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Mini-implant assisted rapid palatal expansion: New perspectives

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SUMMARY

Maxillary endognathy is a fundamental problem of the transverse dimension, which is very common during childhood. The conventional treatment for this dysmorphia is rapid maxillary expansion using a mid-palatal jack screw. Widely described in literature, it provides many functional and morphological benefits. Unfortunately, there are side effects caused by these devices, especially in patients with thin periodontium. For improving the management of these patients, we use mini-implant assisted rapid palatal expansion. The anchorage is directly on the palate, closer to the hemimaxillary resistance center, and it allows for a better skeletal maxillary expansion. It decreases the size of the vestibular cortical is very thin. Benefits, side effects, and implementation of this device will be discussed in this article.

KEY WORDS

Endognathy, rapid palatal expansion, mini-implant, orthopedic treatment, bone anchorage

INTRODUCTION

Transversal anomalies are very common in clinical practice. In 80% of cases, their interceptive treatment is essential and must be administered as soon as possible to avoid periodontal, joint, or functional problems. It is based on an orthopedic technique aimed at separating the two maxillae above the level of the intermaxillary palatal suture.

In 1860[2], Angell who first described rapid maxillary expansion, which was very quickly discredited; however, since the 1960s it has been most widely used treatment in our arsenal.

Conventionally, rapid maxillary expansion is performed in children who are still growing (no suture synostosis; at approximately 12 years), using a disjunctor (described by Biederman) supported by the teeth (two or four rings) and using a median activator twice a day, or 0.5 mm per day. Many studies, including meta-analyses, have

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investigated the actual effects of rapid maxillary expansion at the skeletal, alveolar, and periodontal levels. Despite the beneficial effects of this method, there are still several disadvantages, which has led to new research.

The introduction of mini-implants and mini-implants over the last 20 years offers patients new treatment alternatives by allowing dental displacements when conventional approaches reach their limitations of usefulness. The use of mini-implants and mini-implants becomes the first treatment choice when correcting the transverse dimension to counter any undesirable effects and exceed the limits of conventional devices.

The aim of this article is to focus on the importance of mini-implants and mini-implants in rapid maxillary expansion and to highlight their potential use following a brief review of conventional rapid maxillary expansion.

BENEFICIAL EFFECTS OF RAPID MAXILLARY EXPANSION

Skeletal and anatomical

The major effect sought during rapid maxillary expansion is skeletal, with the separation of the two maxillae at the medial palatal suture in the form of V at the posterosuperior apex, because of the resistance offered by the pterygoid processes of the sphenoid bone[8].

According to a literature review published in 2005 by Lagravère et al., only 25% of this expansion is skeletal; therefore, three-quarters of the expansion is alveolar[35]. On the other hand, Krebs in 1964 attributed 50% to skeletal expansion in children[31].

This evolution of thought encourages us to find a way to increase the ratio of skeletal effects to alveolar effects.

The suture

The maxilla is the centerpiece of the middle segment of the face; it consists of two maxillae joined by an intermaxillary suture. Ten bones affect its articulation; rapid maxillary expansion, therefore, directly or indirectly affects the structures in relation to the maxilla, mandible, nasal cavity, pharyngeal structures, and the pterygoid processes of the sphenoid bone[5].

A direct relationship has been established between increased resistance to skeletal expansion and patients older than 12–13 years.

Soft tissues

Numerous studies have been published on the skeletal effects of maxillary expansion, but very few have considered the effects on soft tissues.

In 2010, Johnson et al. published a study of 78 patients treated with rapid maxillary expansion compared to a control group of 437 untreated patients.

In the transverse direction, they observed an increase in the interalar distance (measured with calipers) of +1.7 mm on average in growing patients, in correlation with the increase in size of the nasal fossae[27].

These results are supported those published by Kim et al., in 2012, on cone-beam computed tomography

(CBCT)[30], which shows an average 1.8-mm increase in the interalar distance, as well as a significant increase in interzygomatic cutaneous distance, interorbital and infraorbital cutaneous distance, distance between eyes, and the average floor width of the face.

In the sagittal direction, Kim shows that the nose makes an overall anterior movement. The sub nasal point advances on average 2.21 mm, 0.79 mm for the nasal bridge, and tip of the nose advances 1.58 mm.

Rapid maxillary expansion causes morphological changes in growing children, giving their maxillae a little more volume, thus decreasing their adenoid appearance.

The hyoid bone and the tongue

The position of the hyoid bone changes with age. According to Tourné[64], the hyoid bone descends as a patient ages, and then maintains its position between the C3 and C4 cervical vertebrae. He also proved that the position of the hyoid bone could be affected by upper airway resistance.

Phoenix et al., in 2011[51], published a study on the position of the hyoid bone after rapid maxillary expansion in adolescents. The results showed that after the expansion, the hyoid bone is 2 mm higher than in untreated adolescents.

The expansion therefore tends to normalize the position of the hyoid bone.

Arcade shape and size

- **The maxilla**

In a meta-analysis published in 2006, Lagravère et al.[34] noticed a significant increase in the maxillary intermolar coronal distance following rapid maxillary expansion of 6.74 mm on average, an increase of 4.44 mm in the root, as well as an increase in intercanine distance of 5.35 mm on average.

However, the intermolar angle increases by 3.1° on average, but this increase is not significant.

This meta-analysis also reported an interincisor diastema following rapid maxillary expansion, averaging 2.98 mm (closing spontaneously after stopping activations)[1]. The arcade perimeter also tends to increase.

- **The mandible**

Ugolini et al.[65] published a study in 2016 on the effects of rapid maxillary expansion on the mandible. The study included a subject group of patients with a mean age of 8.5 years as well as a control group. They reported a significant increase in the intermolar distance in the treated group compared to the untreated group (+1.9 mm), and an increase in the molar angulation (+9°). The intercanine distance and the canine angulation are also increased in the treated group (+1 mm and +5.1°), whereas they decrease in the control group.

Many authors agree with Ugolini's results on the increase in mandibular intermolar distance ranging from 0.24 mm to 2.8 mm according to the studies[71,56].

Upper airways

The role of the nasal cavity is to prepare the air before reaching the lungs by humidifying, cooling, and removing impure particles. Because the maxillae make up half of the anatomical structure of the nasal cavity, the hypothesis that maxillary expansion affects the anatomy and physiology of the nasal cavity was made[50].

Oliveira De Felippe et al., in 2006, published a study showing a significant

30.12% increase in the volume of nasal cavities after rapid maxillary expansion and a restraint period[50].

Kilic et al., in a literature review published in 2008, which included 11 studies, described an increase of 2–4 mm in the transverse dimension of the nasal fossae.

A tonsillectomy and, in some cases, continuous positive airway pressure were the treatment of choice for obstructive sleep apnea (OSA) in children but would not have fully improved the management of this disease.[44]

Numerous studies have shown that rapid maxillary expansion would have a beneficial effect on OSA. In fact, a recent meta-analysis published in 2016 shows a significant decrease in apneas/hypopneas with a drop of –6.86 points on the apnea/hypopnea index after maxillary expansion in patients with OSA[43].

Ventilation

The physiological ventilation is nasal. Oral ventilators have traditionally been described as having narrow maxillae, with a deep V-shaped palate and a long face (adenoid profile)[38].

Gray studied 310 cases after rapid maxillary expansion and finds that >80% of cases change their mode of ventilation from oral to nasal. Approximately 50% are more protected against respiratory infections, allergies, and asthma [21].

Nasal resistance

Several authors have shown that by increasing the nasal cavity width, nasal resistance decreases thereby improving nasal ventilation[24,69]. In fact, the nasal canals occupy the lowest transverse section of the nose where nasal resistance is greatest. Rapid maxillary expansion separates the maxillary bones in a pyramidal form with maximum expansion at the incisors just above the nasal canals[50]. Hershel et al. even noted that rapid maxillary expansion can decrease nasal resistance by 45%[25].

Sleep Apnea syndrome/Hypopnea

Sleep apnea syndrome during childhood leads to significant physical and neuro-psychomotor impairments. It is therefore important to detect and treat it as soon as possible to avoid or alleviate chronic OSA related problems, which can be deleterious to the child's development[43].

Hearing

Several studies have shown beneficial effects of rapid maxillary expansion on hearing. Indeed, the middle ear is part of a functional system composed of the nasopharynx, the Eustachian tube, and the mastoid cells. The Eustachian tube provides ventilation to the middle ear and protects it from excessive pressure, sounds, and nasopharyngeal secretions. The Eustachian tube opening is partially controlled by median portion of the tensor veli palatini muscle.

Villano et al. in 2006, observed a significant hearing improvement in all their patients with rapid maxillary expansion and concluded that the correction of palatal anatomy by maxillary expansion influenced the muscular function of the Eustachian tube and allows for normal eardrum activity and hearing[67].

Enuresis/Bedwetting

Timms et al.[63] found an association between rapid maxillary expansion and reduction of enuresis. In fact, upper airways obstruction as a contributing factor in persistent enuresis is not a new concept.

Schütz-Fransson conducted a study in 2008 on 23 patients[57] and hypothesized that maxillary expansion treatment, which improves ventilation, positively affects children with enuresis by lowering their alertness thresholds (by decreasing the phases of deep sleep).

The study's results are in agreement with the pilot study conducted by Kurol in 1998[32].

Postural Functional Harmonization and Growth Direction

Research in the area of craniofacial growth and development has shown that respiratory function influences facial morphology and cephalic posture.

Ricketts hypothesized that head extension is a functional response to facilitate oral respiration to compensate for nasal obstructions[54]. According to this theory, one would expect patients with upper airway obstructions to show an increase in craniocervical angulation.

Many authors observe a significant change in cephalic position and craniocervical angulation after treatment to improve nasal ventilation (removal of tonsils and adenoids).

Tecco et al. in 2004[62], performed a random study to compare the changes of cephalic posture and the craniocervical angle of a female cross section treated with rapid maxillary expansion with a control group. The results show a significant flexion of the head in the treated group (>4°), whereas an extension of 0.5°–1.6° is observed in the control group. The craniocervical angle decreases significantly by about 5° in the treated group, whereas the control group shows a change of only 0°–2.2°.

Rapid maxillary expansion therefore tends to normalize the posture and improve posture in growing patients.

Linder–Aronson hypothesized that the establishment of nasal ventilation in a patient with a nasopharyngeal obstruction may be a determining factor in the suppression of mandibular growth. The results of his study published in 1986 show that there is an association between a tonsillectomy with change of ventilation mode and establishment of a more horizontal growth of the mandible[39].

IATROGENIC EFFECTS OF CONVENTIONAL METHODS

Age-dependent sutural resistance

The possibility of carrying out orthopedic treatment on the intermaxillary suture depends essentially on the patient's age and the force applied, according to Sander[55], Bell[7], and Zimring[75], it varies from 1.5 to 10.5 kg.

All studies agree, but there is no consensus as to the age limit for which it would be necessary to perform an associated surgical procedure. In fact, there are currently few reliable parameters that allow us to predict the success or failure of our orthopedic therapy. The bone age method predicted by a radiograph of the wrist seems to be the most widely used.

Baccetti and Franchi[3] have published a method of determining peak growth by the maturation stage of cervical vertebrae. They show that up to the cervical stage 3 (CS3), i.e., before the peak, the rapid maxillary expansion produces better skeletal effects.

Melsen investigated the palatal growth and morphology of palatal suture from autopsies performed on children aged 0–18 years. It shows that the transversal growth of medial palatal suture continues until age 16 for girls and 18 for boys. She described three stages of endosseous integration, which occur during adolescence and sees the formation of numerous interdigitations between the bone processes, preventing any separation of the two hemimaxillary muscles without causing a fracture of these bone bridges[46].

Periodontium

Reduction of alveolar bone thickness

Starnbach et al. described the dental changes caused by rapid maxillary expansion 50 years ago.

They reported that the forces exerted by the disjunctor on the support teeth produce areas of compression on the alveolodental ligament[58].

These data are taken up by several authors like Ballanti[4] and Garib et al.[19] which, in a study conducted in 2006, show that rapid maxillary expansion induces a decrease in vestibular bone thickness next to the disjunctor teeth.

In fact, rapid maxillary expansion on a ring decreases the thickness of the vestibular bony crest of the supporting teeth from 0.6 to 0.9 mm, whereas that of adjacent teeth is not affected[19].

Reduction of the height of the alveolar bone

Numerous studies have linked orthodontics and the periodontium, including the impact of tooth movements on periodontal reduction. Greenbaum and Zachrisson[22], Vanarsdall as well as Watson[70] hypothesized that rapid maxillary expansion could cause dehiscence.

Garib et al.[19] validated this hypothesis by studying the height of the vestibular bone crest of the teeth supported by the disjunctor. They report a dehiscence of 7.1 ± 4.6 mm at the level of the premolars and 3.8 ± 4.4 mm at the level of the molars. These height losses vary according to the initial thickness of the bone crest.

Dental

Tipping

In a study published in 2008 by Garrett et al.[20], the dental version would play an important role on the total expansion. In fact, they attribute 39% of the total expansion to the vestibular version at the level of the first premolars (2.34 mm), and 49% at the level of the first molars (3.27 mm).

A meta-analysis, published in 2012 by Lagravère, also reports a 2–3 mm increase in maxillary interalveolar distance, clearly showing that much of the palatal expansion is dental rather than skeletal[34].

As for McNamara et al., they reported an ≤6° maxillary molar vestibuloversion after rapid maxillary expansion[45].

Figure 1
Hybrid disjunctor with dental and bone joint supports.

External resorptions

Since the earliest days of maxillary rapid expansion, root resorptions of the support teeth have emerged as one of the major adverse effects and have been studied by many authors.

Many report that they appear on the buccal side of the roots. This evaluation was based on the analysis of extracted teeth.

It is with the advent of 3D imaging that another study has appeared[6], showing that external resorptions were greater at the buccal surface of the root of the first molar (loss of 18.60 mm^3 on average) than at the level of the first premolar (13.93-mm loss[3]).

Posterior skeletal rotation

The vertical dimension is also affected by rapid maxillary expansion and in some cases poses a major problem, which may compromise treatment success, especially in hyperdivergent patients.

Many studies have been conducted describing the effects of rapid maxillary expansion on the vertical dimension and aesthetics[14,15].

In fact, after opening the intermaxillary suture, the maxilla shows a severe displacement compared to the frontal, nasal, and ethmoid bones. The maxillofacial complex was completely dislodged from the pterygoid processes and pushed forward and downward, displacing the latter in the same direction by 2.5 mm.

The mandible has also been rotated downward and backward[71].

In a study published in 2016, Conroy-Piskai shows that after rapid maxillary expansion, the Frankfort mandibular plane angle value increases slightly, but that it remains within the standard range[14].

This increase may be because of cuspidal occlusion induced by overcorrection and displacement of the maxilla forward and downward. It would be partly transient, if we consider the secondary linguoversion of maxillary molars recurrence.

However, this statistically significant 1°–2° increase in angulation of the mandibular and palatal plane compared to the anterior cranial base (SN) plane is not clinically significant[34].

Recurrence

A retention period of three months seems to be sufficient to prevent any relapses. In fact, it is enough time to see a sutural regeneration and allow the stabilization of the separated maxillary segments[7].

However, according to Wertz recurrence would depend on the age at which the rapid maxillary expansion is performed. In a study of 60 patients that examined the changes in intermolar distance, Wertz shows that in the 12–18-year age group, recurrence is 10% after a retention period of 3 months, and 63% in the >18-year age group[71].

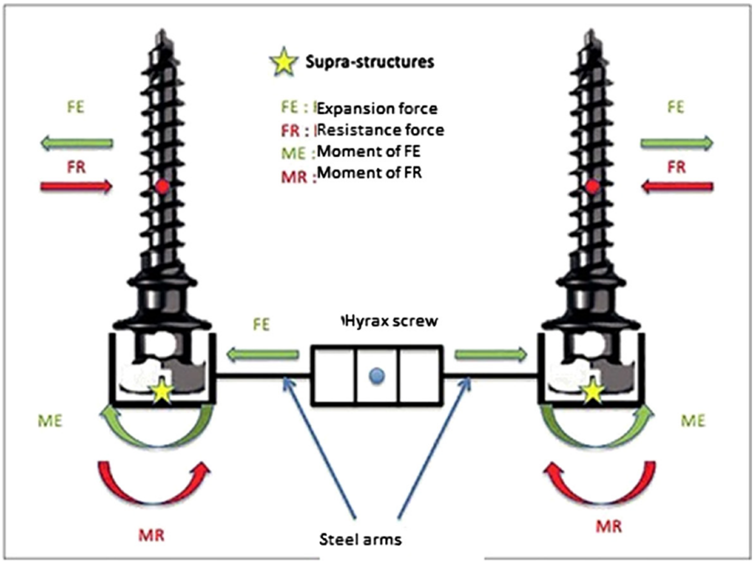

Figure 1
Biomechanical diagram of the forces exerted by the hybrid disjunctor.

MIXED-SUPPORT APPLIANCES

As described above, it is not possible to obtain a purely skeletal expansion and many adverse effects, including gingival recessions and fenestrations, counteract the beneficial effects of this device.

These adverse effects occur in patients who already have an unfavorable periodontal typology (seen in jawbone atresia).

Garib et al. reported that the largest recessions and the largest bone loss were on the first premolars[19]. Actually, according to a study published in 2011, it is at the level of premolars that the vestibular cortex seems thinnest (0.9 mm)[17].

To overcome these disadvantages, the use of mini-implants has been proposed as an anchor to the disjunctor replacing the premolar support, offering a new perspective in the use of these devices.

General information

A Hyrax expansion device is supported on two molar rings as well as two anterior palatal mini-implants from 1.8 to 2.2 mm in diameter and 7–9 mm in length inserted in paramedian from the premolar region to 2–4 mm from the transverse palatal suture.

This situation would be the most favorable according to the cartographic study of the palate conducted in 2010, respecting 5–6 mm of intraosseous anchorage[9]. This situation is also preferable because numerous studies have located the resistance center of the nasomaxillary complex in the premolar region[36,60,40].

The Hyrax expansion device is connected to the two screws and the molar rings by means of a 1.3-mm steel wire, as rigid and short as possible to avoid the torsional movements of the device (Fig. 1).

In some cases, especially when faced with severe nausea and tongue position, the Hyrax® expansion device must be placed in a more anterior position, therefore taking the predefined place of mini-implants. It is therefore possible to place the mini-implants in a more posterior position in relation to the molars[18].

The position of the screw can also vary (being more or less anterior) and be adapted to the clinical form of the malocclusion.

Double steel arms and mini-implants at least 1.8 mm in diameter to counter the resistance force since the resistance center is at a distance from the expansion force exerted[68].

Biomechanics of mixed-support disjunctors

The expansion screw transmits its force via the force transmission system (steel arms, suprastructures, and mini-implants) to the hemimaxillary muscles (Fig. 2).

The anterior arms deliver the forces via the mini-implants to the anterior palate, whereas the posterior arms deliver their forces via the molars to the posterior segment of the palate.

The anterior force transmission system is supported by the bone and transmits force directly to the maxillary bone.

The more central the screw, the more the force will be close to the center of resistance of the hemimaxillary and alveolar torsion will be less important [11].

A very rigid structure of the force transmission system is therefore necessary with, if possible.

Indications

Nowadays, maxillary expansion assisted by mini-implants prevents irreversible damage (periodontal and dental). It is proposed to relieve anchoring molars, to decrease the alveolodental effects described above, and to obtain a more stable expansion[18].

Toklu[23] and Wilmes[72, 73] recommend the use of mixed-support disjunctors in the case of weakened vestibular periodontium at the premolar level.

Wilmes also proposes to use them in case of weakened anterior dental anchorage because of the absence of temporary or resorbed molars.

In early skeletal class-III cases requiring treatment with a Delaire mask in conjunction with a expansion where traction can be skeletal using mini-implant.

The mixed support used for this technique also helps treat OSA syndrome[18].

Implementation

After contact or infiltration anesthesia, the thickness of the palatal mucosa is measured with a probe, to determine the thinnest region (≤2 mm). This data is important for acquiring sufficient primary stability and avoiding excessive leverage[73].

The placement of palatal mini-implants (range, 1.8–2.2 mm in diameter, and 7–9 mm long) is performed at an axis of 30° to the maxillary teeth, paramedian in the premolar region, where the bone thickness would be most optimal.

To improve the axis and the position of the mini-implants, in view of the an-

a b

Figure 3
a) Mechanical contra-angle. b) Screwdriver and handle for contra-angle.

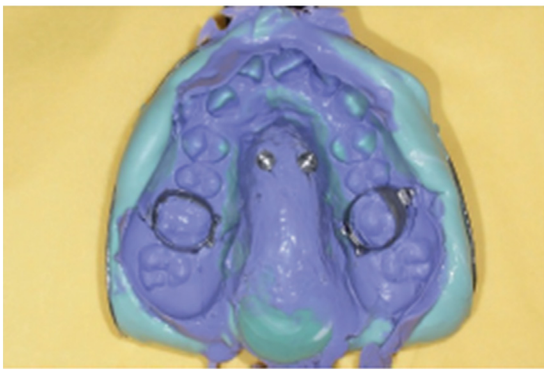

Figure 4
Silicone impression in double mixture.

Figure 5
Mixed support disjunctor made from the intraoral molds.

atomical difficulties encountered in certain patients with highly ogival palatal forms and a small mouth opening, a mechanical contra-angle (Fig. 3a) seems preferable compared to a straight screwdriver for screwing in mini-palatal implants (Fig. 3b).

The rings on the first molars are then tested and then the mini-implants are placed.

A double-mixed silicone impression is made to obtain high precision in the positioning of the mini-implants (Fig. 4).

Analogs of mini-implants are then placed in both the mini-implant impressions and also on the rings. The resulting molding therefore accurately reflects the intraoral situation.

The disjunctor is then made from the intraoral molds, welded with a laser to suprastructures provided by the prosthetist, and to the rings (Figure 5).

The apparatus is therefore tested in the mouth, the suprastructures are screwed into the heads of the mini-implants and the rings are placed on the first molars. Everything is sealed with a glass–ionomer cement (preferably photo-polymerizable to have sufficient positioning time).

There is no consensus in the literature for the device implementation.

Some studies recommend activating the device only a few days after the installation of the screws[18], whereas others recommend waiting 4–6 weeks after installing the screws allowing for a more organized bone matrix around the mini-implants (lamellar structure)[18].

As for the activation of the device, we found different methods in the literature, but the most used seems to be activating the disjunctor twice a day (once in the morning, once in the evening), i.e., an expansion of 0.5 mm/day like a conventional disjunctor[16,23,47,74]. Wilmes recommends activating twice at 90°, i.e., an activation of 0.8 mm/day[18].

Benefits

In light of the many disadvantages of the conventional disjunctors described above, the use of mixed anchors seems to be a good alternative to overcome the various problems encountered.

In fact, disjunctors anchored on the posterior side of the first molars and palatal mini-implants on the anterior side provide many advantages:

Compared to the strict bone disjunctor:

- *Elimination of the need for invasive surgery.* In fact, the strictly bone-supported disjunctors require surgical implantation via a palatal flap lift to insert the implant and the osseointegration screw. Whereas the placement of the mini-implant supports for the hybrid disjunctor is flapless because the mini-implants used are self-drilling.

- *No need for osseointegration.*

Unlike implants used in the Dresden system, osseointegration is not necessary for a miniscrew because the stability is based on mechanical retention.

- *Easy to remove.* In most case, anesthesia is not necessary.

Compared to the conventional disjunctor:

- *Pushes the boundaries of orthopedic expansion.* A recent study published by Choi in 2016[12] shows that maxillary expansion assisted by mini-implants was effective in almost 87% of patients with an average age of 20 years. In different studies[10,37], patients receiving rapid maxillary expansion with a hybrid disjunctor appear to be older than those treated with conventional devices. In fact, to minimize the deleterious effects on the teeth and the periodontium in the event of sutural resistance, the age window used is narrower than that for hybrid disjunctors[48]. In contrast, skeletal effects are always greater in subjects treated earlier[66]. It would make it possible to avoid a surgical phase in patients generally presenting with a major sagittal problem requiring an additional sagittal correction surgery[12].

Cases are also described in the literature in young adults, to avoid surgery on the transverse dimension[10,37].

- *Can be used in patients with weak anterior tooth anchorage (resorption, deciduous teeth).* The support being skeletal and not dental, in case of absence of dental organs or weakness of the latter in prior, its implementation is not compromised[18,49].

- *A repositioning rather than a rotation of the two maxillae.* The horizontal force generated by the disjunctor anchored to the mini-implants in an apical position is transmitted to the palate at a high point located, which is thus closer to the resistance center of the jaw than the dental disjunctors (horizontal V). This allows more horizontal movements and therefore a mass translation of the two hemimaxillae. This decreases the movement (V frontal) and rotation of the left and right separated jaws (vertical V)[61,53].

- *Prevents mesialization of the anchor molars until the premolars erupt*. In fact, the rigid structure connected to both mini-implants serves as a space maintainer, and acts as a Nance arch, thus preventing the molars from undergoing mesialization and stunting the development of definitive premolars[68].

-*The versatility of mini-implants palatins*[73]. In patients with skeletal class-III dentition who require rapid maxillary expansion, the use of the hybrid disjunctor seems to be the best option. According to Hourfar et al. who published a retrospective study in 2015 on 100 patients, maxillary traction would be more effective if supported by two anterior mini-implants connected to the disjunctor rather than a conventional disjunctor[26].

- *Increased volume of nasal fossae.* It has been proven that rapid maxillary expansion improves nasal ventilation, increases the volume of the upper airways, and decreases nasal resistance. A recent study, published in 2014 by Motro et al. reports that the hybrid disjunctor produces exactly the same benefits as a conventional disjunctor on ventilation and the upper airways especially in the nasopharynx and oropharynx[48]. These results have been called into question by the study published by Kabalan in 2015, which does not report significant differences after rapid maxillary expansion with a hybrid expansion (none of them with a conventional disjunctor) in regard to upper airway volume[28].

-*Treatment of sleep apnea syndrome.* As explained above, the effects of rapid maxillary expansion largely exceed the simple correction of the morphological anomaly of endognathy. It helps to standardize functions and is one of the treatments of choice for the correction of sleep apnea syndromes[52,13].

Often treated by the removal of the tonsils and adenoids during childhood without any real skeletal action, it is common to see the appearance or reappearance of sleep apnea syndrome during adolescence. The mixed-support expansion, pushing the age limits of a conventional expansion, has become the treatment of choice for sleep apnea syndrome in adolescents, also having an indirect action on the repositioning of the tongue[16].

- *Skeletal stability after removal of the disjunctor.* At the end of the expansion, skeletal stability can be maintained without keeping the disjunctor. Indeed, the Beneplate, the plate to be placed between the two mini-implants, makes it possible to maintain the distance[72] (Fig. 6).

- Minimizes loss of vestibular thickness of the bony crest in the premolars. Effectively, in a comparative study published by Toklu et al., show that the loss of thickness of the bone crest at the level of the premolars is 0.80 ± 0.65 mm on average for patients treated with a conventional disjunctor compared to patients treated with a disjunctor with mixed supports, which does not present a loss of thickness[23]. These results are in agreement with those found in ChaneFane's preliminary study, which shows that there would be no loss of vestibular thickness of the bone crest at the level of the premolars following the mixed-support expansion[11].

- *Fewer alveolar effects and reduction of the dental version at the molar and premolar levels.* A comparative study conducted by Lagravère et al. in 2010, reports that a dental disjunctor produces more vestibulo-versions of the premolars than a device with bone supports[33]. As Toklu shows in his study in 2015, the inclination of the maxillary premolar remains unchanged in the mixed-support expansion compared to conventional expansion.

- *Fewer adverse effects on the vertical dimension.* It goes hand in hand with the reduction of alveolar effects and would increase the therapeutic possibilities, especially for dolichofacial patients[42].

Lower cost. In fact, even if the device used seems slightly more expensive than a conventional disjunctor (because of the use of mini-implants), this cost is still lower than that of a surgical operation on the transverse dimension requiring general anesthesia and all the equipment associated with the operating theater.

Disadvantages

Anatomical

- Bone thickness

To maintain good primary stability of the mini-implant, it is necessary to have a minimum of 6 mm of bone, to prevent the perforation of the nasal cortical bone. The choice of the positioning of the mini-implants strongly depends on this factor. The preferential location was defined as being at the level of the first maxillary premolar at 2–4 mm of the intermaxillary suture, representing a low perforation risk[29].

- Nasal-palatal canal

A mini-implant that is positioned too anteriorly could damage the nasopalatal canal and any nerves and vessels passing through it. The risk is low, but this occurs in some cases.

Similarly, at the level of the canine pillars, in the lateral palatal region, this nerve and blood plexus anastomoses with the vessels from the palatal foramen in the anterior direction. An installation position that is too lateral and too anterior will cause problems.

- Salivary glands

The posterior segment of the hard palate includes many small salivary glands, a mini-implant placement that is too posterior could affect these structures and cause mucus retention (oral mucocele and/or necrotizing sialometaplasia)[59].

- Shape of the palate

Patients requiring rapid maxillary expansion most often have narrow palates with deep palatal clefts and lateral palatal bulges. The palatal mucosa is often thick.

This morphology increases the difficulty of installation and can compromise the correct position of mini-implants.

- Dental roots

The insertion of mini-implants at the palatal level carries the risk of damaging the maxillary tooth roots. This risk is especially pronounced at the posterior level, at the level of the palatal roots of maxillary molars. This is one of the reasons why the dental anchor is used in later stages[18].

But this risk is rare when angulation, length, and position are respected.

Linked to the position

Oral opening. The precise positioning of mini-implants is essential to avoid problems during installation. Patients with a small oral opening will have two problems:

- poor visibility of the laying position;
- interference of the right screwdriver with the mandible. The use of the mechanical contra-angle solves this problem.

Local anesthesia. The placement of the palatal mini-implants is done under local anesthesia. This step can lead to difficulties, including all complications related to local anesthesia:

- local and regional complications:
  - equipment complications (needle breakage, bursting of the cartridge);
  - mucosal lesions (ulceration, necrosis, hematoma);
  - neurological complications (sensitivity, sensory);
- general complications:
  - toxic accidents;
  - allergic reactions.
  - Also, it is necessary to have all necessary equipment validated:
- syringe;
- needle;
- injectable anesthetic solution: articaine, adrenaline 1/200.

Loss of the mini-implant and inflammation of the palatal mucosa. One of the problems encountered is the loss of the mini-implant after installation, occurring when primary stability is not achieved[16]. The loss rate is estimated at 25% in any position, but the palate seems to be the most stable position[41].

A new position may be considered after palatal mucosa healing.

Following the positioning, the palatal gingiva may bud around the screw due to compression and create inflammation. To avoid this phenomenon, it is preferable to use mini-implants with high collars and fairly large heads. Good hygiene should also be maintained (chlorhexidine mouthwash). Antibiotic therapy may complement the prescription if necessary[16].

Pain. The pain recorded on an analog pain scale, appears to be higher after the first activation in patients with a mixed-press disjunctor compared to patients wearing a conventional disjunctor[33].

CONCLUSION

Rapid maxillary expansion as a treatment for maxillary endognathy in children has been proven time and time again, it is well established. In addition, it has disadvantages that have been discussed previously.

To improve the management of these patients, new techniques have recently emerged.

Through this article, we have tried to put them in perspective, by detailing their indications, the advantages as well as the disadvantages, and their implementations.

Mixed-feed disjunctors have many advantages but are still seldom used. The habits of the practitioners and the small difficulties that arise from their installation and use mean that they are not always considered as the first choice of treatment.

They are nevertheless a good alternative in certain clinical situations in children/adolescents.

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