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A Comprehensive Review of Rapid Palatal Expansion and Mini-Screw Assisted Rapid Palatal Expansion

Sandip Thakkar
Dental surgeon class-1, MGG General Hospital, Navsari, Gujarat, India

Abstract:
The objective of this review is to familiarize the dentists and orthodontists with the different methods of maxillary expansion. It undertakes a literature review of rapid palatal expansion (RPE) as well as the recently introduced method of mini-screw assisted rapid palatal expansion (MARPE). The contemporary literature with the help of 3D imaging helps answer the questions on how the skeletal and dental effects of mini-screw rapid palatal expansion compare to the effects of conventional rapid palatal expansion. In addition, the modification of expansion protocols such as alternate maxillary expansion and constriction, slow expansion are also covered in this review. The modifications of expansion appliances such as AMEX appliance and modification of MARPE appliances such as unilateral MARPE (U-MARPE) for the correction of unilateral posterior crossbite have been explained in this review.

Key Word*: Mini-screw Assisted Rapid Palatal Expansion (MARPE); Rapid Palatal Expansion (RPE); Bone-anchored Maxillary Expansion; Alternate Rapid maxillary Expansion and Constriction (Alt-RAMEC); Cone-Beam Computed Tomography (CBCT); Airway.*

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I. Introduction

There has been an emphasis on skeletal anchorage and 3-dimensional (3D) imaging in the modern orthodontics.[1] Skeletal anchorage has played an important role in expanding the boundaries of orthodontic treatment.[2] With the help of skeletal anchorage, orthodontic treatment can be done predictably in the correction of malocclusion in all three dimensions. The sagittal or anteroposterior (AP) dimension, which is responsible for class III malocclusions can be corrected with distalization of the dentition using skeletal anchorage.[3] In addition, the vertical dimension in open bite patients can be managed successfully by performing intrusion of posterior teeth with skeletal anchorage.[4] The transverse dimension can be managed successfully by performing the expansion of maxillary arch with skeletal anchorage.[5]

The utilization of 3D imaging has led to important advances in the analysis of the effects of different interventions on the orthodontic treatment. The side-effects of orthodontic treatment such as root resorption can be measured more accurately now with 3D imaging of the orthodontic patients as compared to the previous 2-dimensional radiographs.[6,7] In addition, 3D imaging has helped in the identification of how the errors in recording the 2D radiographs affects the orthodontic diagnosis and treatment planning.[8,9] Recently, with the help of 3D imaging, more evidence is being generated regarding the effects of rapid palatal expansion on the skeletal and dental tissues. In addition to the advancement in the imaging techniques, the advancements in the bonding materials such as composite bonding materials and cyanoacrylate bonding materials have led to increased stability of the expansion appliances when cemented on the premolars and molars. This in turn, leads to decreased failure rates of the expansion appliances due to reduced accidental debonding of the appliances. This review will discuss about the different methods of palatal expansion highlighting the current literature on the effects of different types of expansion investigated with advanced 3D imaging techniques.

II. Rapid Palatal Expansion

Rapid palatal expansion (RPE) has been used since a long time in the orthodontic world to correct the transverse maxillary deficiency and manage posterior crossbite successfully.[10] The design of RPE can be divided into two main categories: i) Tooth-borne appliances, and ii) Tooth-tissue borne appliances. The tooth-borne appliances such as Hyrax appliance are designed with the expander connecting with the first molars and often the first premolars.[11] There is no coverage of the palatal tissue with tooth-borne appliances which makes it easier to clean and more hygienic. The tooth-tissue borne expander were designed by Dr. Andrew Hass and in this design the expander covers the palatal tissue with acrylic while connecting with the molars and premolars bilaterally.[12] The hypothesis and the proposed rationale for the palatal coverage was that when the expansion screw is activated, the expansion force is distributed on the palatal tissues which allows the adaptation and the

remodeling of the palate. Thus, Dr. Hass proposed that this led to more skeletal or orthopedic expansion than tooth-borne expanders.[12]

III. Mini-Screw Assisted Rapid Palatal Expansion

In the recent times, mini-screw assisted rapid palatal expansion (MARPE) appliances have been introduced in the orthodontic armamentarium.[11] MARPE appliances are designed with an expander that obtains anchorage from the palatal bone with the help of temporary anchorage devices (TADs). There are different designs of MARPE appliances, i)Bone-anchored expansion appliances (BA), ii) Bone and tooth-anchored expansion appliances (BTA) also known as hybrid appliances.[11,13,14] Bone- anchored appliances are designed with the expansion appliances anchored only to the TADs, whereas bone and tooth anchored appliances derive anchorage from both palatal bone and maxillary molars (and/or premolars).[11,13,14]

Modification of Mini-screw assisted rapid palatal expansion appliances

Rapid palatal expansion appliances lead to bilateral expansion of the maxillary arch, which is useful in the correction of bilateral posterior crossbite. Many times, orthodontic patients present with unilateral crossbite. In such cases, the bilateral expansion of maxillary arch leads to unnecessary expansion of the normal side of the maxilla leading to buccal crossbite on the normal side. This leads to increased treatment time to correct the buccal crossbite after bilateral expansion. Thus, in such cases unilateral expansion of the maxillary arch would be useful to expand only the crossbite side.

An appliance used to correct unilateral crossbite has been reported in the literature known as asymmetric maxillary expansion or AMEX appliance.[15] In this appliance, the activation of the expansion screw is done outside of the oral cavity. The anchorage is obtained from both maxillary and mandibular teeth. This can lead to some side-effects such as buccal tipping of the mandibular teeth on the side without crossbite.[15] Recently, an appliance has been introduced which does not have such disadvantages of AMEX appliance for the correction of posterior crossbite with the help of skeletal anchorage. This appliance is a modification of the MARPE appliance and has been named as U-MARPE or Unilateral MARPE.[16] U-MARPE appliance is designed with temporary anchorage devices (TADs) on one side of the maxillary arch. In this design, the maxillary expansion screw is anchored to the TADs placed on normal (non-crossbite) side of the mid-palatal suture and the arms of the expansion screw are connected to the molar and premolars on the crossbite side. Thus, when the expansion appliance is activated, it only leads to expansion of the teeth on the crossbite side resulting in the correction of unilateral crossbite.[16]

IV. Activation of Expansion appliances

In both the designs used for rapid palatal expansion, the expansion is performed by turning the expansion screw. Typically one turn activation of the expansion screw leads to 0.25 mm of opening of the screw.[13,14] However, different screws are available with different activations per turn ranging from 0.1 mm to 0.3 mm. The usual protocol for the activation of the expansion screws used for rapid palatal expansion is two turns per day (or one turn in the morning, one turn in the evening) - which amounts to approximately 0.5mm of opening of the screw.[13,14] Some authors have advocated up to 4 turns per day in adolescents or younger patients. However, some others have suggested to be a little more conservative and perform 1 turn per day, especially in adult patients. As the expansion screw is activated, the arms of the expander move out transversely and consequently lead to expansion of the maxillary arch. The expansion of maxillary arch occurs due to a combination of dental and skeletal effects.

V. Slow maxillary Expansion

Another type of maxillary expansion is the slow maxillary expansion. Slow maxillary expansion can be achieved with i) Removable Schwarz plate and ii) arch-wire expansion. Removable Schwarz plate is an acrylic plate anchored to maxillary molars with an Adams clasp and multiple Delta clasp on other maxillary teeth for retention. The activation of the Schwarz plate is done with the opening of the expansion screw that is embedded in the acrylic plate.[17] The schedule for the opening of the maxillary expansion plate is different than that of the rapid palatal expansion. Usually, one turn per 3 days or one turn per week, has been recommended for the activation of Schwarz plate for slow expansion. The disadvantage of Schwarz plate is that it depends on the patient compliance for achieving the results. Meaning that if the patients do not wear the plate as recommended, the results may not be satisfactory.

Another method used for slow maxillary expansion is with arch-wires. The arch-wires can be used to expand the maxillary arch by exerting low continuous forces on the maxillary dentition. To achieve maxillary expansion, rigid arch-wires need to be rigid in order to handle the pressure and not deform. Thus, stainless-steel arch-wire are more efficient in developing the arch-form or expanding the arch-form compared to Nickel-Titanium and CNA arch-wires. For achieving the slow-expansion, the arch-wires are expanded from the normal

arch form and inserted in the bracket slots. The arch-form development is monitored at every visit with the patients. And the expansion can be adjusted according to the need for more expansion. Care should be taken to coordinate upper and lower arches while undertaking arch-wire expansion so that the maxillary and mandibular arch-form are in harmony.

VI. Alternate maxillary expansion and constriction (Alt-RAMEC)

Alt-RAMEC is a modified expansion protocol developed in order to increase the opening of the maxillary sutures. In Alt-RAMEC, the maxillary expander is repeatedly opened and closed every week so that the maxillary arch is not expanded but the maxillary sutures are loosened.[18] This protocol is used frequently in the management of class III malocclusion patients. In a patients with class III malocclusion, the maxillary expander is subjected to Alt-RAMEC protocol followed by facemask to allow the forward movement of maxilla.[19] It has been shown that there is greater protraction of maxilla with Alt-RAMEC approach followed by facemask compared to expansion alone.[20]

VII. Skeletal and dental effects of expansion

With rapid palatal expansion, the skeletal effects occur due to the opening of mid-palatal suture and movement of the two halves of the maxilla away from each other transversely. It has been postulated that when rapid palatal expansion is performed, there is a high amount of skeletal expansion.[21] However, in the long-term there is relapse and the ratio of dental and skeletal expansion amounts to 1:1 ratio. However, the dental effects of maxillary arch expansion include the buccal tipping of the maxillary molars. It has been reported that the dental side effects of rapid palatal expansion can lead to buccal dehiscence, fenestration, as well as root resorption.[22] Thus, there has been increasing interest in achieving more skeletal effects and less dental effects with the different designs of the expansion appliances. In order to maximize the skeletal effects of expansion, MARPE appliances have been introduced as they derive anchorage from the bone with the help of TADs.

It has been reported that MARPE leads to increased skeletal effects of expansion than dental effects.[14] The mid-palatal suture opens parallel with MARPE appliance compared to RPE appliance in which mid-palatal suture opens in a triangular option. In a study comparing MARPE and RPE, it was observed that there is increased pterygoid disjunction with MARPE appliance compared to RPE. The amount of buccal molar tipping achieved with RPE appliances is higher than MARPE. This could also be the reason why the expansion achieved with MARPE is more stable than that with RPE. Garrett et al. showed that there is higher dental expansion and higher rate of relapse with RPE due to the relapse of the buccal tipping of molars.[23] In addition, as there is higher skeletal expansion of maxilla, there is less chances of dental side effects such as dehiscence and fenestration.

VIII. Effects of rapid palatal expansion on airway and nasal tissues

Rapid palatal expansion has been shown to have beneficial effects on nasal resistance. In previous studies, it has been reported that the amount of nasal resistance decreased significantly in adolescents with rapid palatal expansion.[24] These effects could be due to the expansion of the nasal cavity with rapid palatal expansion. As the palatal bone and nasal bone are connected, expansion of the palatal bone would lead to expansion of the floor of the nasal cavity.[25] Thus, it is logical to assume that the expansion of maxilla with expansion appliances would lead to more width of nasal cavity. With MARPE appliances there is higher opening of the mid-palatal sutures and nasal cavity width, thus there is higher decrease in the nasal resistance with MARPE compared to RPE. This can be appreciated by the fact that both RPE and MARPE increased the nasopharyngeal area in the short term as compared to controls.

In the recent years, increased importance has been given to airway and how different treatment modalities can affect airway.[14] One such modality is rapid palatal expansion. The amount of rapid palatal expansion has not shown a correlation with the amount of change in the airway.[14,26] However, it has been shown both RPE and MARPE can lead to a significant increase in the airway volume immediately after expansion.[26] However, most studies have evaluated the effects of expansion appliances on the airway in the short term and have not analyzed the long-term effects of expansion appliances.[26,27] However, recently Mehta et al. conducted a study on the long-term effects of MARPE and RPE in comparison with the controls.[14] The strength of this study was that the observation period was about 2 years 7 months which was higher than the previous studies and that the samples were obtained from a randomized controlled clinical trial. In this study, the authors found in the short-term there was a significant increase in the airway volume with both RPE and MARPE but in the long-term only MARPE led to an increase in the nasopharygeal airway volume compared to RPE and controls.[14] This is a significant finding as it indicates that the long-term effects of MARPE may be beneficial on airway compared to the long-term effects of RPE. However, an interesting finding of this study was that in the long term the controls also showed an increase in the airway volume. So it begs the question, whether the increase in the airway volume achieved with the expansion appliances is dependent on the type of expansion appliance used or could it also

happen without undertaking any treatment due to the growth of the patient. Another randomized clinical trial has been published recently by Cheung et al. on the effects of different expansion appliances on airway.[28] The authors found that there was not a significant difference between the effects of different expansion appliances on airway.[28] However, in this trial, there was no control group as in the study by Mehta et al. That is why the conclusion of this study do not give an inference as to how the expansion groups behaved as compared to controls.[14,28]

There is a controversy in the literature regarding the effects of expansion appliances on airway. One of the main reasons for this controversy is that the airway volume as measured on the CBCT gives a dimensional analysis of the airway. Meaning that increased airway volume can mean the dimensions of the airway boundaries increased. However, the airway function is detected by respiratory functional tests such as rhinomanometry, acoustic rhinometry, peak expiratory and inspiratory flow, as well as respiratory muscle strength.[31,32] Rhinomanometry is a popular method of assessing the resistance of nasal cavity. The peak expiratory and inspiratory flow is particularly valuable in patients with breathing disorders such as chronic obstructive pulmonary disorders (COPD) and asthma. Acoustic rhinometry on the other hand utilizes the reflection of the sound signals in order to estimate the dimensions of the airway, meaning the airway volume and airway area.[29,30]

IX. Conclusion

Further studies especially randomized controlled clinical trials are required to generate credible evidence regarding the effects of expansion appliances on dental, skeletal and soft-tissues. In addition, the effects of expansion appliances on airway need to be investigated in more detail. Specially, the effects of recent design of expansion appliances used with skeletal anchorage such as MARPE show promise in that they lead to more skeletal effects than dental effects. These appliances need to be investigated in detail with studies having a large sample size from multiple centers and a long follow-up period.

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