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Comparison of Conventional Rapid Palatal Expansion with Bone Anchored and Tooth-Bone Anchored Rapid Palatal Expansion Appliances

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Abstract **Review Article**

In modern orthodontics, several types of designs for bone anchored expansion appliances have been developed with the objective to increase the amount of skeletal expansion with rapid palatal expansion. In the present review, the skeletal and dental effects of rapid palatal expansion have been evaluated immediately following expansion and in the long-standing interval following expansion. The effects of conventional rapid palatal expansion appliances are compared with bone anchored maxillary expansion appliances and tooth-bone anchored maxillary expansion appliances. Temporary Anchorage Devices (TADs), or mini-screws, or mini-implants are used for the insertion of bone anchored and tooth-bone anchored maxillary expansion appliances. These lead to higher forces on the bone while expansion is undertaken and consequently more orthopedic effects. This article will discuss how the modern bone anchored expansion appliance used in modern orthodontics compare to conventional rapid palatal expansion appliances.

Keywords: Maxillary expansion, rapid palatal expansion, bone anchored expansion, tooth anchored expansion, mini implant supported maxillary expansion, MARPE, RPE.

INTRODUCTION

Rapid palatal expanders (RPE) are frequently utilized for the correction of transverse malocclusion between maxilla and mandible. The expanders apply horizontal force on the right and left parts of maxilla and lead to widening of the mid palatal suture. The result is the widening of maxillary arch and correction of the malocclusion. The effects of rapid palatal expanders have been investigated intensely in young adolescents [1, 2]. It has been reported that due to the articulation of maxilla with different bones, the expansion of maxilla is higher in the palatal aspects of maxilla and decrease as we move higher towards the cranium. Moreover, it has been reported that there is higher opening of the maxilla anteriorly than posteriorly [3]. This leads to a triangular opening of the mid palatal suture with conventional RPE. These effects can be different when bone anchored expansion appliances are used. This review will critically assess the literature and compare the changes achieved with conventional rapid palatal expansion and bone anchored and tooth-bone anchored rapid palatal expansion appliances.

Bone Anchored Expanders

With the utilization of mini-screws in orthodontics, bone anchored expanders have been designed by orthodontists to obtain more skeletal expansion and parallel suture opening. The conventional RPE appliances apply the forces to the right and left parts of maxilla by a teeth supported appliance. In contrast, the bone anchored expansion appliances apply the forces to maxilla by mini-screw supported appliance. The appliance may or may not be connected to the teeth for a bone anchored expansion appliance design. Different designs for bone anchored expansion appliance have been introduced in the orthodontic field [4-8]. The bone anchored expansion appliances are also known as MARPE that is, Mini-screw Assisted Rapid Palatal Expansion. A type of MARPE appliance is also known as MSE that is, Maxillary Skeletal Expander. MARPE can be purely bone anchored or both tooth-bone anchored appliance. MSE is a tooth-bone anchored RPE.

Opening of Mid-palatal Suture

Bone anchored expansion appliances produce a parallel opening of the mid-palatal suture compared to the triangular opening of mid-palatal suture with conventional RPE. The reason for the triangular opening of mid-palatal suture with conventional RPE is the resistance from the posterior part of maxilla and the pterygoid plates [9]. With bone anchored expansion appliances, the forces are applied to the temporary anchorage devices (TADs) inserted into the palatal bone. This results in the higher forces on the posterior part of palatal bone which lead to increased opening of suture posteriorly with MARPE compared to conventional RPE [3, 6]. The parallel expansion of the mid-palatal suture with bone anchored expansion appliances is considered to be responsible for the increase in the nasopharyngeal airway volume in the long run following expansion [3].

Sleep Apnea and Expansion

There has been an increased interest in sleep apnea in modern orthodontics [10-13]. More emphasis has been placed on performing research on the skeletal effects of bone anchored expansion appliances and the resultant effects in the dimensions of oral and pharyngeal airway [5, 6, 9]. The introduction of three dimensional volumetric imaging systems with cone beam computed tomography CBCT has enabled orthodontists to measure the effects of expansion appliances on airway dimensions [14]. Cone beam computed tomography allows the clinician to observe the effects of maxilla and mandible without magnification [15, 16]. Moreover, the cone beam computed tomography measurements are not affected by errors due to rotation of head position which affects the two dimensional radiographs [16]. Cone beam computed tomographs are reconstructed with 3D imaging software and aligned in the desired orientation by the researchers. These reconstructions enable the view of axial, sagittal, and coronal slices of the CBCT at different location in additional to the volumetric reconstruction [16]. The measurements of maxilla, maxillary basal bone, mandible, mandibular basal bone, and the effects on dentition such as dental tipping, root resorption can be measured with the help of the CBCT [17].

Skeletal and dental effects with conventional RPE and bone anchored and tooth-bone anchored expansion appliances

The effects of expansion appliances can be analyzed by the transverse changes observed after expansion for assessing the immediate effects. For the long-standing, the changes are analyzed at extended intervals of time after the expansion. Immediately after expansion, conventional RPE showed significant increase in the opening of mid palatal suture [18, 19]. This indicates that there is skeletal expansion following conventional RPE. The pattern of suture opening was observed to be parallel with bone anchored and tooth-bone anchored expansion appliances and the magnitude of suture opening was higher [20]. The suture opening can be measured both at the ANS for identifying the effects of expansion on anterior aspects of suture anterior opening and PNS for posterior aspects of suture [21]. A slightly higher opening anteriorly than posteriorly has been reported with bone and tooth-bone anchored expansion appliances, however the suture opening is relatively parallel. It is worthwhile to note that the position of the mini-implants influence this outcome of the suture opening [22].

The literature search for the long-standing outcomes with maxillary expansion did not lead to a high number of studies. However, it has been reported that the palatal width of maxillary arch increases with both bone anchored and tooth-bone anchored expansion appliances in the long run [3]. Moreover, the skeletal width of maxilla is observed to be higher with bone anchored expansion appliances and conventional RPE compared to controls [3]. The long standing results show that both conventional RPE and bone anchored expansion appliances do not affect the condyle negatively and no side effects are observed on the Temporomandibular Joint (TMJ) [23]. In recent years, different MARPE designs have been introduced. But the long standing results of these appliances are not observed in literature frequently. Moreover, the evaluation of the CBCTs with such expansion devices is subject to human error [24]. With the development of artificial intelligence, the radiographs can be evaluated by computer vision and minimizing the human error [25]. Aritifical Intelligence uses the processing of digital images with the help of different algorithms. In the earlier stages, the rule based systems were used for identification of radiographic images with AI. With the development of better algorithms and introduction of deep learning in the dental field, the emphasis is on using convoluted neural networks in evaluating the dental and orthodontic radiographs [25].

Therefore, more studies focusing on the long-standing effects of bone anchored and tooth-bone anchored expansion appliances need to be evaluated. If the assessment of the results of the expansion appliances can be performed with artificial intelligence in the future, it will limit the human error and a large dataset of information with high accuracy can be generated with the help of machine learning.

CONCLUSIONS

The evaluation of the effects of expansion appliances with the help of cone beam computed tomography helps the clinicians and researchers to identify the effects of conventional rapid palatal expansion and bone anchored expansion appliances. The magnitude and pattern of mid palatal suture opening was different with bone anchored expansion appliances compared to conventional appliances. More skeletal changes can be observed with bone anchored expansion appliances. Bone anchored and tooth-bone anchored expansion appliances are a viable and effective option for the correction of narrow maxilla.

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