



Maxillary Transverse Expansion: What Are the Limits? A Case Report and Literature Review

Amal El Aouame , Salma Sair , Farid El Quars

Department of Dentofacial Orthopedics, Faculty of Dentistry, University Hassan II, Casablanca, Morocco

Email: amal.elaouame@gmail.com, salmasair@gmail.com, faridelquars@gmail.com

How to cite this paper: El Aouame, A., Sair, S. and El Quars, F. (2024) Maxillary Transverse Expansion: What Are the Limits? A Case Report and Literature Review. *Open Access Library Journal*, **11**: e11283. <https://doi.org/10.4236/oalib.1111283>

Received: February 3, 2024

Accepted: March 22, 2024

Published: March 25, 2024

Copyright © 2024 by author(s) and Open Access Library Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Transverse maxillary deficiency is a common discrepancy in both children and adults, which can lead to serious health problems, such as prejudicial malocclusions, breathing problems and a higher risk of developing obstructive sleep apnea. By considering the patient's age and situating him or her on the growth curve, several treatment options can be envisaged, a rapid maxillary expansion (RPE), mini-implant-assisted rapid palatal expansion (MARPE), Surgically assisted rapid maxillary expansion (SARPE), Slow maxillary expansion and aligners. The aim of this article is to describe two methods of maxillary expansion in adults, and to discuss the different methods of maxillary expansion through a review of the literature.

Subject Areas

Dentistry

Keywords

Maxillary Transverse Deficiency, Maxillary Expansion, Palatal Expansion Technique

1. Introduction

Transverse deficiency, or maxillary hypoplasia, is one of the most detrimental problems to facial growth and to the integrity of the dentoalveolar structures.

In a Moroccan sample, transverse maxillary deficiency represents 67.5% of patients, of which 64.9% had allergies and 58.3% had mouth breathing, according to Bourzgui and coll [1].

Therefore, it should be corrected as soon as diagnosed, to reestablish a normal transverse skeletal relationship between basal bones, fundamental to achieving a satisfactory and stable occlusion.

It is usually characterized by posterior crossbite that may be unilateral or bilateral, total or partial, and may even not be present in cases with simultaneous mandibular arch constriction [2].

The etiology is complicated and is related to genetic and environmental factors, including congenital abnormalities, cheek sucking habit, mouth breathing, low tongue position, etc [3].

However, there are few definitions of an adequate transverse relationship in the orthodontic literature, which may contribute to a lack of knowledge regarding the importance of transverse control.

Evident transverse discrepancies that cause disruption to the occlusal relationship and make it more difficult for orthodontic correction to restore normal occlusion include facial asymmetry, midline deviation, posterior crossbite, and scissors bite.

As such, the transverse relationship diagnosis holds equal significance to the anterior-posterior discrepancy diagnosis.

In addition, maxillary transverse deficiency is related to the occurrence of some sagittal malocclusions and may affect the dental and maxillofacial growth in the opposite direction because the sagittal and vertical growth continues after the completion of transverse growth.

Nasal breathing facilitates the proper growth and development of the craniofacial complex, which interacts with other functions like mastication and swallowing, according to Moss's functional matrix theory.

As a result, the constant stimulation of the nasal passage during breathing causes the maxilla to grow laterally and the palatal vault to descend.

On the other hand, nasal obstruction that causes mouth breathing causes variations in the positions of the tongue and lips as well as open mouth posture, mandibular rotation both downward and backward, constricted and V-shaped maxillary dental arch, and a higher incidence of posterior crossbite [3].

The objective of this study was to analyze and discuss different treatment approaches for the correction of transverse maxillary deficiencies in patients with advanced skeletal maturation, and limits between orthopedics, orthodontics and orthognatic surgery, through a literature review and two clinical cases carried out within the service of dento-facial othopedics in Casablanca dental consultation and care center (CDCC).

2. Research Strategy

We performed an electronic bibliographic search using (Pubmed, google scholar, science direct).

The MeSH terms used were "orthodontics", "palatal expansion technique".

The period considered was from 2014 to 2024.

The selection of articles was based on the different palatal expansion techniques by highlighting the advantages and limits of each technique.

We included case reports, clinical studies, meta-analysis, randomized con-

trolled trials, reviews and systematic reviews.

We excluded articles judged to be expert reports, letters, commentaries, editorials, articles not meeting the objectives of our work based on abstract reading and critical reading of the full text, articles in languages other than French and English. We also excluded the animal studies.

We found 453 articles. After reading the titles, abstracts and full texts, we have selected 20 articles for our study.

We will also present two clinical cases carried out within the service of dento-facial orthopedics, CCTD, UHC CASABLANCA to illustrate two methods of maxillary expansion among adults

3. Discussion

In order to restore normal maxillary growth and the proper transverse relationship between the maxilla and mandible, orthodontic treatment should prioritize the correction of transverse deficiencies as soon as they are identified. Dentoalveolar expansion, midpalatal suture opening, and skeletal level corrections are all possible. A number of factors, including age, sex, the degree of maxillary hypoplasia, and the maturity of the midpalatal suture, influence the choice of treatment alternative [2].

Bibliographical research was carried out in this direction, to explore the various treatments of maxillary transverse deficiency.

3.1. Rapid Maxillary Expansion

Expanding the maxilla in young patients with transversal maxillary constriction, deep palatal vault, and accompanying cross-bite and crowding is the primary goal of Rapid Maxillary expansion, which has been used as a routine clinical procedure in orthodontics.

The RPE-hyrax device transmits bilateral forces from the expansion screw via the first upper molars and premolars to the palatal bone, indirectly leading to separation of the midpalatal suture [4].

It consists on the opening of the midpalatal suture. It should be done primarily in growing patients, prior to suture ossification.

RME is an unpredictable treatment for patients nearing the end of adolescence or the beginning of adulthood because it has more skeletal effects when administered before skeletal maturation peak than when it is administered after growth peak [2].

In cases with mild to moderate maxillary hypoplasia in adult patients, these results may be achieved with the same appliances used in RME, such as Haas or Hyrax expanders, but activated at a lower frequency.

3.1.1. Treatment Time

The application of the Cervical Vertebral Maturation method for the assessment of differences in the outcome of RME therapy in relation to treatment timing revealed that RME therapy with the Haas expander induces clinically significant

and reproducible transverse changes at the dentoalveolar level in patients treated before or after the peak in skeletal growth velocity. Patients treated before the pubertal peak exhibit significant and more effective long-term changes at the skeletal level in both maxillary and circummaxillary structures. When RME treatment is performed after the pubertal growth spurt, maxillary adaptations to expansion therapy shift from the skeletal level to the dentoalveolar level [5].

3.1.2. Functions Effects

There is a moderate level of evidence that RME therapy during the growth period causes increases in nasal, cavity width and in the posterior nasal airway, associated with reduced nasal airway resistance NAR and increased total nasal flow.

All changes in airway dimensions and functions might improve the conditions for nasal breathing but cannot be indicated only for this purpose [6].

3.1.3. Limits

Limited skeletal movement, dentoalveolar tipping, root resorption, harmful periodontal effects like dehiscence, and a lack of long-term stability are common undesirable outcomes of conventional RME [7].

3.2. MARPE

Miniscrew-Assisted Rapid Palatal Expansion (MARPE) is a non-surgical treatment for transverse maxillary deficiency [4].

More than ten years ago, the idea of mini-screw-assisted rapid palatal expansion/midfacial skeletal expansion (MARPE/MSE) was introduced [8].

The midpalatal suture has a higher degree of interdigitation in late adolescents and adults, so more force is needed to open it. Unwanted dental side effects could result from treatment with a traditional expander [4].

For the purpose of transferring the expansion force to the underlying skeletal structures and maintaining the positions of the two expanded maxillary halves during the bony bridging of the two segments, mini-screws are used in place of teeth in the MARPE designs.

The MARPE method is technique-dependent, and the success rate and pattern of expansion of these devices can be greatly influenced by the placement of the mini-screws.

A thorough examination of the surrounding anatomical structures and maxillary bone thickness should be performed prior to mini-screw placement.

The two competing concepts of resistance-driven system vs. bone-driven system must be taken into consideration before choosing which MARPE to use. The location of the min-implant is preferred by the bone-driven system to be near a substantial bone mass for stability, typically in the anterior palate [8].

The midpalatal suture has a higher degree of interdigitation in late adolescents and adults, so more force is needed to open it. Unwanted dental side effects could result from treatment with a traditional RPE.

According to Haichao Jia and coll, MARPE enabled more predictable and greater skeletal expansion, as well as less buccal tipping and alveolar height loss on anchorage teeth. Thus, MARPE is a better alternative for patients with skeletal maxillary deficiency during the post-pubertal growth spurt stage [9].

In addition, adolescents with incomplete ossification of the midpalatal suture, observing a significant maxillary expansion, can be effectively treated with MARPE with tooth bone-borne expanders [10].

According to Kapetanović A and coll [4]., Dental side effects were the subject of four studies. An overview of the dental tipping of the upper first molars is provided. A statistically significant amount of dental tipping was reported in all the studies. The mean amount of dental tipping varied greatly between the studies, ranging from -5.5° to 8.01° , and the precise measurement techniques were different as well.

3.3. SARPE

Conventional RME has limited efficacy in adult patients who present following growth cessation and complete ossification of the mid palatal suture. Surgically assisted rapid palatal expansion (SARPE) is required due to the following factors: decreased bone elasticity, decreased numbers of fibroblasts and collagen fiber bundles, and increased resistance to expansion as a result of inter-digitation of the mid palatal and lateral maxillary sutures [11].

Adult patients with skeletal deficiencies frequently undergo segmental Le Fort I osteotomy (bipartition) or surgically assisted rapid palatal expansion (SARPE) to increase the transverse diameter of the maxilla.

When a transverse defect of the maxillary bone is an isolated skeletal anomaly, or when there is a severe deficit, the SARPE technique is typically employed.

Le Fort I bipartition or the segmented Le Fort I maxillary osteotomy, which releases the maxilla from adjacent bones and defines segments to correct the transverse relationship during surgery (segmental maxillary expansion, SME).

On the other hand, is advised for more minor defects (up to 6, 7 mm) or when the transverse deficit is just one of several maxillary skeletal deficits, such as sagittal and vertical defects, that would still necessitate surgical intervention [5].

These protocols aim to separate the maxilla from its main cranial supports, reduce resistance to opening the midpalatal suture, and permanently increase maxillary width with minimal tooth inclination.

It is a therapeutic approach to remedy the maxillary transverse deficit. Its main role is to achieve skeletal expansion while minimizing the dento-alveolar effect, through the palatal-medial and lateral separation of the maxillary sutures. In the majority of cases, this surgical technique can be applied to patients with maxillary hypoplasia and endognathia, whether or not associated with a retro-maxilla.

The Hyrax expander (a tooth borne expander supported by premolars and molars) is activated at a daily rate of 0.5 mm, a quarter turn in the morning and

a quarter turn in the evening, until the lateral sectors were in occlusion, as recommended by Ilizarov for good bone formation [12].

According to Carvalho PHA and coll [13], no research comparing the various expansion screw activation patterns has been done that used a prospective design, randomization, or sufficient measurement methods. Several studies suggested that the orthodontist's instructions were followed when activating the teeth.

Limits :

Bone defects, gingival recession with loss of interdental papillae, pulp vitality loss, mobility or even loss of the maxillary central incisor, postoperative infection, flap dehiscence, and external root resorption can all be caused by an asymmetrical rupture of the palatal suture. Activations in periodontal disease cases ought to be stopped until the tissues recover [14].

3.4. Slow Maxillary Expansion

In cases with mild to moderate maxillary hypoplasia (less than 5 mm, clinically measured in the region of the molars), among adults, slow maxillary expansion may be indicated.

Slow maxillary expansion (SME) applies low-force systems continuously for an extended duration, in contrast to RME.

Different appliances (such as the Quad helix, W arch, expanders with stainless steel, nickel-titanium springs, or nickel-titanium wires) or the same jackscrew expander with a different central screw activation technique can be used to generate SME [15].

In these cases, transverse maxillary remodeling may be achieved by the expansion of the alveolar processes and buccal tipping of crowns of the posterior teeth. These results may be achieved with the same appliances used in RME, such as Haas or Hyrax expanders, but activated at a lower frequency, or after the expansion of the maxillary arch and constriction of the mandibular arch by means of a fixed appliance.

Traditionally, with straight-wire appliances, when thick round or rectangular stainless steel archwires are used, changes in arch form mostly happen in the last stages of comprehensive treatment.

In the clinical management of fixed appliances with preadjusted brackets, new perspectives have been brought about by the development of low-friction techniques.

For example, during the early stages of therapy with superelastic nickel-titanium archwires, self-ligating appliances and other low-friction systems have been reported to induce arch development and dentoalveolar expansion of the maxillary arch [16].

According to Eman Alsayegh and coll, the Damon philosophy indicates that light forces do not overpower the musculature and periodontium, but rather the arch form aligns by posterior expansion due to the lesser resistance of the mus-

culature [17].

3.5. Clear Aligners

In recent years, patients concerned with esthetics and comfort have opted for clear aligners, which have been helpful in their improving self-esteem and well-being [18].

According to Figueiredo and coll [18], the average rating for the effectiveness of maxillary arch transverse expansion is 70%; this rating is independent of the kind of tooth taken into consideration. With an average of 55% at the intermolar level and 46% at the canine level, effectiveness is lower at the lingual level.

There is more tipping movement than body movement, as evidenced by statistically significant differences between the efficacy measured at the cuspal level and the most apical point of the palatal surface of the tooth. They have obtained a tipping movement, while the ClinCheck programs a body movement.

Dentoalveolar expansion can correct mild maxillary transverse deficiencies.

Morales-Burruezo and coll [19]. suggested that Aligners are an effective tool for producing arch expansion, being more effective in premolar area and less effective in canine and second molar area. Predictability was reasonable for expansion movement. Overcorrection should be considered at the virtual planning stage in order to obtain the expected outcomes.

The clear aligners are effective for simultaneous intra-arch expansion in both jaws [20].

Bouchant and coll concluded that Maxillary transverse expansion can be achieved with Invisalign[®] treatment. Nonetheless, the majority of this expansion is dentoalveolar, with the posterior teeth's facial crown tipping. The predictability of movement is low because Clincheck[®] software tends to overestimate the expansion movement when compared to the clinical outcome [21].

4. Illustration by Clinical Cases

4.1. First Clinical Case: Diagnosis and Etiology

A 15-year-old, young patient, with a functional aesthetic reason for consultation.

The interrogation revealed that the patient is in apparent good general health.

She had already orthodontic treatment with extraction of the 34.

The pretreatment facial photographs showed a long adenoid face, characteristic of mouth breathing.

Profile examination revealed a concave profile, a hypoplastic middle section, an inverted labial ratio and a predominant lower section of the face. The smile was unsightly, with a mandibular projection associated with an anterior crossbite.

The endobuccal examination reveals good hygiene with:

- Maxillary endognathy with an anterior and lateral crossbite (**Figures 1(a)-(c)**).
- V-shaped maxilla with retention of 13 due to lack of space and ectopia of the 23 (**Figure 1(d)**).
- Parabolic mandible with slight crowding and absence of 34 (**Figure 1(e)**).

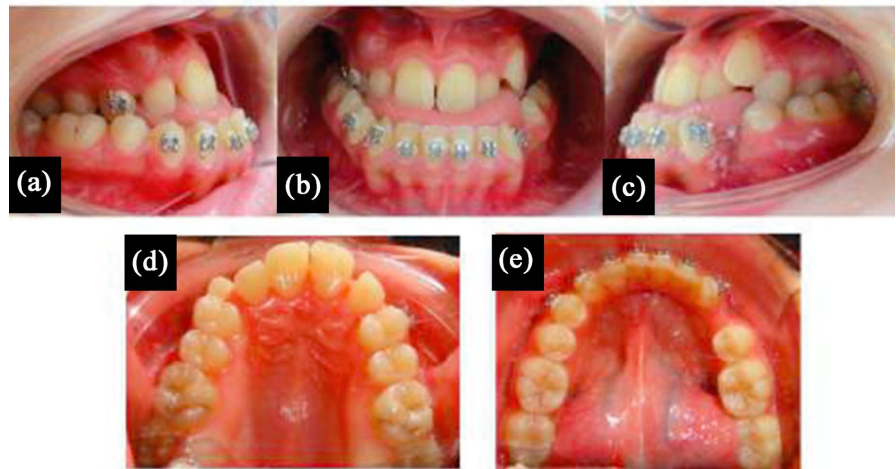


Figure 1. Intraoral photographs before treatment (a) Right lateral, (b) frontal, (c) left lateral, (d) maxillary occlusal, (e) mandibular occlusal.

- A class III angle right and left molar and left canine, with undetermined class canine right

- Transverse dento-maxillary disharmony (DDM) measured at 10 mm.

This was a hyperdivergent skeletal class III associated with severe maxillary endognathia (10 mm transverse deficit).

She presented an Angle class III with upper protrusion and lower normotrusion associated with DDM due to relative macrodontia.

The objectives were to re-establish a functional anterior and lateral dental articulation, and to re-establish class I canine and molar relationships, while ensuring long-term stability of the corrections.

In order to respond to the patient's reason for consultation and objectives, we opted for a two-stage ortho-surgical treatment plan: A surgically assisted disjunction, followed by an orthodontic phase in preparation for the second surgery to correct the sagittal and vertical anomaly, with wisdom teeth extractions, while maintaining the space of the extracted 34 space for prosthetic rehabilitation.

Initially, a surgically-assisted disjunction was performed. Regular daily activations of 0.5 mm were indicated, a quarter turn in the morning and a quarter turn in the evening, until the lateral sectors were occluded (**Figures 2(a)-(c)**).

During this phase, a medial diastema appeared four days after surgery (**Figure 2(d)**).

A second orthodontic phase consisted in levelling the maxillary arch, placing the retained 13 and ectopic 23 and coordinating the maxillary and mandibular arches in preparation for sagittal and vertical surgery.

First surgery: Surgically-assisted rapid maxillary expansion, appearance of the diastema at the end of the 4th day of activation (**Figure 2(d)**), mandibular alignment and opening the space of the 34 (**Figure 2(e)**).

We noted a good transverse expansion of the maxilla after SARPE (**Figure 3(a)**, **Figure 3(b)**), a stable occlusion, a correct overjet and overbite, with right and left Class I canine and molar (**Figure 4**).

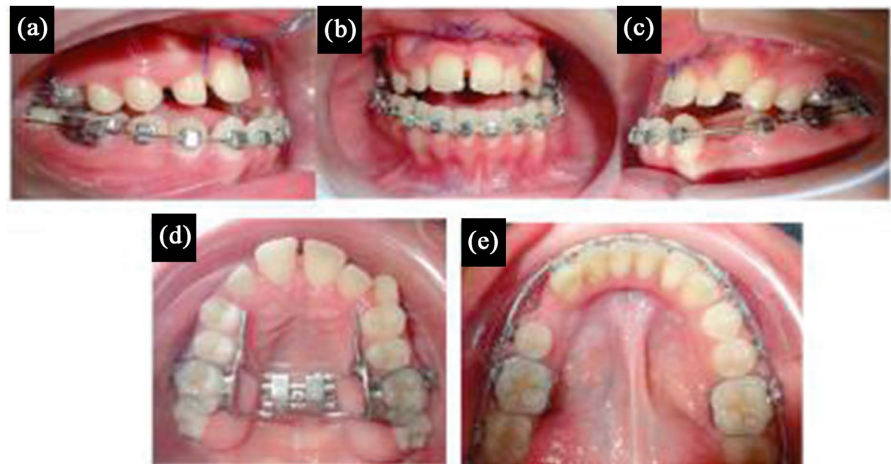


Figure 2. Endobuccal view of the first orthodontic phase, Placement of a tooth-borne Hyrax in the maxilla.

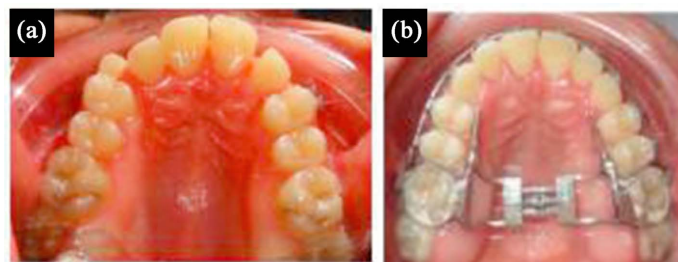


Figure 3. Intraoral photographs before (a) and after (b) maxillary expansion.



Figure 4. Intraoral photographs after the second phase of orthognathic surgery and a refinement of occlusion.

4.2. Second Clinical Case: Diagnosis and Etiology

An adult patient, 36 years old with an aesthetic reason for consultation. The interrogation revealed that the patient is in apparent good general health. She had already orthodontic treatment with extraction of the 14, 24, 34, 44. The endobuccal examination reveals a good hygiene with:

- She presented a wide oral corridor.

- Maxillary endognathia with no transverse deficiency between the maxillary and mandibule arches (**Figure 5(b)**).
- V shaped maxilla (**Figure 5(d)**) with an amalgame obturation on the 26 and a crown on the 16, we noted the missing 14, 24.
- The mandibule presents a composite obturation on the 36 and 46, the missing 34 and 44 (**Figure 5(c)**).
- A class I canin and molar right and left (**Figure 5(a)**, **Figure 5(c)**).

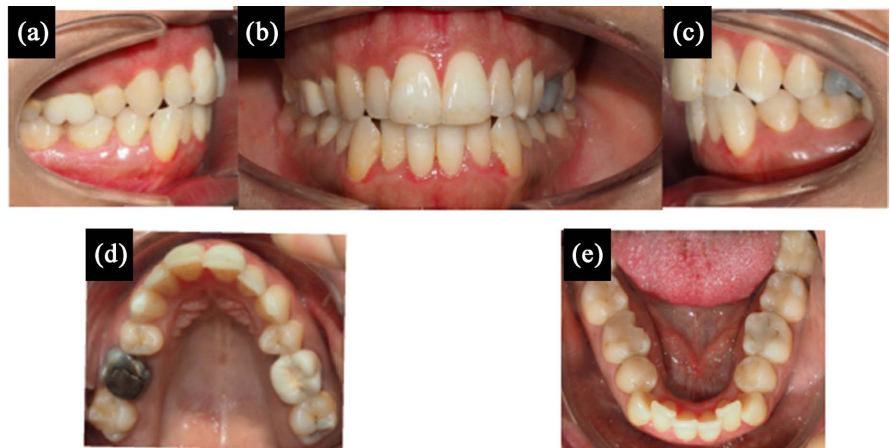


Figure 5. Intraoral photographs before treatment.

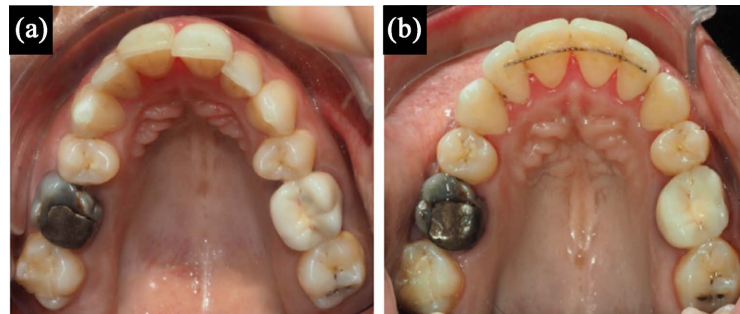


Figure 6. Maxillary before and after dento-alveolar maxillary expansion.



Figure 7. Intraoral photographs after treatment.

In order to respond to the patient's reason for consultation and objectives, and as the patient had already undergone orthodontic treatment with extraction of the first four premolars and did not require invasive treatment, we opted for a slow maxillary expansion using a succession of arch wires (Cooper-Niti and Stainless steel) and a passive self-ligating bracket.

We noted a transverse expansion and reshaping of the maxilla (**Figure 6**), the patient has regained a large smile and a clear improvement in buccal corridors (**Figure 7**).

5. Conclusions

According to the literature and the clinical cases, it is clear that there are several treatments available for management of maxillary transverse deficits.

The key to success in these cases lies in the correct diagnosis of the anomaly, its skeletal or dentoalveolar origin, and the patient's age.

In both clinical cases, patients showed a clear improvement in their quality of life, a functional and an esthetic smile and occlusion.

The limits of our study are that we included just two clinical case to show up the different techniques of maxillary expansion, so we cannot make a conclusion or generalize the findings of this study.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Les anomalies du sens transversal (2023) Dossiers du mois. <https://www.lecourrierdudentiste.com/dossiers-du-mois/les-anomalies-du-sens-transversal.html>
- [2] Andrucioi, M.C.D. and Matsumoto, M.A.N. (2020) Transverse Maxillary Deficiency: Treatment Alternatives in Face of Early Skeletal Maturation. *Dental Press Journal of Orthodontics*, **25**, 70-79. <https://doi.org/10.1590/2177-6709.25.1.070-079.bbo>
- [3] Kiliç, N. and Oktay, H. (2008) Effects of Rapid Maxillary Expansion on Nasal Breathing and Some Naso-Respiratory and Breathing Problems in Growing Children: A Literature Review. *International Journal of Pediatric Otorhinolaryngology*, **72**, 1595-1601. <https://doi.org/10.1016/j.ijporl.2008.07.014>
- [4] Kapetanović, A., Theodorou, C.I., Bergé, S.J., Schols, J.G.J.H. and Xi, T. (2021) Efficacy of Miniscrew-Assisted Rapid Palatal Expansion (MARPE) in Late Adolescents and Adults: A Systematic Review and Meta-Analysis. *European Journal of Orthodontics*, **43**, 313-323. <https://doi.org/10.1093/ejo/cjab005>
- [5] Rachmiel, A., Turgeman, S., Shilo, D., Emodi, O. and Aizenbud, D. (2020) Surgically Assisted Rapid Palatal Expansion to Correct Maxillary Transverse Deficiency. *Annals of Maxillofacial Surgery*, **10**, 136-141. https://doi.org/10.4103/ams.ams_163_19
- [6] Baratieri, C., Alves, M., De Souza, M.M.G., De Souza Araújo, M.T. and Maia, L.C. (2011) Does Rapid Maxillary Expansion Have Long-Term Effects on Airway Dimensions and Breathing? *American Journal of Orthodontics and Dentofacial Orthopedics*, **140**, 146-156. <https://doi.org/10.1016/j.ajodo.2011.02.019>
- [7] Lin, L., Ahn, H.W., Kim, S.J., Moon, S.C., Kim, S.H. and Nelson, G. (2015)

- Tooth-Borne vs Bone-Borne Rapid Maxillary Expanders in Late Adolescence. *The Angle Orthodontist*, **85**, 253-262. <https://doi.org/10.2319/030514-156.1>
- [8] Hsu, L.F., Moon, W., Chen, S.C. and Chang, K.W.C. (2023) Digital Workflow for Mini-Implant-Assisted Rapid Palatal Expander Fabrication—A Case Report. *BMC Oral Health*, **23**, Article No. 887. <https://doi.org/10.1186/s12903-023-03589-5>
- [9] Jia, H., Zhuang, L., Zhang, N., Bian, Y. and Li, S. (2021) Comparison of Skeletal Maxillary Transverse Deficiency Treated by Microimplant-Assisted Rapid Palatal Expansion and Tooth-Borne Expansion during the Post-Pubertal Growth Spurt Stage. *The Angle Orthodontist*, **91**, 36-45. <https://doi.org/10.2319/041920-332.1>
- [10] Solano Mendoza, P., Aceytuno Poch, P., Solano Reina, E. and Solano Mendoza, B. (2022) Skeletal, Dentoalveolar and Dental Changes after “Mini-Screw Assisted Rapid Palatal Expansion” Evaluated with Cone Beam Computed Tomography. *Journal of Clinical Medicine*, **11**, Article 4652. <https://doi.org/10.3390/jcm11164652>
- [11] Dahiya, S., Chitra, P., Rao, S.S. and Bindra, S. (2023) Modified SARME (Surgically Assisted Rapid Maxillary Expansion) in Conjunction with Orthodontic Treatment—A Case Report. *Journal of Clinical and Diagnostic Research*, **9**, ZD20-ZD22. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4625349/>
- [12] Ilizarov, G.A. (1990) Clinical Application of the Tension-Stress Effect for Limb Lengthening. *Clinical Orthopaedics and Related Research*, **250**, 8-26. <https://doi.org/10.1097/00003086-199001000-00003>
- [13] Carvalho, P.H.A., Moura, L.B., Trento, G.S., Holzinger, D., Gabrielli, M.C., Gabrielli, M.F.R., *et al.* (2020) Surgically Assisted Rapid Maxillary Expansion: A Systematic Review of Complications. *International Journal of Oral & Maxillofacial Surgery*, **49**, 325-332. <https://doi.org/10.1016/j.ijom.2019.08.011>
- [14] Loriato, L. and Ferreira, C.E. (2020) Surgically-Assisted Rapid Maxillary Expansion (SARME): Indications, Planning and Treatment of Severe Maxillary Deficiency in an Adult Patient. *Dental Press Journal of Orthodontics*, **25**, 73-84. <https://doi.org/10.1590/2177-6709.25.3.073-084.bbo>
- [15] Rutili, V., Nieri, M., Franceschi, D., Pierleoni, F., Giuntini, V. and Franchi, L. (2022) Comparison of Rapid versus Slow Maxillary Expansion on Patient-Reported Outcome Measures in Growing Patients: A Systematic Review and Meta-Analysis. *Progress in Orthodontics*, **23**, Article No. 47. <https://doi.org/10.1186/s40510-022-00440-5>
- [16] Franchi, L., Baccetti, T., Camporesi, M. and Lupoli, M. (2006) Maxillary Arch Changes during Leveling and Aligning with Fixed Appliances and Low-Friction Ligatures. *American Journal of Orthodontics and Dentofacial Orthopedics*, **130**, 88-91. <https://doi.org/10.1016/j.ajodo.2006.01.017>
- [17] Alsayegh, E., Balut, N., Ferguson, D.J., Makki, L., Wilcko, T., Hansa, I., *et al.* (2022) Maxillary Expansion: A Comparison of Damon Self-Ligating Bracket Therapy with MARPE and PAOO. *BioMed Research International*, **2022**, Article ID: 1974467. <https://doi.org/10.1155/2022/1974467>
- [18] de Figueiredo, M.A., Romano, F.L., Feres, M.F.N., Stuani, M.B.S., Ferreira, J.T.L., *et al.* (2023) Maxillary Alveolar Bone Evaluation following Dentoalveolar Expansion with Clear Aligners in Adults: A Cone-Beam Computed Tomography Study. *Korean Journal of Orthodontics*, **53**, 264-275. <https://doi.org/10.4041/kjod22.243>
- [19] Morales-Burruezo, I., Gandía-Franco, J.L., Cobo, J., Vela-Hernández, A. and Bellot-Arcís, C. (2020) Arch Expansion with the Invisalign System: Efficacy and Predictability. *PLOS ONE*, **15**, e0242979.

<https://doi.org/10.1371/journal.pone.0242979>

- [20] Rocha, A.S., Gonçalves, M., Oliveira, A.C., Azevedo, R.M.S. and Pinho, T. (2023) Efficiency and Predictability of Coronal Maxillary Expansion Repercussion with the Aligners System: A Retrospective Study. *Dentistry Journal*, **11**, Article 258. <https://doi.org/10.3390/dj11110258>
- [21] Bouchant, M., Saade, A. and El Helou, M. (2023) Is Maxillary Arch Expansion with Invisalign® Efficient and Predictable? A Systematic Review. *International Orthodontics*, **21**, Article ID: 100750. <https://doi.org/10.1016/j.ortho.2023.100750>