, it can produce high rates of midpalatal suture separation. Current reports further indicate that changes achieved by expansion can be maintained at reasonable levels and that skeletal effects demonstrate more consistent persistence than purely dental effects. Beyond transverse improvement, MARPE may be accompanied by favorable changes in nasal cavity dimensions and parameters related to upper airway function, which supports evaluation of this method in selected patients with airway-related concerns. However, evidence level remains limited due to heterogeneity in study designs and follow-up durations; well-designed investigations—particularly those including older age groups—are still necessary to clarify long-term stability, the magnitude of dentoskeletal effects, and the clinical significance of airway-related outcomes.

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Table 1. Recommended Activation Schedules by Age Group

Age Category	Initial Activation Frequency	Activation After Diastema Formation
Early Adolescence	3 turns per week	3 turns per week
Late Adolescence	1 turn per day	1 turn per day
Mature Adults	2 turns per day	1 turn per day
Advanced Mature Adults (>30 years)	2 turns per day	1 turn per day