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Mid-Palatal Suture and Mini-Screw Assisted Rapid Palatal Expansion

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Abstract: *The mid-palatal suture represents the junction of right and left maxillary halves. It presents with a variable degree of ossification depending on the patient maturation status. Rapid palatal expansion (RPE) is commonly used in young adolescents to expand the maxilla and correct the posterior crossbite. Often in adolescents, mid-palatal suture is ossified and does not open in response to conventional rapid palatal expansion. In such patients, undesirable effects such as ulcers in the palatal tissue, root resorption and even necrosis of palatal tissue have been reported. On the other hand, mini-screw assisted rapid palatal expansion (MARPE) appliances can lead to predictable opening of the mid-palatal suture compared to conventional RPE. MARPE appliances can cause more orthopedic change compared to RPE appliances. Thus, MARPE appliances may be a preferred alternative to RPE appliances in a majority of orthodontic patients.*

Keywords: *Mini-screw assisted rapid palatal expansion; Rapid palatal expansion; mid-palatal suture.*

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I. INTRODUCTION

Mid-palatal suture

The mid-palatal suture forms the junction of the right and left maxillary halves. Because of its anatomical location, the mid-palatal suture plays an important part in the expansion of maxillary arch. The mid-palatal suture is tortuous and interspersed with bone and connective tissue. Thus, a thorough knowledge of the biology and morphology of the mid-palatal suture would help the clinicians to better understand the indications, and effectiveness of different types of maxillary expansion at different age groups.

The classification of mid-palatal suture maturation has been explained by Angelieri et al. (Angelieri et al., 2013) The mid-palatal sutures signify the location of the junction of palatal process of maxilla and horizontal plates of palatal bone. When the mid-palatal suture is affected, it also affects the anatomy of the associated structures.(Spedicato et al., 2021) Overall, the mid-palatal suture can be divided into three major parts: i)anterior segment: This is the segment of mid-palatal suture anterior to incisive foramen (intermaxillary segment), ii) middle segment: This is the segment of mid-palatal suture posterior to the incisive foramen to the transverse palatal suture, iii) posterior segment: This is the posterior most segment of mid-palatal suture posterior to the transverse palatal suture.

II. EXPERIMENTAL PROCEDURE

2.1 Literature search.

The articles from 1950 to present were serached in multiple databases including Medline/Pubmed to serach for terms including mini-screw assisted rapid palatal expansion, MARPE, Rapid palatal expansion (RPE), mid-palatal suture and the data and information obtained from the articles was analyzed and systemically presented in this review.

2.2 Maxillary expansion

Maxillary expansion procedures affect the mid-palatal suture by applying a transverse force on the two halves of the maxilla. Different approaches to maxillary expansion have been studied. Rapid palatal expansion (RPE), also known as rapid maxillary expansion (RME) exert an influence on the maxillary structures. The palate is developed at embryonic-stage at the age of 6-12 weeks.(Weng et al., 2018) It is formed of two parts - primary palate and secondary palate. The primary palate is formed by the fusion of two medial nasal process. The premaxilla and maxilla are joined with the fusion of primary palate to the secondary palate.(Danescu et al., 2015) The right and left sides of maxilla are connected with each other with the mid-palatal suture. The mid-

palatal suture responds to the application of force by remodeling. Thus, it is obvious that the mid-palatal suture will be affected by orthodontic and orthopedic forces such as rapid palatal expansion (RPE) and mini-screw assisted rapid palatal expansion (MARPE). Because of the fusion of mid-palatal suture, the maxillary expansion obtained with arch-wires and aligners is mainly dental and such appliances with a jack-screw such as RPE and MARPE are required for skeletal expansion.(Mehta et al., 2021, a)

2.3 Conventional rapid palatal expansion

Rapid palatal Expansion was first developed by Emerson Angell in 1860.(Angell, 1860) It was later popularized by Dr Andrew Hass in 1961 in the United States.(Hass, 2006) The technique used for rapid palatal expansion has been considered safe for the transverse expansion of maxillary arch to relive the posterior crossbite. This allows the clinicians to achieve harmony in the balance of buccal overjet between maxillary and mandibular teeth. The reason, this technique is known as rapid palatal expansion is because of the short duration of time, in which it corrects the maxillary deficiency.(Korkhaus et al., 2008) In the technique of rapid palatal expansion, an expansion jack screw is connected to the molars and premolar teeth and thus, it is known as tooth-anchored expansion appliance.

The rapid palatal expansion appliance, whether with a palatal acrylic covering or without any acrylic covering, applies forces on the anchored teeth from the palatal side. This leads to a reduction in the blood-flow on the periodontal structures on the buccal side of teeth, which results in the development of hyalinzed areas. (Haas, 2006) With an increased opening of the expansion screw, the transverse force keeps on building up on the teeth. Thus, bone modeling occurs in the surrounding areas with bone resorption and bone deposition and eventually the mid-palatal suture opens to the force.

When the mid-palatal suture opens and the expansion is started, the maxillary central incisors move away from each other resulting in the appearance of a mid-line diastema. In many cases, the expansion appliance is allowed to be stabilized for 3 months. In some cases, it is allowed to be stabilized for 6 months.(Mehta et al., 2021, b) This period of stabilization entails no further expansion of the screw and allowing the bone to be formed in the region of mid-palatal suture

2.4 Undesirable effects of conventional rapid palatal expansion

There are certain undesirable effects of rapid palatal expansion such as discomfort in the incisor-region and the nasal-suture region. It may also result in ulcers on the palatal tissue, or even necrosis in extreme cases. Right after the expansion, the mid-palatal suture area may show some signs of swelling. In certain cases, the rapid palatal expansion is unsuccessful, meaning that the mid-palatal suture does not open and the maxillary segments do not move apart. In such cases, ischemic regions may be observed in the palatal tissue. Silva et al. showed that this tends to occur more commonly in the RPE appliances with an acrylic covering on the palate.(Silva et al., 1989) Some reports have also shown the anchor teeth to experience root resorption.(Odenrick et al., 1982)

In such cases when RPE does not show evidence of adequate expansion, surgical intervention may be required to achieve the maxillary expansion known as surgically assisted rapid palatal expansion (SARPE). However, there are disadvantages with SARPE procedure such as additional surgical intervention, epistaxis, local anesthesia, patient discomfort.(Smeets et al., 2020) Thus, SARPE is not a very popular option for maxillary expansion.

2.5 **Mini-screw Assisted Rapid Palatal Expansion**

Thus, to overcome these challenges with rapid palatal expansion and surgically assisted rapid palatal expansion, new improvement and innovations have been made in the orthodontic field. It has been shown that mini-screw assisted rapid palatal expansion can be used to predictably produce maxillary expansion as evident by the increased the dental and skeletal maxillary width.(Mehta et al., 2021, a) These appliances cause parallel expansion of mid-palatal suture as compared to a triangular expansion achieved by conventional RPE appliances.(Mehta et al., 2021, a; Baik et al., 2020) Patients with posterior crossbite due to maxillary deficiency and class III malocclusion with anterior crossbite could be managed by expansion of maxillary arch with MARPE appliance and followed with surgical intervention for correction of class III malocclusion. (Lee et al., 2010) Thus, the MARPE appliance in such cases can reduce the number of surgeries to be conducted as it eliminates the procedure of SARPE

III. RESULTS AND DISCUSSIONS

3.1. Innovative designs with Mini-screw Assisted Rapid Palatal Expansion

Different types of MARPE design have been introduced by innovative clinicians in the orthodontic field. The MARPE appliance design as described by Mehta et al. is a pure bone-anchored appliances meaning only connected to the palatal bone with the help of mini-implants and having no connection to the posterior

teeth.(Mehta et al., 2021, a) Such appliances have been shown to not only increased the maxillary arch-width but also cause significant improvement of the nasopharyngeal airway. Whereas, Suzuki et al. have described the MARPE appliance with mini-implants in the palatal bone and the extension arms connected to the maxillary posterior teeth. (Suzuki et al., 2016) This design is known as hybrid bone-tooth anchored appliances.

With various modifications of MARPE design, it has been shown that MARPE, specially the bone-anchored expansion appliances led to an increase in the skeletal maxillary width more than controls (Mehta et al., 2021, a). Thus, MARPE is an efficient appliance to correct the posterior crossbite.(Ludwig et al., 2013). Furthremore, MARPE does not lead to any significant side effects on the TMJ (Mehta et al., 2021, b). In some situations, the patients have only unilateral posterior crossbite and not bilateral posterior crossbite. In such cases, only on one side of maxilla needs expansion. The U-MARPE design was developed in 2020 for the correction of unilateral crossbite (Dzingle et al., 2020). In this design, the MARPE appliance is connected to palatal bone with mini-screws and to maxillary teeth with extension arms.

3.2 Evaluation of outcomes of expansion

The evaluation of maxillary expansion is performed to identify the opening of mid-palatal suture and the increase in dental and skeletal maxillary width. The mid-palatal suture extends anterior-posteriorly from incisive foramen to the posterior hard palate and it extends superior-inferiorly from the nasal cavity floor to the palatal vault. Thus, the expansion of maxilla with the opening of mid-palatal suture leads to an opening of the nasal cavity as well. To identify the effects of rapid palatal expansion, occlusal radiographs can be recorded to identify the mid-palatal suture in the axial plane. Moreover, a posterior-anterior radiograph can help to evaluate the effects of the maxillary expansion in the coronal plane, and lateral cephalogram in the sagittal plane. However, these radiographs are 2-dimensional (2D) and thus, have a disadvantage of being affected by positioning of the patient and lead to errors in the measurement (Mehta et al., 2020). 2D radiographs cannot do justice to the 3-dimensional anatomy of the maxilla and associated structures (San José et al., 2017). Thus, the evaluation of maxillary expansion has been performed with 3-dimensional (3D) radiographs such as cone beam computed tomography (CBCT) in modern orthodontic research. Newer advances with artificial intelligence can be used for automated assessment of the radiographs to evaluate the effect of such expansion appliances (Mehta et al., 2021, c).

Suzuki et al. evaluated the effect of maxillary expansion with mini-screw assisted rapid palatal expansion with the help of CBCT and found significant expansion with MARPE (Suzuki et al., 2016). MacGinnis et al. analyzed the 3D model with finite element analysis how MARPE affects the nasomaxillary complex (MacGinnis et al., 2014). The appropriate protocol for the selection of palatal mini-implants has been reported (Nojima et al., 2018; Kharadi, 2021). Lee et al. showed that MARPE appliances can lead to significant expansion based on CBCT studies (Lee et al., 2010). One thing to note in the research on MARPE is that most of the studies have evaluated the outcomes immediately after expansion. Mehta et al. described the long-term outcomes of MARPE and showed that MARPE led to increased dental and maxillary width compared to controls in the long-term (Mehta et al., 2021, a).

MARPE is designed to reduce the increased amount of load on the periodontal structures of the posterior teeth with rapid palatal expansion and thus, decrease the undesirable effects of conventional RPE such as root resorption. MARPE does not involve any significant risks to the orthodontic patients compared to surgically assisted rapid palatal expansion. Using the 3D radiographs, a better assessment of mid-palatal suture ossification can be made to identify cases in which MARPE would be more advantageous than RPE (Mann et al., 1991; Melsen et al., 1975). With the innovative design of pure bone-anchored expansion design, there are significantly reduced changes of the dental effects on the anchor teeth. Thus, MARPE appliances present a new technique to overcome the resistance of mid-palatal suture to effect maxillary expansion (Wertz et al., 1970; Wertz et al., 1977).

IV. CONCLUSION

Rapid palatal expansion can be used for expansion of maxilla in patients at pre-pubertal or pubertal period. It can lead to increase maxillary arch-width. However, there are certain side-effects with rapid palatal expansion design.

Mini-screw assisted rapid palatal expansion (MARPE) can be used in orthodontic patients safely to increase the maxillary arch-width predictably. The advantages of MARPE design make it an appropriate choice for orthodontic clinicians to manage patients with transverse maxillary deficiency.

Conflict of interest

There is no conflict to disclose.

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