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Maxillary Expansion: From Past to Present

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Abstract

Maxillary expansion is a common treatment option for upper crowded dentition and posterior lingual crossbite in children and adolescents. As the midpalatal suture is not yet completely interlocked at these ages, the midpalatal suture can be opened via maxillary expansion to increase the length and width of the upper arch. This solves the problems of posterior crossbite and upper crowded dentition. Since the midpalatal suture is stiff in adults, many clinicians believe that adults require surgical intervention to achieve maxillary expansion. However, recent reports indicated that several cases have been treated successfully with the aid of TADs for maxillary expansion. This article discusses the various protocols for performing maxillary expansion from past to present.

Keywords

maxillary expansion; transverse maxillary deficiency; mini-implant assisted rapid palatal expansion (MARPE).

Review Article

Maxillary Expansion: From Past to Present

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INTRODUCTION

Narrowing of the maxillary arch is usually accompanied by different types of malocclusion, including anterior or posterior crossbite, crowded tooth alignment, and skeletal Class III. The concept of maxillary expansion was first introduced by Angell[1] and later repopularized by Haas.[2]

Compared to dental expansion, skeletal expansion is difficult to achieve in the maxilla by using fixed appliances alone. Additional appliances or orthognathic surgery may also be required. For a nonsurgical approach to maxillary expansion, opening the midpalatal suture is preferable to dental tipping, i.e., the so-called orthopedic effect. The possibility of achieving maxillary expansion by nonsurgical approaches depends on the age of the patient. Nonsurgical approaches were usually limited to children or adolescents and only those with palatal expanders (in primary dentition or mixed dentition) are likely.

Recently, many clinicians have attempted to use mini-implants to assist nonsurgical maxillary expansion procedures in adult patients. The mini-implant assisted rapid palatal expansion (MARPE) is controversial not only due to the lack of long-term follow-up studies, but also because palatal expansion in adults tends to cant the upper arch, which can then cause periodontal damage and relapse.

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ANATOMY

Up to 10 sutures may be involved for a maxillary expansion procedure. Notably, Ceylan et al.[3] reported that maxillary expansion can affect hearing (i.e., significantly improved hearing during active maxillary expansion followed by degraded hearing during the retention period). However, midpalatal suture is the most connected one. Haas[4] indicated that a midpalatal suture should not be opened in patients aged 16 years or older. A study on cadavers even reported that only 5% of the suture to be invisible by the age of 25 years.[5] Melsen[6] observed that the midpalatal suture is Y-shaped in infants, T-shaped in juveniles, and jigsaw puzzle-shaped in adolescents. Melsen[6] also performed a histological microradiographic study in a human autopsy, which revealed that osteoblasts become inactive after age 15 years in girls and after age 17 years in boys. These studies indicated that the shape of the midpalatal suture was not constant and that the difficulty of opening the midpalatal suture increased with age.

In Angelieri et al.,[7] cone-beam computed tomography (CBCT) of midpalatal suture maturation revealed that criteria other than age should be considered when planning the time to open midpalatal suture. In practice, CBCT performed before treatment enables the most precise indication of the time when the midpalatal suture should be opened. Moreover, maxillary expansion was reported to affect other different sutures, including zygomaticofrontal, zygomaticomaxillary, frontomaxillary, zygomaticotemporal, nasomaxillary, frontonasal, and internasal sutures.[8]

INDICATIONS

The main indication for maxillary expansion is transverse maxillary deficiency which may occurs in Angle Class I, II, and III malocclusions, which may then progress to anterior, unilateral, and/or bilateral posterior lingual crossbite.

Transverse maxillary deficiency can have multiple causes,[9] including congenital (systemic disease), developmental (oral habit), traumatic, and iatrogenic (cleft-palate repair) causes. The most common etiology is long-term thumb sucking.

The Rocky Mountain analysis developed by Ricketts could be used to determine the severity of a transverse maxillary deficiency.[10] The length of the antegonial notch is subtracted from the length of the bilateral jugular point. If the expected-actual maxillomandibular differential exceeds 5 mm, surgical intervention is needed. Notably, a recent study[11] recommended the use of CBCT or dental casts for measurement of the maxillomandibular transverse differential at the estimated center of resistance.

RAPID MAXILLARY EXPANSION

Rapid maxillary expansion (RME) can be classified as banded or bonded. Fixed appliances are used in both banded and bonded approaches. The most commonly used banded appliances are the tooth-borne Hyrax expander, the tooth-borne Minn expander, and the tooth- and tissue-borne Haas expander. For most clinicians, the Hyrax expander remains the preferred appliance for treating transverse maxillary deficiencies. The use of bonded expanders is increasing because they require relatively fewer appointments and less technique sensitive. Additionally, bonded expanders use a bite plate that covers the upper posterior teeth, which reduces the possibility of tipping and extrusion of the teeth. The occlusal bite plate on a bonded expander also helps to correct anterior crossbite.

SLOW MAXILLARY EXPANSION

Slow maxillary expansion (SME) techniques are relatively diverse. The available SME appliances include removable expansion plate with a jack-screw, fixed

Table 1. *The comparison of RME and SME.*[12]

	RME	SME
Expansion rate	0.5–1.0 mm/day*	1.0 mm/week
Force	10–20 lb	2–4 lb
Dental / skeletal effect	attained 1:1 at last	
Stability in long term	similar[13]	

∗ Semi-rapid: 0.25 mm/day

appliance with bends in the main wires, W-arch and Bi-helix/Quad-helix.

The comparison between RME and SME is listed in Table 1.

EFFECT

Upper anterior teeth

An RME can cause diastema. The size of the diastema usually approximates half distance of jack-screw activation.[2] In some cases of the diastema, however, transeptal fibers result in self-corrective.

Upper posterior teeth

Conventional methods of maxillary expansion use the posterior teeth for anchorage, which inevitably has negative effects on dental outcomes. The most common side effects are tipping and extrusion of the upper posterior teeth causing lateral bending of the buccal alveolar process and gingival recession over the buccal side.

Maxilla

In occlusal view, the midpalatal suture opening is nonparallel and triangular. The width of the opening is maximal at the incisor region and gradually decreases with the distance to the posterior part of the palate. In frontal view, it also separates supero-inferiorly in a nonparallel manner. The base of the triangular midpalatal suture opening is on the oral side of the bone. The outward tilt of the maxillary halves also reduces the palatal vault.

Mandible

Upper posterior teeth that extrude and drop down the palatal cusp cause concomitant downward and backward rotation of the mandible. Therefore, conventional rapid palatal expansion should be avoided in patients with a high mandibular angle and/or open bite.

Nasal airflow

Another indication for maxillary expansion is nasal obstruction, since RME can reportedly increase nasal width and volume.[14] Deeb reported that, on average, patients who have undergone RME have a 5.1% increase in nasal volume. Increases in nasal cavity volume and nasopharynx volume can also cause an oral breathing pattern to change to a nasal breathing pattern.

SURGICAL MAXILLARY EXPANSION

Patients with maxillary collapse associated with cleft palate usually exhibit extremely thin and delicate gingival tissue with severe buccal gingival recession in the canine bicuspid and severe posterior crossbite (>5–7 mm).

Surgically assisted rapid palatal expansion (SARPE)

During a surgical intervention, a rupture of the midpalatal suture can decrease mechanical resistance to lateral forces. If the patient is skeletally mature, the

orthodontist can then use an RME appliance to perform the required maxillary expansion.

Segmental maxillary surgery

Skeletal disharmony in the anteroposterior direction and vertical dimension can be corrected simultaneously by performing 3-piece Le Fort I osteotomy.

Non-surgical MARPE

In a MARPE (mini-implant-assisted rapid palatal expansion), mini-implants in the palatal jackscrew are used to facilitate palatal expansion. Since mini-implants localize forces lateral to the midpalatal suture, anchorage does not depend entirely on dentition. Mini-implants are available for treating transverse maxillary constriction in older patients.

This technique was described in articles by Dr. Kee-Joon Lee at Yonsei University, Korea[11,15,16] and by Dr. Won Moon at University of California at Los Angeles, USA.[17,18,19,20]

The Yonsei University appliance has the following notable features:[11,15,16] The center of the appliance is a modified Hyrax-type expander with two premolar bands and two molar bands.

1. Four helical hooks (diameter, 4mm) soldered on the base of Hyrax screw.
2. After cementation, a miniscrew is inserted perpendicularly to the center of each helical hook.
3. Two anterior miniscrews are implanted in the rugae area, and two posterior miniscrews are implanted in the para-midsagittal area.
4. The expansion screw is turned once daily (0.2 mm per turn) until the required expansion is achieved. Separation of the midpalatal suture is confirmed by periapical radiography.
5. The required duration of retention approximates 4 months.

A recent clinical study of this appliance reported an 86.96% success rate in young adult patients with stable results after 30 months of follow up.[14]

The UCLA appliance has the following notable features:[17,18,19,20,21]

1. Four tubes are welded to the expansion screw in the center of the body of the appliance.
2. The lateral arms are soldered to two molar bands. Since the molars are used to stabilize the position of the jackscrew during expansion rather than to provide anchorage, two molar bands is sufficient (Carlson et al.[18]).
3. Each tube (diameter, 1.5 mm; length, 2 mm) acts as a template for placement of the four micro-implants.
4. The expander should be centralized to the palatal raphe and be placed in the most posterior position possible and slightly before the boundary between the soft and hard palate.
5. After cementation, a miniscrew is inserted perpendicularly to the center of each welded tube.
6. The expansion screw is turned twice daily for the first 2 weeks until a diastema appears. If the patient experiences headaches and/or discomfort in the hard palate or nasal cavity, activation is stopped. When the pain is resolved, activation can resume at a slower rate of 1 turn per day.
7. A bone engagement of at least 5- to 6-mm is required to achieve bicortical engagement of the micro-implant. Finite-element analysis[19] reveals that mini-implants engaging the cortical bone of the palatal and nasal layers can improve parallel expansion of the midpalatal suture in either the occlusal view or frontal view of the maxilla.
8. The required duration of retention approximates 3 months.

This nonsurgical expansion technique can effectively achieve maxillary expansion in many adult patients with transverse maxillary deficiency.

The authors have also used superimposed CBCT images to compare outcomes between the UCLA appliance and the conventional Hyrax expander. Noted differences were as follows:[23]

- In frontal view, less buccal tipping of the axis of the upper first molar.
- In lateral cephalometric view, showed almost no downward or backward rotation of the mandible and no obvious extrusion in the upper first molar. Therefore, the technique can be used to treat shallow overbite and even open bite.
- Both frontal view and occlusal view showed that the suture opening has a parallel shape rather than a V shape or a triangular shape.
- Posteroanterior cephalometry revealed increases in the distance between the bilateral jugular point, even increases in the distance between the zygomatic bone, and nasal cavity volume was also increased.

CONCLUSION

Maxillary expansion can achieve good dental and skeletal effects in children. Regardless of the types of expansion appliances used, many studies agree that maxillary expansion is a stable procedure that consistently achieves favorable short- and long-term outcomes.[22] In adults, expansion can be achieved by either surgical intervention or by nonsurgical MARPE if the midpalatal suture is not fully interlocked. Long-term use of retainers is required to stabilize the occlusion and to prevent relapse. For adults, the long duration of an expansion treatment is a major concern.

Although palatal expansion combined with mini-implant insertion is apparently a good alternative for adults, the efficacy of this treatment option is still questioned by many clinicians. Therefore, further efficacy studies are still needed.

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