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Benefits of Palatal Expander in Class III Patients: A Literature Review

Vivianny Sales Araújo [a++], Rachel Brazuna Solidônio [b], Francisbênia Alves Silvestre [b], Ana Letícia Daniel Fontenele [b], Ana Carolina Lima Moreira [b], Nicole Escórcio de Meneses [b], Isaac Augusto Dantas Nogueira [b], Hana Arielle Oliveira Pereira [b], Elizon Sampaio Coelho Junior [b] and Raniel Fernandes Peixoto [b*]

[a] Catholic University Center of Quixadá, Quixadá, Ceará, Brazil.
[b] Federal University of Ceará - Fortaleza, Ceará, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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[++] *Principal;*
**Corresponding author: Email: raniel.peixoto@ufc.br;*

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ABSTRACT

Rapid maxillary expansion (RME) is widely recognized in the literature as a fundamental component of the orthopedic management of Class III malocclusion. Its primary objective is to facilitate maxillary protraction and establish a more favorable skeletal relationship between the maxilla and mandible. Various types of palatal expanders are available, and these devices can be effectively combined with other treatment modalities. This study aimed to conduct a literature review on the benefits of using palatal expanders in Class III patients, with a particular focus on comparing the most commonly adopted techniques. A structured literature search was performed in the PubMed and Virtual Health Library (VHL) databases using the descriptors “Palatal Expansion Technique,” “Class III,” and “Orthodontics,” combined with the Boolean operator “AND.” Only articles published in English were included. The reviewed studies indicate that palatal expansion remains a valuable therapeutic approach for Class III malocclusion, with its effectiveness enhanced when combined with complementary techniques such as facemasks or skeletal anchorage (e.g., mini-implants), particularly during early growth phases. Consistent improvements in skeletal structure and occlusion were reported. Palatal expansion corrects maxillary constriction and improves the maxillo-mandibular relationship. Additionally, it provides functional benefits for respiration, phonation, and mastication, as well as significant aesthetic and psychological advantages.

Keywords: Palatal expansion technique; Class III angle; orthodontics.

1. INTRODUCTION

Class III malocclusion is characterized by dental disharmony, with or without skeletal discrepancies, in which the mandible is positioned anteriorly relative to the cranial base and the maxilla. This unfavorable positioning may result from maxillary growth deficiency, excessive mandibular prognathism, or a combination of both, leading to impaired facial aesthetics and social and psychological effects on affected individuals (Vaz et al., 2023).

Individuals with Class III malocclusion typically present a concave facial profile due to an increased lower facial third, a prominent chin, and the absence of passive lip seal. Transverse alterations, such as posterior crossbite, and vertical changes, including excessive vertical growth, may also occur. Additionally, functional impairment is common, as speech and mastication can be affected. The incidence of this malocclusion ranges from 3% to 13% of the general population (Araújo & Araújo, 2008).

The etiology of this malocclusion involves both hereditary patterns and environmental factors that interact to influence mandibular growth. The greater the genetic contribution to the origin of a dentofacial irregularity, the poorer the prognosis for orthodontic and orthopedic treatment. Environmental influences primarily consist of pressures and forces related to physiological activities, such as mastication and swallowing (Dehesa-Santos et al., 2021).

According to Ngan and Moon (2015), Angle, Tweed, and Moyers classified Class III malocclusions into three types: pseudo, dentoalveolar, and skeletal. Pseudo-Class III is characterized by the presence of an anterior crossbite due to functional mandibular forward displacement. Dentoalveolar Class III is defined by dental compensation, including maxillary incisor protrusion and mandibular incisor retrusion. Skeletal Class III involves maxillary retrusion and/or mandibular protrusion (Reyes et al., 2014). Treatment of Class III malocclusion is rarely satisfactorily achieved with intraoral appliances alone and often requires the use of extraoral forces.

Cases presenting anteroposterior and vertical maxillary deficiency, with a normal or slightly protruded mandible, are typically treated with rapid maxillary expansion (RME) and facemask therapy (Moussa et al., 1995). The use of a palatal expander provides several benefits, including widening the narrow maxilla, correcting posterior crossbite, increasing arch length, opening the bite, loosening or activating sutures adjacent to the maxilla, and initiating downward and forward movement of the maxillary complex. The outcomes of this approach are influenced by the timing of treatment initiation, appliance design, and duration of use (Masucci et al., 2022).

The Haas-type expander was the first to be developed and featured bands supported by four dental elements connected to an expansion screw and a metal framework, which was covered by acrylic in the palatal region to better distribute forces and relieve pressure in the marginal gingival area (Cannavale et al., 2018; Huang et al., 2021).

The Hyrax-type expander, developed in 1973, consists of rigid wires with the screw positioned close to the palate, aiming to centralize forces at the center of maxillary resistance. It does not have acrylic, which facilitates oral hygiene (Rinaldi et al., 2018).Given the widespread use of palatal expanders to establish harmony between the maxilla and mandible in the correction of Class III malocclusion, this study presents a literature review comparing other techniques with the use of palatal expanders in the treatment of cases involving maxillary atresia.

2. METHODOLOGY

This study is an integrative literature review, guided by the following research question: What are the effects of using palatal expanders in patients with Class III malocclusion? The bibliographic search was conducted for the period from 2014 to 2024 in the PubMed and Virtual Health Library (BVS) databases, including only articles published in English. The terms “Palatal Expansion Technique,” “Class III,” and “Orthodontics,” indexed in the Health Sciences Descriptors (DeCS), were combined using the Boolean operator “AND.” The inclusion criteria encompassed studies that evaluated the effects of palatal expansion in Class III patients. Conversely, the exclusion criteria were theses, monographs, literature reviews, and articles that did not address the topic under investigation.

3 LITERATURE REVIEW

3.1 Classification, Definition of Class III Malocclusion, and Prevalence

According to Angle, malocclusions are classified into three main classes: Class I, Class II, and Class III. Class I is characterized by an appropriate relationship between the upper and lower first molars, whereas Class II involves a protrusion of the maxilla relative to the mandible. Class III, on the other hand, is identified by mandibular protrusion relative to the maxilla, often resulting in an anterior crossbite (Hu et al., 2024).

Class III malocclusion, also known as mandibular prognathism, is characterized by protrusion of the mandible relative to the maxilla, resulting in an unfavorable relationship between the dental arches. This may cause aesthetic and functional problems, including difficulties in chewing and speech. The condition can have a skeletal origin, related to disproportionate growth of the facial bones, or a dental origin, when only the teeth are misaligned (Zere et al., 2018).

The prevalence of malocclusions varies among different populations and geographic regions. Class III malocclusion is less common than Classes I and II, with a prevalence ranging from 3% to 7% worldwide. Studies indicate that genetic factors play a significant role in its etiology, although environmental factors may also influence its development (Cenzato et al., 2021).

This condition can lead to a series of functional and aesthetic complications, negatively affecting chewing, speech, and facial appearance. Furthermore, it is associated with an increased risk of psychological issues, such as low self-esteem and dissatisfaction with body image. Studies suggest that early treatment can prevent the need for more complex and invasive surgical interventions in the future (Zere et al., 2018; Lathrop-Marshall et al., 2022).

Understanding the prevalence and impact of Class III malocclusion is essential for developing effective treatment strategies. Recent epidemiological studies have shown a trend of increasing Class III diagnoses, which may be related to genetic factors and changes in facial growth patterns (Azamian & FARINAZ, 2016). This underscores the importance of preventive and interceptive approaches in orthodontics.

3.2 Etiology of Class III Malocclusion

The etiology of Class III malocclusion is multifactorial, with a significant genetic component. Heredity plays a crucial role, particularly in Asian populations, where the prevalence of this condition is higher. Genetic transmission can affect both mandibular growth and maxillary development, resulting in the skeletal discrepancies characteristic of Class III malocclusion (Dilio et al., 2014).

Although genetics is an important factor, environmental influences also contribute to the development of Class III malocclusion. Harmful

oral habits, such as prolonged digit sucking and atypical swallowing, can affect the growth and position of the jaws. Additionally, conditions such as mouth breathing may alter tongue posture and impact facial development (Guglielmi et al., 2024).

Abnormal jaw growth is one of the primary skeletal factors involved in the etiology of Class III malocclusion. Mandibular prognathism, characterized by excessive mandibular growth, is commonly observed. Conversely, maxillary hypoplasia, in which maxillary development is insufficient, can also contribute to this malocclusion, leading to a discrepancy between the dental arches (De Clerck & Proffit, 2015).

Functional factors, including abnormal tongue and masticatory muscle function, also play a role in the etiology of Class III malocclusion. Inadequate tongue posture during rest and swallowing can influence mandibular growth, while muscular imbalances may exacerbate mandibular protrusion, worsening the malocclusion (Sugawara et al., 2016).

Early diagnosis of Class III malocclusion is essential for successful treatment. Identifying the underlying causes—whether genetic, environmental, or functional—allows for more effective orthodontic and orthopedic interventions. The use of palatal expanders in young patients, for example, can promote proper maxillary growth and help prevent the need for future surgical procedures (Ryu et al., 2015; Sugawara et al., 2016).

3.3 Palatal Expanders as Orthodontic Treatment for Class III

The use of palatal expanders is common in the treatment of Class III malocclusion, particularly in young patients, where the palatal suture is still open. Rapid maxillary expansion (RME) is a widely used orthodontic approach to correct transverse discrepancies by promoting anterior maxillary growth. RME is especially effective in children and adolescents due to the greater flexibility of craniofacial sutures during growth (Lione et al., 2017).

RME is often combined with other orthopedic devices, such as face masks, to maximize its effects on maxillary growth. Clinical studies indicate that combining these devices can significantly improve the maxillomandibular relationship, thereby minimizing the need for future surgical interventions (Shih et al., 2022). Additionally, RME can correct posterior crossbite, which is common in patients with skeletal Class III malocclusion, and can improve facial aesthetics.

The literature also emphasizes that the timing of intervention is critical for treatment success. The use of palatal expanders during the peak growth phase produces better orthopedic outcomes compared to later interventions. This underscores the importance of early detection of Class III malocclusion and timely intervention with RME (Baccetti et al., 2001; Ferrillo et al., 2024).

Early treatment of Class III malocclusion with palatal expanders can prevent the need for invasive surgical procedures in the future. By correcting the maxillomandibular relationship at early developmental stages, it is possible to improve not only facial aesthetics but also masticatory function and speech. The combined use of palatal expanders and face masks can significantly enhance treatment outcomes in young patients (Lione et al., 2017).

3.4 Mechanisms of Action of Palatal Expanders

Palatal expanders are devices used to correct transverse maxillary discrepancies by expanding the upper arch through separation of the midpalatal suture. The mechanism of action depends on the type of expander employed, whether tooth-supported (such as rapid maxillary expanders – RME) or bone-supported (such as mini-implant-assisted palatal expanders – MARPE) (Maino et al., 2020). In the case of RME, the applied force is transmitted directly to the teeth, which in turn exert pressure on the alveolar bone and the palatal suture, promoting skeletal expansion. In MARPE, forces are distributed directly to the bone via mini-implants, allowing for more controlled expansion with fewer side effects on the teeth (Zeng et al., 2023).

An important aspect of the mechanism of palatal expanders is the biomechanical response of craniofacial structures. Finite element analysis studies show that activation of expanders generates three-dimensional displacements in the palate, with the greatest deformation observed in the anterior region. Expansion follows a decreasing pattern toward the posterior palate, producing a pyramidal expansion effect

(Maino et al., 2020; Meng et al., 2022). These displacements are responsible for the separation of the midpalatal suture and the transverse increase of the maxilla.

The efficiency of expanders depends on the developmental stage of the palatal suture. In young individuals, where the suture is not yet fully fused, expansion occurs in a more predictable and controlled manner. In adolescents and adults, in whom the suture tends to be more calcified, techniques such as MARPE are preferred, as they minimize unwanted effects on the teeth and maximize skeletal expansion (Zeng et al., 2023).

Comparisons between different types of expanders, such as tooth-supported and bone-supported devices, demonstrate that bone-supported expanders are more effective in providing greater and more symmetrical skeletal expansion, particularly in patients with cleft palate or adults. This type of expander distributes force more homogeneously, reducing unwanted side effects such as asymmetric displacement of teeth and palate (Maino et al., 2020).

Furthermore, the selection of the type of expander and treatment protocol must take individual factors into account, including patient age, palatal suture maturation stage, and clinical case complexity. Patients with Class III malocclusion have shown promising results with devices such as MARPE due to their effectiveness in transverse expansion, which is essential for correcting maxillary discrepancies (Tarraf et al., 2023).

3.5 Impact on Transverse Expansion

Palatal expanders for transverse expansion in Class III malocclusion have been widely studied due to the anatomical and functional changes they may induce. Transverse maxillary expansion using palatal expanders has demonstrated positive results in correcting Class III malocclusion. Correction of posterior crossbite, which is common in these patients, is one of the primary objectives of orthodontic treatment (Rutili et al., 2021).

The dentoalveolar effects resulting from maxillary expansion are highly relevant. Patients undergoing treatment with palatal expanders, such as the Ni-Ti Memoria® Leaf Expander, exhibit increased distances between the canines and between the molars, as well as an increase in the dental arch perimeter. These changes help correct transverse discrepancies and create adequate space for the eruption of permanent teeth without causing excessive dental tipping. These benefits are particularly advantageous in growing patients, where bone remodeling occurs more effectively (Inchingolo et al., 2023).

In adolescent or adult patients, the use of devices such as the mini-implant-assisted palatal expander (MARPE) may be necessary to achieve the desired skeletal expansion without resorting to orthognathic surgery. This device provides more controlled expansion and is recommended for patients with higher bone density, contributing to improved facial symmetry and dental occlusion (Hsu et al., 2023).

Correction of transverse discrepancies also contributes to an improved facial profile, particularly in patients with mandibular prognathism. Maxillary expansion helps establish a more balanced proportion between the maxilla and mandible, resulting in a more harmonious and symmetrical facial appearance (Iodice et al., 2013). However, some side effects may occur, such as buccal tipping of molars and alveolar bone resorption. These effects can be minimized with proper device use and careful treatment monitoring. Precise control of expander activation, combined with the use of digital technologies in planning and execution, is essential to ensure optimized outcomes (Ugolini et al., 2024).

3.6 Comparison Between Tooth-Supported and Skeletal Expanders

The choice of expander type in Class III patients has been widely debated due to differing implications regarding efficacy, skeletal effects, and stability of outcomes. Skeletal expanders are often regarded as more effective in promoting significant skeletal changes, particularly in transverse maxillary expansion. Conversely, tooth-supported expanders tend to exert a greater effect on the teeth than on the bone structure, which may limit their efficacy in severe Class III cases (D'apuzzo et al., 2022).

The main advantage of skeletal expanders lies in their ability to minimize dental side effects, such as tipping of posterior teeth and protrusion of upper incisors, which are commonly observed with tooth-supported expanders like the Hyrax model. These unwanted effects can compromise orthodontic treatment outcomes, especially in patients requiring substantial skeletal correction.

Skeletal expanders, particularly hybrid models that use both bone and dental anchorage, reduce these negative impacts, providing a more balanced and effective expansion (Carter et al., 2023; Rozzi et al., 2023).

Comparative studies show that patients treated with skeletal expanders, such as skeletal Hyrax or mini-implant-anchored devices, experience greater expansion of nasomaxillary structures and fewer dentoalveolar changes. These findings suggest that skeletal devices are better suited for Class III patients who require significant skeletal correction. Their effectiveness in promoting skeletal changes without compromising dental positioning is a key factor in treatment selection (Alves et al., 2020; Bistaffa et al., 2023).

Current clinical recommendations emphasize the importance of using skeletal or hybrid expanders in young patients with Class III malocclusion to optimize skeletal outcomes and reduce dental complications. These devices are particularly effective during growth phases, allowing for more natural and less invasive expansion. Scientific literature supports this approach as one of the most efficient strategies for treating considerable skeletal discrepancies.

The choice of device for a Class III clinical case should be based on individual patient characteristics, including age, residual bone growth, and severity of malocclusion. While tooth-supported expanders may be appropriate for mild to moderate cases, skeletal expanders are recommended for severe cases where bone correction is essential. This strategic selection is crucial for optimizing treatment outcomes and minimizing complications (Mosleh et al., 2015).

3.7 Long-term Stability of Results

Long-term stability of results following the use of palatal expanders is an important consideration for evaluating the efficacy of these devices in Class III patients. Palatal expansion can produce significant improvements in arch width and occlusal relationships, but the maintenance of these outcomes may vary (Foersch et al., 2015). These results are influenced by several factors, including patient age, the technique employed, and post-treatment follow-up. Combining expanders with other therapeutic approaches, particularly in adults, is crucial to ensure long-term treatment success (Foersch et al., 2015).

In young patients, expanders promote beneficial skeletal changes that can be maintained over time, especially when combined with additional orthodontic interventions. Conversely, in adults, stability tends to be less predictable due to the maturity of craniofacial sutures, often requiring complementary procedures such as mini-implants (Papadopoulou et al., 2022).

Various factors affect the long-term stability of expansion, including patient age and the technique applied. Studies indicate that rapid maxillary expansion can achieve stable skeletal correction; however, the use of retainers is essential to prevent relapse, particularly in severe Class III cases. Regular post-treatment monitoring is vital to detect potential changes in dental alignment and bone structure (Ryu et al., 2015; Antelo et al., 2020).

In adolescents, devices such as MARPE (Mini-implant Assisted Rapid Palatal Expander) have proven effective in maintaining results, primarily due to the greater bone remodeling capacity at this age. Early intervention during growth facilitates adaptation of bone structures, increasing the likelihood of prolonged stability of the achieved outcomes (Maino et al., 2023). In adults, however, results are more challenging. Class III patients present greater resistance of palatal sutures, which may limit skeletal expansion. In such cases, combining palatal expanders with surgical techniques may be necessary to achieve stable and lasting correction (Lin et al., 2023).

3.8 Effect on Respiratory Function

The use of palatal expanders in Class III patients can have a significant impact on respiratory function. Maxillary correction improves the upper airway by increasing the sagittal dimensions of the pharynx, which facilitates airflow and reduces respiratory resistance, particularly during sleep (Aniceto et al., 2015).

A study demonstrated that palatal bone thickness of the maxilla also influences respiratory outcomes in Class III patients, especially when using expanders. Tomographic analysis indicated that specific areas of palatal bone thickness may be associated with the effectiveness of airway improvement, highlighting the importance of careful planning when employing these devices (Chen et al., 2021).

Mini-implant-assisted maxillary expansion (MARPE) can produce positive effects in adults with obstructive sleep apnea. Patients treated with MARPE exhibited notable improvements in quality of life, which were related to enhanced respiratory function during sleep (Feng et al., 2023). Furthermore, the combination of rapid palatal expansion (RPE) with a face mask in Class III patients has also been shown to improve respiratory function. This protocol has been associated with increased nasopharyngeal airway dimensions, reducing airflow resistance and enhancing breathing during sleep (Benetti et al., 2024).

Additionally, the combination of RPE with a face mask in Class III patients is effective not only in correcting skeletal discrepancies but also in enlarging nasopharyngeal airway dimensions, resulting in significant improvements in respiration. These treatment protocols demonstrate promise for both resolving malocclusion and improving respiratory function, particularly in adults (Chami et al., 2024).

3.9 Effects of Palatal Expansion on Facial Aesthetics

Palatal expansion not only corrects functional problems but also has aesthetic impacts on the face. This procedure can significantly contribute to improving facial harmony, particularly in patients with a narrow maxilla, helping to balance facial proportions and, in some cases, achieve a more even projection of the midface (Guerra & Ijz, 2018).

Palatal expansion also influences the appearance of the smile by increasing the width of the upper dental arch, providing a broader and more harmonious smile. Facial aesthetics further benefit from improved symmetry, especially in young patients, where early treatment can prevent the need for more complex surgical interventions later in life (Grassia et al., 2014).

With increased upper maxillary width, the position and shape of the nose can be positively modified, contributing to a more balanced and aesthetic facial appearance. These aesthetic effects complement the functional improvements provided by the procedure, as demonstrated by research analyzing palatal shape changes using deep learning technologies and 3D geometric modeling. Moreover, approaches such as the use of orthodontic devices like Homeoblock, which promote palatal expansion, can remodel underlying bony structures, affecting the appearance of the cheekbones and periocular region. This remodeling can soften expression lines and enhance facial contour, particularly in adult patients (Nauwelaers et al., 2021).

Patients undergoing palatal expansion report improvements in overall aesthetics, as the procedure can correct facial asymmetries and enhance facial projection, increasing confidence and satisfaction with their appearance. Careful and personalized evaluation by orthodontists is essential to ensure that these aesthetic outcomes are effectively achieved (Guerra; Ijz, 2018).

3.10 Technological Advances and Development of New Devices

Technological advances in the development of palatal expanders have played a crucial role in the treatment of patients with Class III malocclusion. Three-dimensional (3D) printing has facilitated the creation of customized palatal expanders, allowing for a more precise fit to the patient and reducing undesirable side effects such as dental tipping and root resorption. Finite Element Analysis (FEA) has also been applied to optimize the design of micro-implant-assisted expanders, resulting in more controlled and efficient expansion, particularly in cases of maxillary transverse deficiency in Class III patients (Wang et al., 2024).

New technologies, such as 3D-printed MARPE devices, have shown promising results in treating transverse maxillary deficiencies in Class III patients. Furthermore, these devices induce changes in both transverse and anteroposterior dimensions, which can significantly improve the facial profile of patients. Another technological advancement is the use of Temporary Anchorage Devices (TADs), which have increased the effectiveness of palatal expanders, particularly in adult patients. These devices provide more stable anchorage, allowing greater control during maxillary expansion and minimizing common adverse effects observed with tooth-supported expanders (ANDRÉ et al., 2024).

The application of MARPE has also demonstrated a positive impact on correcting anterior and posterior crossbites in Class III patients. This technology not only facilitates maxillary expansion but also promotes better

distribution of orthodontic forces, contributing to more stable and efficient treatment outcomes (Wilmes et al., 2022).

3.11 Complications and Limitations of Treatment

One of the risks associated with the use of palatal expanders, particularly tooth-borne devices, is asymmetric expansion. When the device is not activated correctly or the applied force is irregular, uneven expansion of the maxillary halves may occur, leading to issues such as dental deviation and facial discomfort. Strict control of applied forces during treatment is essential to minimize these adverse effects (Winsauer et al., 2021).

In adult Class III patients, palatal bone thickness may be insufficient to properly anchor skeletal expansion devices. Bone thickness, particularly in the posterior palate region, can be limited, compromising the stability of anchorage screws. In extreme cases, this limitation may result in treatment failure or necessitate more invasive interventions, such as surgically assisted expansion (Chen et al., 2021).

Another critical factor that can limit treatment is the resistance of the palatal suture. In adult patients, the bony interdigitation of the midpalatal suture makes palatal expansion more complex and less predictable. As age increases, the bone within the palatal suture becomes more rigid and dense, making separation of the palatal halves more difficult. In Class III malocclusion patients, this bone resistance can limit treatment outcomes with expanders, often requiring more aggressive approaches that combine orthodontic techniques with surgery (De Oliveira et al., 2021).

In cases of severe bone resistance, palatal expansion cannot be achieved using conventional devices alone, necessitating surgical interventions. However, maxillary expansion surgery carries risks, including infection, excessive bleeding, and poor healing. These complications can prolong recovery time, increase patient discomfort, and potentially compromise the desired aesthetic and functional outcomes (Costa et al., 2024).

The use of expanders anchored to teeth can also result in undesirable complications in dental and periodontal tissues, including gingival recession, inflammation, and root resorption. These complications are particularly relevant in Class III patients, where periodontal health may already be compromised. Continuous periodontal monitoring during treatment is essential to minimize these effects (Vidalón et al., 2021).

Skeletal expanders, such as MARPE, although highly effective, may present failures in screw anchorage. In patients with low bone density, such as those with osteoporosis or malnutrition, screws may not properly fixate to the bone, necessitating removal and reimplantation of the device, which prolongs treatment and increases the risk of infection. Studies indicate that such failures can compromise treatment success, making careful evaluation of the patient's bone condition prior to screw insertion essential (Kapetanović et al., 2022; Brunetto et al., 2022).

Despite technological advances, limitations remain in current expander devices. Devices such as the Leaf Expander and MARPE have demonstrated effective palatal expansion, but challenges persist regarding uniformity and predictability of results. This is particularly relevant in Class III malocclusion patients, where case complexity may require ongoing adjustments, prolong treatment time, and increase patient discomfort (Jeon et al., 2022; Ludwig et al., 2022).

4. FINDINGS AND DISCUSSION

The choice of an appropriate approach is crucial in patients with deciduous or mixed dentition, aiming to take advantage of bone growth and minimize aesthetic and functional problems. According to Pires and colleagues (2017), early intervention is fundamental and should be carried out immediately after diagnosis. It is initially recommended to perform rapid maxillary expansion, followed by reverse mandibular traction, both combined with retention, to prevent relapse.

The main expanders used to promote rapid maxillary expansion are the Haas and the Hyrax. The Haas is a tooth-and-mucosa-supported device and includes acrylic components, while the Hyrax is solely tooth-supported, with orthodontic bands cemented in place, which facilitates oral hygiene. Both are effective in the palatal disjunction process. This procedure is indicated when the patient presents skeletal alterations, including Class III malocclusion, true and relative maxillary deficiency, nasal stenosis, and palatal clefts (Pires et al., 2017).

In some cases, the palatal expander is used in combination with other techniques. Some authors advocate the use of titanium miniplates as anchorage for applying orthopedic forces to treat Class III malocclusion. According to these authors, this approach allows facial growth without producing previously reported adverse effects; the technique involves applying reverse forces to mini-implants rather than to the anchor teeth of the maxilla (Suresh et al., 2021).

Akbulut, Yilmaz, and Yagci (2022) compared two different protocols of maxillary expansion combined with a face mask, aiming to protract a retruded maxilla. These protocols are the Alternative Rapid Maxillary Expansion and Constriction (Alt-RAMEC) procedure and conventional Rapid Maxillary Expansion (RME).

The Alt-RAMEC/FM group proved to be more effective in correcting Class III malocclusion than the RME/FM group, with greater improvements in SNA (3.11° vs 1.45°, $p = 0.008$), ANB (4.29° vs 2.95°, $p = 0.023$), convexity (8.91° vs 5.61°, $p = 0.016$), and overjet (5.86 mm vs 4.61 mm, $p < 0.001$). Both treatment modalities caused an increase in the vertical skeletal dimension (Akbulut et al., 2022).

It is further emphasized that this study considered the fact that treatment applied at different stages of skeletal maturation may induce varying amounts of skeletal response, potentially affecting outcomes. Therefore, the groups were divided to match individuals in terms of skeletal maturation and sex (Akbulut et al., 2022).

Miranda et al. (2021) conducted a randomized clinical trial to compare the dentoskeletal effects of the Maxillary Protraction Anchored on Miniscrews (MAMP) protocol using a Hybrid Hyrax (HH) versus a Conventional Hyrax (CH). Their findings suggest that MAMP therapy using the HH expander as anchorage achieved an overjet correction frequency of 94.4% and greater control of dental side effects compared to the CH protocol, indicating that the HH expander should be the clinical choice. Additionally, younger patients exhibited fewer orthodontic side effects even when using the CH expander.

The success rate for palatal miniscrews in the HH group was 97.36%, whereas the rates of instability or loss of mandibular miniscrews in the HH and CH groups were 15.78% and 17.85%, respectively. Moreover, negative overjet persisted after intervention in 5.6% of the HH group and 28.6% of the CH group (Miranda et al., 2021).

Papadopoulou et al. (2021) conducted a retrospective study to evaluate whether early-treated Class III cases using the established RME–FM protocol would differ in the post-pubertal phase from patients receiving late treatment with a modified Alt-RAMEC protocol combined with a lower lingual arch (LLA) anchored in miniscrews (Alt-RAMEC-LLA). Both groups achieved anterior and vertical movement of the maxilla, mandibular repositioning, and improved soft tissue convexity. However, in younger age ranges, greater changes were observed at the apical base and complete molar correction. These findings corroborate previous studies, as RME–FM is more effective when applied during early mixed dentition rather than later stages of dental development, particularly regarding maxillary advancement (Papadopoulou et al., 2022).

Rutili et al. (2024) evaluated the short- and long-term effects of early treatment of Class III malocclusion with RME/FM compared to a control group of untreated Class III individuals, highlighting the importance of long-term follow-up, as active mandibular growth continues well after the post-pubertal phase. In the short term, RME/FM significantly improved sagittal skeletal relationships due to maxillary protraction rather than mandibular retrusion. Long-term improvements in the Class III maxillomandibular relationship remained stable, primarily owing to favorable mandibular changes rather than continued maxillary protraction.

Willmann et al. (2018) compared the use of a Hybrid Hyrax combined with a face mask (FM) and with a Mentoplate (ME), a titanium plate inserted sub-apically to the lower incisors with hooks directed distally emerging through the mucosa. This eliminates the need for a face mask, which often has low patient compliance, and allows for earlier treatment initiation without waiting for canine eruption. Both protocols achieved comparable maxillary protraction, and the Mentoplate may serve as an alternative for patients unwilling to use a face mask.

Tarraf et al. (2023) also compared the Hybrid Hyrax maxillary expander with mandibular miniplates (HE-MP) and Class III elastics versus a conventional Rapid Maxillary Expander plus face mask (RME–FM). Maxillary advancement

Table 1. Comparative summary of key studies on the use of palatal expanders in Class III malocclusion patients

Study	Type of Expander / Protocol	Sample / Age	Main Findings / Results	Clinical Implications
De Souza; Rino Neto; De Paiva, (2019)	RME–FM vs Miniscrews (MI) + intraoral elastics	Children	Both improve facial concavity; RME–FM requires longer treatment, more dental/skeletal side-effects	MI offers less invasive, lower-cost alternative with faster treatment and fewer side-effects.
Miranda et al., (2021)	Hybrid Hyrax (HH) vs Conventional Hyrax (CH) – Maxillary protraction anchored on miniscrews (MAMP)	Not specified / Children	HH: 94.4% overjet correction; better control of dental side-effects. CH: more negative overjet post-treatment (28.6%). Miniscrew success: 97.36%	HH is preferred for overjet correction with fewer dental side-effects. Younger patients show fewer side-effects even with CH.
Papadopoulou et al., (2021)	RME–FM early treatment vs Alt-RAMEC-LLA late treatment	Post-pubertal / Children	Both groups: maxillary advancement, mandibular repositioning, improved soft tissue convexity. Early treatment: greater apical base changes and molar correction	Early RME–FM is more effective in promoting maxillary protraction in mixed dentition.
Rutili et al., (2024)	RME/FM vs untreated Class III	Children / Adolescents	Short-term: maxillary protraction dominates; Long-term: mandibular changes maintain improvement	Early treatment provides lasting skeletal benefits; long-term follow-up is essential.
Tarraf et al., (2023)	Hybrid Hyrax + Mandibular miniplates + Class III elastics (HE-MP) vs RME–FM	Children	HE-MP: 3x greater SNA increase; fewer dental side-effects than RME–FM	HE-MP may be more effective for maxillary advancement with reduced side-effects.
Willmann et al., (2018)	Hybrid Hyrax + Face Mask (FM) vs Hybrid Hyrax + Mentoplate (ME)	Children	Both achieved comparable maxillary protraction. Mentoplate avoids need for FM and allows earlier intervention	Mentoplate is a viable alternative for patients with poor face mask compliance.

Source: Elaborated by the author

was significantly greater in the HE-MP group, with over three times the increase in the SNA angle compared to the RME–FM group, alongside a reduction in dental side effects.

De Souza, Rino Neto, and De Paiva (2019) emphasize that rapid maxillary expansion is widely accepted as an essential step in Class III treatment because it destabilizes the maxillary sutures and facilitates maxillary protraction. However, they note that studies comparing maxillary protraction with and without RME have not demonstrated it to be mandatory.

Another alternative to the face mask is the use of titanium miniplates for skeletal anchorage of intermaxillary elastics, although this approach is more invasive, often requiring surgical intervention and occasionally general anesthesia. The authors highlight the advantages of miniscrews (MI) over miniplates, including reduced discomfort, lower cost, and greater ease of insertion. Accordingly, they compared RME–FM with the use of MI and intraoral elastics for immediate maxillary protraction.

Both procedures proved effective in improving facial concavity in Class III patients; however, RME–FM required longer treatment time and exhibited greater dental and skeletal side effects, such as mesialization of the upper incisors, posterior movement of the lower incisors, increased mandibular plane and lower face height with clockwise rotation, and overall changes in facial pattern (De Souza et al., 2019).

Overall, the use of palatal expanders in all analyzed studies proved effective for correcting maxillary constriction, improving facial profile and intermaxillary relationships, and facilitating correction of conditions such as dental crowding and crossbite, commonly observed in Angle's Class III patients. Furthermore, palatal expansion positively affects quality of life, as widening a constricted maxillary arch improves nasal airflow, benefiting breathing, speech, mastication, and facial aesthetics (Evangelista et al., 2023; Vaz et al., 2023).

5. CONCLUSION

This study emphasizes that early initiation of treatment with palatal expanders in Angle Class III patients is crucial to take full advantage of craniofacial growth potential during childhood and adolescence, when bone structures are more responsive to orthodontic interventions. Early orthodontic treatment can therefore reduce the severity of malocclusions and minimize the need for more invasive surgical procedures later in life. In conclusion, the use of palatal expanders in Class III patients provides substantial benefits in correcting malocclusions, particularly when combined with complementary orthodontic techniques. This approach not only enhances functional outcomes but also contributes to facial esthetic harmony and improves the patient's long-term quality of life.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author(s) declare that generative AI technology was used for translating the text into English and for orthographic and grammatical correction. The AI technology used was ChatGPT, based on the GPT-5 mini model.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Akbulut, S., Yilmaz, S., & Yagci, A. (2022). Comparison of the short-term effects of facemask therapy preceded by conventional rapid maxillary expansion or by an alternate rapid maxillary expansions and constrictions protocol. *Journal of Orofacial Orthopedics / Fortschritte der Kieferorthopädie, 84*(5), 278–286.

Alves, A. C. M., et al. (2020). Maxillary expander with differential opening vs Hyrax expander: A randomized clinical trial. *American Journal of Orthodontics and Dentofacial Orthopedics, 157*(1).

André, C. B., et al. (2024). Miniscrew-assisted rapid palatal expansion (MARPE): Factors influencing planning. *Dental Press Journal of Orthodontics, 29*(3).

Aniceto, M. F., et al. (2015). Importância da expansão rápida da maxila no tratamento do paciente respirador bucal. *Revista da Universidade Ibirapuera*(10), 34–41.

Antelo, O. M., et al. (2020). Long-term stability of a Class III malocclusion with severe anterior open bite and bilateral posterior crossbite in a hyperdivergent patient. *American Journal of Orthodontics and Dentofacial Orthopedics, 157*(3), 408–421.

Araújo, E. A., & Araújo, C. V. (2008). Abordagem clínica não-cirúrgica no tratamento da má oclusão de Classe III. *Revista Dental Press de Ortodontia e Ortopedia Facial, 13*(6), 128–157.

Azamian, Z., & Farinaz, S. (2016). Treatment options for Class III malocclusion in growing patients with emphasis on maxillary protraction. *Scientifica*.

Baccetti, T., et al. (2001). Treatment timing for rapid maxillary expansion. *The Angle Orthodontist, 71*(5), 343–350.

Benetti, M., et al. (2024). Does miniscrew-assisted rapid palatal expansion influence upper airway in adult patients? A scoping review. *Dentistry Journal, 12*(3).

Bistaffa, A. I., et al. (2023). Dental arch changes comparison between expander with differential opening, Hyrax-type and Haas-type expanders: A prospective clinical study. *Orthodontics & Craniofacial Research, 26*(3), 468–475.

Brunetto, D. P., et al. (2022). Mini-implant assisted rapid palatal expansion (MARPE) effects on adult obstructive sleep apnea (OSA) and quality of life: A multi-center prospective controlled trial. *Progress in Orthodontics, 23*(1).

Cannavale, R., et al. (2018). Rapid palatal expansion (RPE): Meta-analysis of long-term effects. *Orthodontics & Craniofacial Research, 21*(4), 225–235.

Carter, A., & Mohamed, A. (2023). Dento-skeletal effects of different rapid maxillary expanders for growing patients—Which is better? *Evidence-Based Dentistry, 24*, 104–105.

Caruso, S., et al. (2023). Effects of rapid maxillary expander and Delaire mask treatment on airway sagittal dimensions in pediatric patients affected by Class III malocclusion and obstructive sleep apnea syndrome. *Life (Basel, Switzerland), 13*(3).

Cenzato, N., Nobili, A., & Maspero, C. (2021). Prevalence of dental malocclusions in different geographical areas: Scoping review. *Dentistry Journal, 9*.

Chen, W., Zhang, K., & Liu, D. (2021). Palatal bone thickness at the implantation area of maxillary skeletal expander in adult patients with skeletal Class III malocclusion: A cone-beam computed tomography study. *BMC Oral Health, 21*(1), 144.

Costa, F. A., et al. (2024). Three-dimensional assessment of the maxilla after modified surgically assisted rapid expansion: A retrospective study. *Oral and Maxillofacial Surgery, 28*(3).

D'Apuzzo, F., et al. (2022). Dento-skeletal Class III treatment with mixed anchored palatal expander: A systematic review. *Applied Sciences, 12*(9).

De Clerck, H. J., & Proffit, W. R. (2015). Growth modification of the face: A current perspective with emphasis on Class III treatment. *American Journal of Orthodontics and Dentofacial Orthopedics, 148*(1).

De Oliveira, C. B., et al. (2021). Microimplant assisted rapid palatal expansion vs surgically assisted rapid palatal expansion for maxillary transverse discrepancy treatment. *American Journal of Orthodontics and Dentofacial Orthopedics, 159*(6).

De Oliveira, C. V., et al. (2024). Effects of rapid maxillary expansion on sleep disturbance scale for children: A longitudinal case-series study. *Orthodontics & Craniofacial Research, 27*(1), 27–32.

De Souza, R. A., Rino Neto, J., & De Paiva, J. B. (2019). Maxillary protraction with rapid maxillary expansion and facemask versus skeletal anchorage with mini-implants in Class III patients: A non-randomized clinical trial. *Progress in Orthodontics, 20*(1), 35.

Dehesa-Santos, A., Iber-Diaz, P., & Iglesias-Linares, A. (2021). Genetic factors contributing to skeletal Class III malocclusion: A systematic review and meta-analysis. *Clinical Oral Investigations*.

Dilio, R. C., Micheletti, K. R., Cuoghi, O. A., & Bertoz, A. P. M. (2014). Tratamento compensatório da má oclusão de Classe III: Revisão de literatura. *Archives of Health Investigation, 3*(3).

Feng, Z., et al. (2023). Evolution, current status, and future trends of maxillary skeletal expansion: A bibliometric analysis. *Clinical Oral Investigations, 28*.

Ferrillo, M., et al. (2024). The effect of vertical skeletal proportions, skeletal maturation, and age on midpalatal suture maturation: A CBCT-based study. *Progress in Orthodontics, 25*(1).

Foersch, M., et al. (2015). Effectiveness of maxillary protraction using facemask with or without maxillary expansion: A systematic review and meta-analysis. *Clinical Oral Investigations, 19*(6).

Grassia, V., et al. (2014). Efeitos dentoesqueléticos da expansão palatina

mista avaliados por análise cefalométrica póstero-anterior. *European Journal of Paediatric Dentistry, 15*(1), 59–62.

Guerra Filho, A. J., & Buchala, I. J. Z. (2018). Systematic review of major considerations of rapid maxillary expansion. *Journal of Dental Health, Oral Disorders & Therapy, 9*(4), 284–288.

Guglielmi, F., et al. (2024). Prevalence of malocclusions and parafunctional habits in pediatric patients with developmental dyslexia. *Korean Journal of Orthodontics, 54*(4), 229–238.

Hsu, L. F., et al. (2023). Digital workflow for mini-implant-assisted rapid palatal expander fabrication – A case report. *BMC Oral Health, 23*(1).

Hu, S., et al. (2024). Mapping the evolving trend of research on Class III malocclusion: A bibliometric analysis. *Clinical Oral Investigations, 28*(8), 420.

Huang, N., et al. (2021). An upstream open reading frame in phosphatase and tensin homolog encodes a circuit breaker of lactate metabolism. *Cell Metabolism, 33*(1), 128–144.

Inchingolo, A. M., et al. (2023). Comparison of different types of palatal expanders: Scoping review. *Children (Basel, Switzerland), 10*(7).

Iodice, G., et al. (2013). Evaluations of sagittal and vertical changes induced by surgically assisted rapid palatal expansion. *The Journal of Craniofacial Surgery, 24*(4).

Jeon, J. Y., et al. (2022). The success and effectiveness of miniscrew-assisted rapid palatal expansion are age- and sex-dependent. *Clinical Oral Investigations, 26*(3), 2993–3003.

Kapetanović, A., et al. (2022). What is the oral health-related quality of life following miniscrew-assisted rapid palatal expansion (MARPE)? A prospective clinical cohort study. *BMC Oral Health, 22*(1).

Kilinç, A. S., et al. (2008). Effects on the sagittal pharyngeal dimensions of protraction and rapid palatal expansion in Class III malocclusion subjects. *European Journal of Orthodontics, 30*(1).

Lathrop-Marshall, H., et al. (2022). Orthognathic speech pathology: Impacts of Class III malocclusion on speech. *European Journal of Orthodontics, 44*(3), 340–351.

Lin, J. H., et al. (2023). Sagittal and vertical changes of the maxilla after surgically assisted rapid palatal expansion: A systematic review and meta-analysis. *Journal of Clinical Medicine, 12*(10).

Lione, R., Franchi, L., Cozza, P., & Pavoni, C. (2017). Bonded versus banded rapid palatal expander followed by facial mask therapy: Analysis on digital dental casts. *European Journal of Orthodontics, 38*(2), 217–222.

Ludwig, B., Glasl, B., Zorkun, B., & Lisson, J. A. (2022). Boneborne rapid palatal expansion—the virtual way. *Journal of Clinical Orthodontics: JCO, 55*(4), 239–243.

Maino, B. G., Maino, G. B., Paoletto, E., Lombardo, L., & Siciliani, G. (2020). Tandem skeletal expander and MAPA protocol for palatal expansion in adults. *Journal of Clinical Orthodontics: JCO, 54*(11), 690–704.

Maino, G. B., Maino, B. G., Lombardo, L., & D'Antò, V. (2023). Class III treatment with mini-implants anchorage in young adult patients: Short and long-term results. *Dental Press Journal of Orthodontics, 28*(2).

Masucci, C., Franchi, L., Giuntini, V., Defraia, E., & Cozza, P. (2022). Post-pubertal effects of the Alt-RAMEC/FM and RME/FM protocols for the early treatment of Class III malocclusion: A retrospective controlled study. *European Journal of Orthodontics, 44*(3), 303–310.

Meng, W. Y., Zhang, Z., Liu, Y., Wu, R., & Jiang, R. P. (2022). The comparison of biomechanical effects of the conventional and bone-borne palatal expanders on late adolescence with unilateral cleft palate: A 3-dimensional finite element analysis. *BMC Oral Health, 22*(1).

Miranda, F., Janson, G., Valarelli, F. P., & Garib, D. G. (2021). Dentoskeletal comparison of miniscrew-anchored maxillary protraction with hybrid and conventional hyrax expanders: A randomized clinical trial. *American Journal of Orthodontics and Dentofacial Orthopedics.*

Mosleh, M. I., Kluemper, G. T., Hickman, J. H., & Jayaratne, Y. S. (2015). Comparison of transverse changes during maxillary expansion with 4-point bone-borne and tooth-borne maxillary expanders. *American Journal of Orthodontics and Dentofacial Orthopedics, 148*(4).

Moussa, R., O'Reilly, M. T., & Close, J. M. (1995). Long-term stability of rapid palatal expander treatment and edgewise mechanotherapy. *American Journal of*

Orthodontics and Dentofacial Orthopedics, 108(5), 478–488.

Nauwelaers, N., Claes, P., De Meyer, G., & Willems, G. (2021). Exploring palatal and dental shape variation with 3D shape analysis and geometric deep learning. *Orthodontics & Craniofacial Research, 24*, 134–143.

Ngan, P., & Moon, W. (2015). Evolution of Class III treatment in orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics, 148*(1), 22–36.

Papadopoulou, A. K., Koletsi, D., & Papageorgiou, S. N. (2022). A retrospective long-term comparison of early RME-facemask versus late Hybrid-Hyrax, alt-RAMEC and miniscrew-supported intraoral elastics in growing Class III patients. *International Orthodontics, 20*(1).

Pires, D. C. C. (2017). Tratamento de classe III na dentição mista–um relato de caso. *Journal of Biodentistry and Biomaterials, 8*(2), 6–16.

Reyes, A., De La Rosa, C., & Lagravere, M. (2014). Diagnosis and treatment of pseudo-Class III malocclusion. *Case Reports in Dentistry, 2014*, 1–6.

Rinaldi, M. R. L., Arreghini, A., Lombardo, L., & Siciliani, G. (2018). Cone-beam computed tomography evaluation of boneplate and root length after maxillary expansion using tooth-bone and tooth-tissue-borne bande expanders. *American Journal of Orthodontics and Dentofacial Orthopedics, 154*(4), 504–516.

Rozzi, M., Pavoni, C., Lione, R., Cozza, P., & Franchi, L. (2023). Dentoskeletal effects of rapid maxillary expander therapy in early mixed dentition patients with different vertical growing patterns without posterior crossbite: A retrospective study. *American Journal of Orthodontics and Dentofacial Orthopedics, 163*(3), 319–327.

Rutili, V., Franchi, L., Lione, R., & Cozza, P. (2021). Dento-skeletal effects produced by rapid versus slow maxillary expansion using fixed jackscrew expanders: A systematic review and meta-analysis. *European Journal of Orthodontics, 43*(3).

Rutili, V., Pavoni, C., Franchi, L., Lione, R., & Cozza, P. (2024). Long-term effects produced by early treatment of Class III malocclusion with rapid maxillary expansion and facemask followed by fixed appliances: A multicentre retro-prospective controlled study. *Orthodontics & Craniofacial Research, 27*, 429–438.

Ryu, H. K., Park, J. H., & Lee, S. H. (2015). Short-term and long-term treatment outcomes with Class III activator. *Korean Journal of Orthodontics, 45*(5), 226–235.

Shih, S. N., Chiang, Y. C., & Lo, L. J. (2022). Management of Class III malocclusion and maxillary transverse deficiency with microimplant-assisted rapid palatal expansion (MARPE): A case report. *Medicina (Kaunas, Lithuania), 58*(8).

Sugawara, Y., Watanabe, H., Mitani, H., & Yamamoto, T. (2016). Orthodontic treatment of a patient with unilateral orofacial muscle dysfunction: The efficacy of myofunctional therapy on the treatment outcome. *American Journal of Orthodontics and Dentofacial Orthopedics, 150*(1), e1–e12.

Suresh, S., Sundareswaran, S., & Sathyanadhan, S. (2021). Effect of microimplant assisted rapid palatal expansion on bone-anchored maxillary protraction: A finite element analysis. *American Journal of Orthodontics and Dentofacial Orthopedics, 160*(4), 523–532.

Tarraf, N. E., Macari, A. T., Hanna, I., & Younes, G. (2023). A retrospective comparison of two protocols for correction of skeletal Class III malocclusion in prepubertal children: Hybrid hyrax expander with mandibular miniplates and rapid maxillary expansion with face mask. *Progress in Orthodontics, 24*(1), 1–11.

Ugolini, A., Doldo, T., Silvestrini-Biavati, A., & Caprioglio, A. (2024). Spontaneous mandibular dentoalveolar changes after rapid maxillary expansion (RME), slow maxillary expansion (SME), and leaf expander—A systematic review. *Children (Basel, Switzerland), 11*(4), 501.

Vaz, N. S. O., Sousa, T. B., & Cunha, D. P. (2023). Uso de disjuntor palatino e tração reversa para tratamento de Classe III associada a atresia maxilar: Uma revisão integrativa de literatura. *ID Online Revista de Psicologia, 17*(65), 445–458.

Vidalón, J. A., Kinzinger, G., & Ludwig, B. (2021). Periodontal effects of maxillary expansion in adults using non-surgical expanders with skeletal anchorage vs. surgically assisted maxillary expansion: A systematic review. *Head & Face Medicine, 17*(1), 1–9.

Wang, C., Qureshi, M. A., Irfan, A. B., & Hussain, M. (2024). CAD/CAM design and 3D printing of a personalised rapid palatal

expander for maxillary transverse deficiency. *JPMA. The Journal of the Pakistan Medical Association, 74*(1), 153–157.

Willmann, J. H., Lisson, J. A., & Bauss, O. (2018). Early Class III treatment with Hybrid-Hyrax-Facemask in comparison to Hybrid-Hyrax-Mentoplate: Skeletal and dental outcomes. *Progress in Orthodontics, 19*(1), 1–9.

Wilmes, B., Nienkemper, M., Ludwig, B., & Drescher, D. (2022). Procedure using CAD/CAM-manufactured insertion guides for purely mini-implant-borne rapid maxillary expanders. *Journal of Orofacial Orthopedics, 83*(4), 253–260.

Winsauer, H., Vlachojannis, C., Bacher, M., & Ludwig, B. (2021). Success and complication rate of miniscrew assisted non-surgical palatal expansion in adults: A consecutive study using a novel force-controlled polycyclic activation protocol. *Head & Face Medicine, 17*(1), 1–10.

Zeng, W., Zhao, Y., & Yu, M. (2023). Long-term efficacy and stability of miniscrew-assisted rapid palatal expansion in mid to late adolescents and adults: A systematic review and meta-analysis. *BMC Oral Health, 23*(1), 1–15.

Zere, E., Chaudhry, K., & Little, R. M. (2018). Developing Class III malocclusions: Challenges and solutions. *Clinical, Cosmetic and Investigational Dentistry, 10*, 99–116.

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