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Miniscrew-Assisted Rapid Palatal Expansion (MARPE): Clinical Application

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Abstract

Transverse maxillary deficiency is a common dentofacial anomaly characterized by posterior crossbite, arch constriction, and compromised nasal airflow. Traditionally, correction in growing patients has relied on conventional rapid maxillary expansion (RME), which separates the midpalatal suture using tooth-borne appliances. However, in late adolescence and adulthood, increasing interdigitation and ossification of the suture reduce skeletal responsiveness, often resulting in undesirable dental tipping and alveolar bending. The advent of miniscrew-assisted rapid palatal expansion (MARPE) offers a hybrid, bone-anchored solution capable of achieving true skeletal expansion beyond the limits of conventional RME. This review explores the evolution, biomechanics, indications, and clinical protocols of MARPE, emphasizing its role as a minimally invasive alternative to surgically assisted expansion (SARPE). Recent clinical and radiographic evidence supporting skeletal, dental, and airway outcomes are critically analyzed, along with considerations for patient selection, retention, and complications. MARPE represents a paradigm shift in transverse maxillary correction, bridging the gap between traditional orthodontic expansion and orthognathic surgery.

Keywords: MARPE, Miniscrew-Assisted Expansion, Maxillary Deficiency, Skeletal Expansion, Orthodontic Anchorage, Nasal Airway, Palatal Suture.

Introduction

Transverse maxillary deficiency manifests as a constricted maxillary arch relative to the mandible, often leading to posterior crossbite, dental crowding, and compromised esthetics. Beyond occlusal consequences, it contributes to impaired nasal breathing, altered tongue posture, and temporomandibular dysfunction. Conventional rapid maxillary expansion (RME) has long been the treatment of choice for young patients, utilizing tooth-borne expanders such as the Hyrax or Haas appliance to separate the midpalatal suture through orthopedic forces. However, as skeletal maturity advances, the midpalatal suture and circummaxillary articulations become increasingly resistant to separation, resulting in limited skeletal effects and undesirable dental side effects including buccal tipping, root resorption, and alveolar dehiscence. [1-3]

The limitations of tooth-borne RME in post-pubertal patients led to the development of surgically assisted rapid palatal expansion (SARPE), which combines surgical osteotomies with mechanical expansion. While effective, SARPE involves hospitalization, surgical morbidity, and higher costs. To overcome these challenges, researchers introduced miniscrew-assisted rapid palatal expansion (MARPE)—a non-surgical, bone-anchored approach capable of achieving skeletal expansion in late adolescents and adults. MARPE appliances, anchored to the palate via temporary anchorage devices (TADs), transmit expansion forces directly to the basal bone and midpalatal suture, minimizing dentoalveolar compensation. [4-7]

Since its introduction by Lee et al. (2010) and subsequent refinement by Moon and colleagues, MARPE has transformed orthodontic management of transverse deficiency in borderline or mature patients. The approach is now considered a biologically efficient and less invasive alternative to SARPE, promoting skeletal widening, airway improvement, and functional rehabilitation. [8]

Evolution and Design of MARPE Appliances

The conceptual foundation of MARPE lies in hybridizing the principles of RME and skeletal anchorage. Conventional expanders rely solely on teeth for anchorage; MARPE distributes the expansion load between teeth and bone through palatal miniscrews.

The earliest prototypes emerged from the Yonsei University Orthodontic Department in Korea, where Lee, Hong, and Moon developed a bone-borne expander known as the Maxillary Skeletal Expander (MSE). This design featured four self-drilling miniscrews (1.8–2.0 mm diameter, 11 mm length) inserted into the posterior palate, directly engaging the cortical bone of the nasal floor. The jackscrew component was centrally located to ensure symmetric force distribution. Variations of MARPE have since evolved, including hybrid Hyrax, C-expander, and Leone 3D expanders, each tailored to patient anatomy and clinician preference. [9]

MARPE appliances are typically fabricated from stainless-steel frameworks attached to molar bands or bonded occlusally using acrylic pads. The miniscrews are strategically positioned between the second premolar and first molar regions, engaging both palatal cortical plates and, in some designs, the nasal floor for bicortical stability. This configuration enhances skeletal loading and minimizes dental tipping. [10]

Biomechanics and Biological Basis of MARPE

The mechanism of action in MARPE is grounded in orthopedic separation of the midpalatal suture through direct skeletal anchorage. Activation of the central jackscrew transmits lateral forces via the miniscrews to the palatal bone rather than through teeth. This load path leads to controlled disarticulation of the midpalatal suture, zygomatic buttress, and pterygopalatine junctions.[11]

Unlike conventional RME, where expansion effects are predominantly dentoalveolar, MARPE induces true skeletal expansion, visualized radiographically as a pyramidal pattern widening anteriorly and inferiorly. The midpalatal suture splits symmetrically from the posterior nasal spine toward the anterior nasal spine, accompanied by parallel opening of the nasal floor. This skeletal displacement improves nasal cavity volume and airflow, with reported increases in minimal cross-sectional area by 15–30 %. [12]

Histologically, mechanical strain from expansion stimulates osteoblastic differentiation and new bone formation along suture margins. Activation typically proceeds at 0.25 mm per turn, with two turns per day during active phase until desired expansion (usually 6–8 mm) is achieved. Following active expansion, a consolidation phase of 3–6 months allows for ossification and stabilization of the new suture width.[4]

The inclusion of TADs alters stress distribution within craniofacial structures, reducing alveolar bending moments and buccal tipping. Finite element analyses demonstrate that MARPE exerts higher forces on basal bone and lower stresses on periodontal ligaments compared to conventional expanders. Thus, MARPE achieves orthopedic effects with minimal dental compromise—a critical advantage in skeletally mature patients.[13]

Indications and Patient Selection

The primary indication for MARPE is transverse maxillary deficiency in patients beyond the peak growth period, where sutural interdigitation limits the efficacy of tooth-borne expanders. It is also indicated in cases of unilateral or bilateral posterior crossbite, narrow nasal airway, or Class III camouflage treatments requiring transverse correction prior to orthognathic alignment.[6,8]

CBCT evaluation is essential for patient selection, assessing suture morphology, palatal bone thickness, and inter-sutural patency. Favorable cases show partially interdigitated sutures and palatal cortical thickness exceeding 1.5 mm at TAD insertion sites. Contraindications include severe skeletal maturity with obliterated sutures, active periodontal disease, or palatal pathology.

Recent studies classify suture maturation into five stages (A–E) via CBCT. MARPE demonstrates high success rates in stages B–C (late adolescence) and moderate in stage D (young adults), but limited skeletal response in stage E (full fusion). Nonetheless, reports of successful expansion in patients up to 30 years of age suggest that localized suture separation is still feasible under optimal biomechanical conditions. [14]

Clinical Protocol [15-17]

The clinical workflow for MARPE typically involves intraoral scanning, digital appliance design, and guided TAD placement to ensure accuracy. After appliance delivery, expansion begins following a latency period of 3–5 days to allow soft-tissue adaptation. The screw is activated by 0.25 mm per turn twice daily, amounting to approximately 0.5 mm/day of expansion.

The patient is reviewed weekly to assess midline diastema formation—a clinical indicator of suture opening. Expansion continues until overcorrection (1–2 mm beyond ideal arch width) is achieved to compensate for potential relapse. Following activation, the appliance remains passively retained for 3–6 months, allowing new bone deposition within the suture.

Post-expansion, comprehensive orthodontic treatment can proceed, aligning arches while maintaining transverse stability. Retention protocols often employ transpalatal arches (TPA) or fixed retainers to preserve achieved width.

Clinical Outcomes of MARPE

Clinical evidence over the last decade consistently supports MARPE as an effective modality for skeletal expansion in late adolescents and adults. Skeletal widening is typically quantified through radiographic assessment using cone-beam computed tomography (CBCT) or posteroanterior cephalometry, while dental effects are evaluated through intraoral measurements. Studies report an average transverse expansion of 6–8 mm at the alveolar level, with 60–80% of the movement attributed to skeletal displacement and 20–40% to dental tipping, depending on patient age and suture morphology. Notably, the pyramidal pattern of expansion results in greater anterior widening compared to posterior segments, reflecting biomechanical constraints imposed by circummaxillary articulations. [18-20]

Dental side effects are markedly reduced in MARPE compared to conventional RME. The use of palatal TADs minimizes buccal tipping of molars, alveolar bending, and root resorption. Wilmes et al. (2018) demonstrated through finite element modeling that stress distribution in MARPE favors basal bone loading with limited periodontal ligament strain. Clinically, this translates to lower incidences of molar extrusion, gingival recession, and alveolar fenestration, thereby preserving periodontal health in skeletally mature patients. Additionally, patient-reported discomfort is generally mild, localized to initial activation days, and self-limited, contrasting with the often pronounced dental soreness observed in tooth-borne RME. [17]

Retention and long-term stability are critical considerations. Studies with follow-up periods of 1–5 years indicate that MARPE-induced skeletal expansion exhibits minimal relapse when appropriate retention protocols are followed[21]. Passive retention via the appliance itself, combined with auxiliary devices such as transpalatal arches (TPA) or fixed lingual retainers, supports consolidation of new bone formation along the suture. Radiographic evidence confirms that ossification along midpalatal margins is generally complete by 6 months post-expansion, underscoring the importance of maintaining passive stabilization during this consolidation phase. [22]

Airway and Nasal Function Implications

Beyond dentofacial correction, MARPE has demonstrated significant improvements in nasal airway volume and respiratory function. Expansion of the maxilla contributes to lateral and inferior widening of the nasal floor, effectively increasing the cross-sectional area of the nasal cavity. CBCT-based volumetric analyses indicate an average increase of 15–30% in minimal cross-sectional airway dimensions following MARPE[23,21]. These skeletal changes translate into functional benefits, including reduced nasal airway resistance, improved nasal breathing, and subjective alleviation of mouth breathing in patients with chronic nasal obstruction.

Polysomnographic studies in patients with obstructive sleep apnea (OSA) or mild-to-moderate snoring suggest that MARPE may contribute to a reduction in apnea-hypopnea index (AHI) by expanding the nasal and retropalatal spaces[24]. While these results are promising, it is important to emphasize that MARPE should not be considered a primary OSA treatment; rather, it may serve as a complementary intervention for patients whose maxillary constriction contributes to airway compromise. Patient selection, CBCT airway analysis, and multidisciplinary collaboration with sleep medicine specialists remain essential for optimal outcomes.

Complications and Risk Management

Despite its minimally invasive nature, MARPE is not devoid of complications. The most commonly reported adverse events include soft tissue irritation at miniscrew sites, transient pain during activation, mucosal ulceration beneath the appliance, and minor inflammation at screw insertion points. Proper preoperative evaluation of palatal thickness, careful screw placement, and strict oral hygiene are critical to minimize these complications [25].

Severe complications, although rare, may include miniscrew loosening, perforation of the nasal cavity, or asymmetrical expansion. Screw stability is contingent on engagement of the cortical bone; patients with thin palatal bone (<1.5 mm) or severely interdigitated sutures are at higher risk of TAD failure. Radiographic planning with CBCT allows precise determination of cortical thickness and safe insertion angulation, reducing the likelihood of adverse events. In addition, periodic clinical monitoring during the activation phase enables early detection of asymmetrical expansion or midline deviation, which can be corrected by selective screw adjustments or modification of activation protocols. [9]

Dental complications, while limited, may still occur. Minor buccal tipping of anchor teeth, temporary occlusal interferences, and diastema formation between central incisors are common and usually resolve spontaneously or with subsequent orthodontic alignment. Root resorption is rare but has been reported in patients with preexisting periodontal compromise or overactivation. Accordingly, activation protocols should adhere to recommended rates (0.25 mm per turn, 2 turns/day), and midline diastema formation should be closely monitored as an indicator of suture opening. [8]

Comparison with Conventional RME and SARPE

MARPE occupies an intermediate position between conventional tooth-borne RME and surgically assisted expansion (SARPE). In growing patients (prepubertal or early adolescent), conventional RME remains highly effective, producing robust skeletal expansion with minimal invasiveness. However, in late adolescents and adults, tooth-borne RME often results in dental compensation rather than skeletal widening, limiting long-term stability [1,10].

SARPE offers predictable skeletal expansion in mature patients but carries surgical morbidity, cost, and patient burden associated with hospitalization and osteotomies. MARPE provides a minimally invasive alternative capable of achieving comparable skeletal effects without surgery in select patients. Clinical studies report success rates of 86–100% in late adolescents and young adults, with skeletal expansion magnitudes approaching those of SARPE in favorable suture morphologies[26]. Nonetheless, MARPE may be less effective in patients with fully fused sutures (Angelieri stage E), in which SARPE remains the gold standard.

Discussion

The clinical adoption of MARPE reflects an evolving understanding of maxillary biomechanics and skeletal anchorage. Its effectiveness stems from the strategic distribution of expansion forces through palatal miniscrews, minimizing dental tipping and optimizing basal bone response. CBCT-based studies have clarified the pyramidal opening pattern of the midpalatal suture, confirming symmetric anterior-posterior widening and improved nasal floor morphology. These anatomical changes not only correct transverse maxillary deficiency but also confer functional benefits for airway patency. [20]

Patient selection is critical to success. CBCT assessment of suture morphology, palatal bone thickness, and cortical engagement guides the feasibility of MARPE and reduces the risk of complications. The incorporation of TADs allows treatment of borderline adult patients who would otherwise require surgical intervention. Importantly, activation protocols must balance orthopedic efficacy with biological tolerance;

overzealous expansion risks miniscrew loosening, asymmetric suture opening, or dental complications.[15]

Long-term retention strategies are essential to maintain transverse correction. Skeletal expansion is generally stable when consolidation of the midpalatal suture is complete, but residual dental tipping or alveolar remodeling may contribute to minor relapse. Passive retention via the appliance itself, or adjunctive use of transpalatal arches or fixed retainers, facilitates bone maturation and ensures enduring outcomes. Furthermore, interdisciplinary collaboration with orthodontists, oral surgeons, and sleep medicine specialists may optimize both occlusal and functional results, particularly in patients with airway compromise. [22,25-26]

The impact of MARPE on airway function represents an emerging frontier. Nasal cavity enlargement, reduction in airway resistance, and potential improvement in OSA parameters highlight the broader clinical implications of skeletal maxillary expansion. Future research employing randomized controlled trials, long-term follow-up, and standardized airway assessments is warranted to quantify these benefits and establish evidence-based protocols for multidisciplinary management. [24]

Conclusion

MARPE represents a significant advancement in the management of transverse maxillary deficiency, bridging the gap between conventional RME and SARPE. By utilizing palatal miniscrew anchorage, MARPE achieves true skeletal expansion with minimal dental side effects, even in late adolescents and adults. Clinical outcomes demonstrate predictable transverse widening, enhanced airway volume, and favorable periodontal responses. While careful patient selection, precise CBCT planning, and adherence to activation protocols are critical, MARPE provides a minimally invasive alternative to surgical expansion, expanding the therapeutic options available to orthodontists and maxillofacial specialists. Ongoing studies and long-term follow-up will further refine its indications, optimize biomechanical strategies, and elucidate its role in airway management.

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