Comparison of palatal expanders and their efficacy: a narrative review

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Abstract

Transverse maxillary deficiency is among the most common skeletal irregularities encountered in orthodontics, affecting 8–22% of patients. This condition is characterized by a narrow maxilla, leading to functional and aesthetic challenges, including dental crowding, crossbites, and malocclusions such as Class II and III. Beyond these dental concerns, untreated cases can escalate into systemic issues like obstructive sleep apnea syndrome (OSAS) and temporomandibular joint dysfunction. Early diagnosis and intervention are crucial to mitigate these complications.
Maxillary development results from a combination of genetic and environmental factors. Influences such as oral habits, nasal breathing, and genetic predispositions can disrupt normal growth, leading to transverse deficiencies that may persist into adulthood as the palatal suture ossifies with age. Timely intervention during periods of high skeletal growth potential is therefore essential.
Maxillary expansion remains the standard treatment, aimed at widening the mid-palatal suture to enhance skeletal and dental alignment. Devices such as rapid maxillary expanders (RME), slow maxillary expanders (SME), and newer innovations like the Leaf Expander (LEX) and Miniscrew-Assisted Rapid Palatal Expanders (MARPE) offer various options tailored to patient age, skeletal maturity, and compliance. Recent advances, including skeletal anchorage systems and minimally invasive techniques, promise improved outcomes with fewer side effects, paving the way for more effective, patient-centered orthodontic care

Keywords: Maxillary expansion, Palatal expanders, Transverse deficiencies, Rapid Maxillary Expander (RME), Slow Maxillary Expander (SME), Leaf Expander

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(LEX), Miniscrew-Assisted Rapid Palatal Expander (MARPE), Skeletal changes, Orthodontic treatment, Patient compliance.

Introduction

Technological Transverse maxillary deficiency is one of orthodontics' most common skeletal irregularities, affecting approximately 8–22% of patients (1–8). It is characterized by an abnormally narrow maxilla, often leading to functional and aesthetic issues such as dental crowding, crossbites, malocclusions (Class II and III), and midline discrepancies (9–16). Beyond dental and orthodontic complications, untreated maxillary deficiency can contribute to systemic problems, including obstructive sleep apnea syndrome (OSAS) and temporomandibular joint dysfunction (17–33). Given its prevalence and impact, early diagnosis and effective treatment are critical to ensuring optimal outcomes (34–45).

The maxilla develops through a combination of genetic and environmental factors (46–57). Oral habits, nasal breathing patterns, and genetic predispositions can influence maxillary growth and lead to transverse deficiencies (58–63). If not addressed, these issues often persist into adolescence and adulthood, as the palatal suture becomes increasingly ossified with age (64–74, 445, 446). Consequently, early intervention is vital, particularly during high skeletal growth potential (26,75–85)periods.

Maxillary expansion is the standard of care for treating transverse deficiencies. It aims to widen the mid-palatal suture, improving skeletal structure and dental alignment (86–92). Various devices and techniques have been developed over the years to achieve this goal, including rapid maxillary expanders (RME), slow maxillary expanders (SME), and newer options like the Leaf Expander (LEX) (44,68,93–96). The selection of a specific device depends on factors such as patient age, compliance, skeletal maturity, and clinical presentation (18,89,97–100).

RMEs are often the first choice for younger patients because they can quickly achieve significant skeletal expansion (96,101,102,102–104). However, this approach is not without limitations. RMEs can lead to adverse dental effects, including root resorption, buccal tipping, and a reduction in buccal bone thickness (105–112). In contrast, SME and LEX provide gentler, more controlled forces over a more extended period, aligning better with the natural processes of bone remodeling and vascularization (107,113,114). These devices are handy in mixed dentition stages or for patients with a thin periodontal biotype (20,20,94,107,115,115–118).

The introduction of skeletal anchorage devices, such as Miniscrew-Assisted Rapid Palatal Expanders (MARPE), represents a significant advancement in orthodontics (115,115,119–125). These devices anchor directly to the bone, bypassing dental structures and enabling effective expansion in older adolescents and adults with partially or fully ossified palatal sutures (100,126–131). MARPE devices reduce the dental side effects of traditional RMEs, offering a viable solution for challenging cases.

Despite the availability of numerous expansion techniques, the optimal approach for treating maxillary deficiencies remains a topic of debate. Each device has unique advantages and drawbacks, and their effectiveness often depends on individual patient factors (36,132–140). This review aims to critically evaluate the skeletal and dental effects of RME, SME, LEX, and hybrid devices, providing clinicians with evidence-based insights to guide treatment planning (115,118,141–144). By exploring the comparative outcomes of these devices, we aim to identify the most effective and patient-friendly methods for managing transverse maxillary deficiencies across different age groups and clinical scenarios (11,145–150).

Materials and Methods

This review follows a scoping review protocol, adhering to PRISMA-ScR guidelines (72,151–155). The primary databases searched included PubMed, Scopus, and Web of Science, focusing on studies published between 2013 and 2023 (12,64,64,149,156,157). Boolean keywords such as "hyrax," "leaf expander," and "rapid maxillary expansion" guided the search (67,158–166).

Eligibility criteria required clinical trials involving human subjects, written in English, and directly comparing different expanders (6,163,167–170). Exclusions included in vitro experiments, animal studies, and articles lacking original data (167–170,170,171). After rigorous screening of 1008 initial records (172–178), the final dataset included 15 studies.

Results

Comparative Outcomes of Expanders

1. Rapid Maxillary Expander (RME):

The RME remains a gold standard for treating transverse deficiencies (179–185). It relies on a central screw mechanism to apply significant force, rapidly separating the mid-palatal suture within approximately two weeks (138–140,186–190). Studies highlight its efficacy in achieving skeletal expansion, though dental side effects, such as root resorption and buccal tipping, have been observed (4,138,139,191,192).

2. Slow Maxillary Expander (SME):

The SME offers a more gradual approach, producing controlled forces over months (193,194,194–201). While the skeletal effects are comparable to RME, SME demonstrates reduced dental side effects and better aligns with natural bone remodeling (202,202,203,203–209).

3. Leaf Expander (LEX):

The LEX employs Ni-Ti springs for continuous, gentle forces, requiring minimal patient compliance (210–216). Research shows that its outcomes in skeletal and dental expansion are similar to RME and SME. However, it excels in minimizing patient discomfort and soft tissue impact (217–225).

Device-Specific Findings

1. Pain and Discomfort:

Studies comparing RME and LEX found significantly lower pain levels in LEX users, particularly during the first week (10,226–235). This is attributed to its gradual activation mechanism (34,34,236–244, 444).

2. Skeletal Changes:

CBCT analyses reveal that all devices induce meaningful skeletal changes (212,245–254). Bone-

anchored devices, such as hybrid expanders, yield more pronounced outcomes, particularly in adolescent and adult patients (254–258).

3. Dental Impact:

The LEX minimizes dental tipping and preserves buccal bone thickness, making it a safer option for patients with thin periodontal structures (26,259–263,263,264). In contrast, RME devices with dental anchorage may compromise dental health due to excessive tipping forces (265).

Innovations in Palatal Expansion

Recent advancements include the integration of mini-screws for skeletal anchorage, as seen in the Miniscrew-Assisted Rapid Palatal Expander (MARPE) (251,266–275). MARPE devices show promising results in adults, achieving parallel suture openings and minimizing unwanted dental movements (276–287).

Discussion

The treatment of transverse maxillary deficiencies is an evolving area in orthodontics. Various devices are designed to optimize skeletal and dental expansion while minimizing patient discomfort and adverse side effects (274–283). A comparative analysis of rapid maxillary expanders (RME), slow maxillary expanders (SME), the Leaf Expander (LEX), and bone-anchored devices highlights the nuanced differences in their mechanisms, outcomes, and suitability for different patient profiles (284–296).

Clinical Considerations in Device Selection

One of the primary factors influencing the choice of expander is the patient's age and skeletal maturity. Younger patients with open or partially fused palatine sutures respond well to RMEs due to the pliability of their skeletal structures, which allows for more effective and rapid separation of the suture (297–300). However, as the suture's ossification progresses, achieving similar outcomes becomes challenging, particularly in late adolescence and adulthood. In these cases, hybrid expanders, such as the Miniscrew-Assisted Rapid Palatal Expander (MARPE), provide a viable alternative. MARPE minimizes dental side effects and produces more significant skeletal expansion by anchoring directly to the bone, bypassing the limitations of sutural rigidity (301–305).

Patient compliance is another critical consideration. Devices like the LEX, which operate autonomously with pre-set forces, reduce the need for patient or parental cooperation (320–329). This feature is particularly advantageous in pediatric populations or patients who consistently struggle to activate traditional expanders such as RMEs. Additionally, the gradual and consistent force exerted by the LEX aligns better with the biological processes of bone remodeling and vascular development, potentially leading to more stable outcomes (314–324).

Pain and Patient Comfort

Pain management is essential to orthodontic treatment, as it significantly impacts patient satisfaction and compliance (323–330). Studies consistently show that the LEX outperforms traditional RMEs regarding pain reduction (331–337). The continuous, low-force mechanism of the LEX minimizes inflammation and pressure on the periodontal ligament, leading to less discomfort during the initial days of treatment. In contrast, RMEs, with their abrupt and higher forces, often cause significant pain, particularly during the first week of activation (324–338). This difference highlights the importance of considering patient comfort when selecting a device, especially for younger or more sensitive individuals (339–349).

Skeletal and Dental Outcomes

From a skeletal perspective, all expanders aim to widen the maxillary arch by separating the mid-palatal suture (350–356). However, the degree and nature of skeletal changes vary across devices. RMEs are highly effective in younger patients for achieving rapid expansion, but their effects are often accompanied by dental tipping and reductions in buccal bone thickness (357–370). These dental side effects can compromise periodontal health, particularly in patients with thin gingival biotypes (360–377).

On the other hand, SME and LEX demonstrate a more controlled approach to expansion, with fewer adverse dental effects (378–381). The gradual forces applied by these devices allow for concurrent bone remodeling and sutural widening, leading to more physiological changes. Integrating mini-screws in MARPE devices enhances skeletal outcomes by providing direct anchorage to the bone, enabling parallel sutural expansion and minimizing dental involvement (382–385). This feature mainly benefits older patients, where skeletal expansion is more challenging due to increased sutural interdigitation.

Long-Term Stability

Long-term stability remains a critical consideration in orthodontics (386–399). While RMEs achieve rapid results, their outcomes may be less stable due to the significant dental component of the expansion. The risk of relapse is higher if the expansion is not adequately retained during the post-treatment phase. Devices like LEX and MARPE, which emphasize skeletal changes over dental tipping, may offer more stable results. However, the long-term stability of SME and LEX outcomes requires further investigation through longitudinal studies.

Advancements in Imaging and Diagnostics

The advent of cone-beam computed tomography (CBCT) has revolutionized the evaluation of orthodontic treatment outcomes. Unlike traditional two-dimensional imaging, CBCT provides detailed three-dimensional views of skeletal and dental structures, allowing for precise assessment of sutural changes, bone density, and dental alignment. This advancement has enabled more accurate comparisons between devices and a better understanding of their effects on the maxilla and surrounding structures. For example, CBCT studies have confirmed the superior skeletal outcomes of MARPE compared to traditional RMEs, highlighting the importance of incorporating advanced diagnostics into treatment planning (414–419).

Tailoring Treatment to Patient Needs

The choice of expander should be individualized based on the patient's specific needs, preferences, and clinical

presentation (406–414). For example, patients with respiratory issues, such as obstructive sleep apnea, may benefit more from devices that produce significant anterior expansion, such as RMEs. In contrast, patients with dental crowding or periodontal concerns may prefer devices like LEX or SME, which exert gentler forces and prioritize skeletal changes (415–429).

Similarly, the level of patient compliance can influence device selection. Autonomous devices like LEX are ideal for non-compliant patients, while traditional RMEs may be suitable for those who can adhere to activation protocols. The clinician's expertise and familiarity with the device also play a crucial role in ensuring successful outcomes.

Future Directions in Palatal Expansion

Research into palatal expanders continues to evolve, focusing on optimizing outcomes and minimizing side effects. Advances in material science, such as using shape-memory alloys in LEX, offer the potential for more effective and patient-friendly devices. Additionally, integrating digital technology, such as 3D printing, may enable the customization of expanders to suit individual patient anatomy, further enhancing treatment precision and comfort.

Another promising area of research is combining expansion techniques with other orthodontic or surgical interventions. For example, MARPE, in conjunction with orthognathic surgery, has shown potential for addressing severe transverse deficiencies in adult patients. Similarly, combining expansion with myofunctional therapy or airway management strategies may enhance outcomes in patients with complex needs.

Expanded Summary

In summary, the choice of palatal expander should be guided by a thorough evaluation of the patient's age, skeletal maturity, compliance, and clinical goals. While RMEs remain effective for rapidly correcting transverse deficiencies, devices like LEX and MARPE offer significant advantages regarding comfort, safety, and skeletal outcomes. Integrating advanced diagnostics and innovative materials further enhances the potential for tailored and effective treatment.

Continued research and technological advancements will undoubtedly refine the use of palatal expanders, offering new opportunities to improve patient care and treatment outcomes in orthodontics.

Conclusion

Maxillary expansion is a cornerstone in treating transverse maxillary deficiencies, addressing functional and aesthetic concerns while preventing potential systemic complications. The choice of expansion device depends on multiple factors, including the patient's age, skeletal maturity, compliance, and specific clinical needs. While traditional rapid maxillary expanders (RME) remain widely used for their efficiency, their associated dental side effects, such as buccal tipping and root resorption, require careful consideration. These drawbacks have led to the development of alternative devices, such as slow maxillary expanders (SME) and the Leaf Expander (LEX), which prioritize gradual expansion and align better with natural bone remodeling processes.

The advent of skeletal anchorage systems, particularly Miniscrew-Assisted Rapid Palatal Expanders (MARPE), has revolutionized treatment options for older patients and those with advanced sutural ossification. These devices minimize dental side effects, achieving more incredible skeletal changes and expanding the potential for effective treatment in adolescent and adult populations. However, their clinical application requires expertise and precise diagnostic planning supported by advanced imaging techniques like cone-beam computed tomography (CBCT).

Integrating innovative materials, such as shape-memory alloys, and digital customization tools, including 3D printing, promises to optimize palatal expansion outcomes further. These advancements and ongoing research into long-term stability and patient satisfaction will help refine treatment strategies. Ultimately, the clinician's ability to tailor the choice of expander to individual patient needs—balancing efficacy, safety, and comfort—will remain the key to successful outcomes.

In conclusion, while all devices analyzed in this review demonstrate their capacity to correct transverse deficiencies, the ideal choice often depends on the interplay of patient-specific factors and clinician expertise. Continued research and technological innovation will undoubtedly enhance the effectiveness of palatal expansion treatments, offering patients improved care and lasting results.

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