SVOA Dentistry
ISSN:2753-9172

ScienceVolks Open Access

Review Article

Bone-Anchored Maxillary Expansion: A Contemporary Evidence Based Review

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Received: *April 16, 2021* ***Published:*** *May 17, 2021*

Abstract:

Rapid palatal expansion is a useful tool in the hands of orthodontists for the correction of posterior crossbite. The design and protocol of rapid maxillary expansion appliances have undergone a series of changes over time. Even though the skeletal effects of maxillary expansion are desirable, the unwanted dental side-effects such as buccal tipping of molars, and alveolar bone loss and dehiscence are a deterrent to its widespread use. The recent developments of bone-anchored rapid maxillary expansion appliances have enabled the orthodontists to achieve more skeletal changes with expansion and reduce the dental side effects of maxillary expansion. This article provides a complete review of the contemporary literature on the effects of bone-anchored maxillary expansion appliances.

Keywords: *Bone-anchored maxillary expansion; Mini-screw assisted rapid palatal expansion; MARPE; Mini-screw assisted rapid maxillary expansion; Rapid maxillary expansion; Rapid palatal expansion; Cone-Beam Computed Tomography; CBCT; 3D Imaging.*

Introduction

Since the beginning of 21st century, the orthodontic field has shown an increase in the use of skeletal anchorage and three-dimensional imaging system. There has been a steady development of better, more systemic examination systems, diagnostic tools, and clinical trials which has led the specialty to adopt a more evidence-based attitude. The current trend in orthodontics can be judged by looking at the recent publications, case-reports, original articles, clinical trials, systematic reviews, and meta-analysis published in the major orthodontic journals in the last few years. It seems that the current trend in orthodontics is towards mini-screw assisted rapid palatal expansion or bone-anchored maxillary expansion, mini-implants or temporary anchorage devices (TADs) in orthodontics, accelerated orthodontic tooth movement, lingual orthodontics, and Invisalign or aligner therapy.[1-5] The articles published on the subject of bone-anchored maxillary expansion has gained more interest in the recent years as these are relatively new appliances in the orthodontic armamentarium and not much is known regarding the effects of these appliances.[5-8] The bone-anchored maxillary expander is a form of rapid maxillary expander (RME). It can be either anchored only to the bone that is using only skeletal anchorage and is known as bone-borne type of maxillary expander. Another type of expander could be anchored both to the bone and tooth, and thus, is known as the hybrid type or bone-tooth borne type of maxillary expander. The effects of bone-anchored maxillary expanders are usually studied for a short duration after the expansion as shown by Lee et al.[9]

However, the effects of bone-anchored maxillary expander in the long term are not well known. This review will highlight the current trends in orthodontics regarding bone-anchored maxillary expansion or mini-screw assisted rapid palatal expansion.

1. How age and maturation affect the success of bone-anchored maxillary expansion:

It has been shown from the histologic studies that midpalatal suture undergoes increased ossification after the age of 14-16 years.[10,11]

Therefore, it is prudent to apply conventional rapid maxillary expansion or tooth-anchored rapid maxillary expansion to patients before this age. Additionally, gender also affects the age of mid-palatal suture ossification as females reach maturation earlier than males. However, as compared to conventional rapid maxillary expansion, the utility of bone-anchored maxillary expansion or mini-screw assisted rapid palatal expansion is that it leads to increased opening of the mid-palatal suture even in older patients.[12] The rate of successful application of bone-anchored maxillary expansion has been estimated to be above 82 percentage.[5,12,13]

2. Asymmetric expansion with rapid maxillary expansion appliances:

Earlier in the orthodontic field, two-dimensional (2D) radiographs have been used widely for the purpose of assessing maturity indicators such as cervical vertebrae maturation, mid-palatal suture ossification, and effects of orthodontic treatment such as root resorption, and alveolar bone loss.[14,15,16] However, it has been reported that the three-dimensional radiographs such as cone-beam computed tomography (CBCT) leads to a more accurate evaluation of cervical vertebrae maturation, mid-palatal suture ossification and root resorption as compared to 2D radiographs.[15,16,17] This is clinically important as with higher ossification of mid-palatal suture, it can lead to unintentional asymmetric expansion.[18,19] In certain cases, such as unilateral crossbite, asymmetric expansion may be required by the clinicians.

In such conditions, unilateral expansion of the maxillary arch will be very useful. Certain designs have been proposed in the past such as unilateral surgical assisted rapid maxillary expansion (SARME) to cause the expansion of maxillary arch only the crossbite side.[20] But this technique involves surgery and patients frequently do not wish to undergo such invasive procedures. Recently, an alternative technique to unilateral SARME has been proposed and is known as unilateral mini-screw assisted rapid palatal expansion (U-MARPE).[21] U-MARPE is a technique in which mini-screws as placed on the non-crossbite side of the palate. The expander is connected to the mini-screws on the non-crossbite side and to the teeth on the crossbite side. As the expander is opened, it applies transverse forces on the teeth on the crossbite side and leads to correction of the unilateral crossbite.[21]

3. Corticopuncturing of palatal bone:

A consideration for increasing the success of bone-anchored maxillary expansion is the procedure of corticopuncturing of the bone in the maxillary palate. This procedure helps to increase the separation of the mid-palatal suture. In some cases, when the mid-palatal suture does not open in adults after mini-screw assisted rapid palatal expansion, the corticopuncturing procedure helps in achieving the mid-palatal suture separation as shown by Suzuki et al.[22]

4. Other Considerations for the successful application of bone-anchored maxillary expansion:

Other than the consideration of unilateral or bilateral crossbite of the patient, other considerations for bone-anchored maxillary expanders are the mid-palatal suture density, length of the maxillary palate, but not the classification of skeletal malocclusion vertically and sagittally.[23] The effects of mini-screw assisted rapid maxillary expanders on the pterygopalatine sutures is also considered to be a determining factor for success. If the pterygopalatine sutures separate, then the chances of separation of the mid-palatal suture increases. However, if the pterygopalatine sutures do not separate after bone-anchored maxillary expansion, then the amount of separation of the mid-palatal sutures is low.[19] One important consideration in the success of rapid palatal expansion is also the type of bonding materials used for cementing the expanders. With the advent of newer materials such as Transbond and Smartbond, the bonding failures have decreased. This is particularly important for bonded rapid palatal expanders.[24-27]

5. Skeletal Effects of mini-screw assisted rapid maxillary expansion

Bone-anchored maxillary expansion when assessed with conventional rapid maxillary expansion have shown comparable effect on increasing the arch-width and the inter-molar distance.[8,28] The proportion of dental expansion and skeletal expansion with mini-screw assisted rapid palatal expansion and conventional rapid maxillary expansion has been shown at various ranges in the previous studies. The determination of how efficient is the expansion appliance in achieving the opening of mid-palatal suture is done by evaluating the ratio of the amount the expansion screw is opened to the amount of separation obtained at the mid-palatal suture. This ratio has been found to be in range of 60 to 71% by Canterella et al.[28] Another study reported the percentage of maxillary skeletal expansion to be 37%.[12] However, these studies only showed the short-term effects of expansion and long-term effects are still not explored. In a study on the long-term effects of bone-anchored maxillary expansion, Mehta et al. reported that that the amount of skeletal expansion is higher in bone-anchored maxillary expansion than tooth-anchored maxillary expansion in the long-term.[8] It can be inferred from the current literature that the amount of skeletal expansion obtained with bone-anchored maxillary expansion is greater than conventional rapid maxillary expansion.

In addition to the amount of separation of mid-palatal suture, the type of mid-palatal suture opening with bone-anchored maxillary expansion and conventional rapid maxillary expansion is also different. Conventional rapid maxillary expansion leads to a triangular opening of the mid-palatal suture.

Whereas, with mini-screw assisted rapid maxillary expansion, is almost parallel or straight.[8,28] The change in the palatal width change with bone-anchored maxillary expansion has been described to be higher than conventional rapid maxillary expansion immediately following expansion.[5,8,9] However, it is important to identify whether these results lead to an increase in palatal width in the long-term. Most studies have not shown an adequate follow-up period for the evaluation of results of stability of the correction achieved with the different expansion appliances. A study by Choi et al. reported the long-term outcomes of mini-screw assisted rapid palatal expansion and showed good stability of the results.[5] But, in this report, even though the long-term outcomes were described, the results were not compared with conventional rapid maxillary expansion. In a study by Mehta et al., the results of the long-term outcomes of mini-screw assisted rapid palatal expansion were evaluated and compared with the results of conventional rapid maxillary expansion and controls.[8] In this study, it was reported that there was a higher palatal width in the patients who underwent mini-screw assisted rapid maxillary expansion compared to the patient with conventional rapid maxillary expansion immediately after expansion, but also in the long-term. Thus, it can be concluded that the stability of the results achieved with mini-screw assisted rapid palatal expansion are acceptable compared to conventional expansion.

6. Dental effects of rapid maxillary expansion appliances

The dental effects of rapid maxillary expansion can be analyzed by the change in molar angulation and evaluating the amount of buccal tipping of maxillary molars. In comparison with conventional rapid maxillary expansion, mini-screw assisted rapid palatal expansion leads to decreased buccal tipping of maxillary molars indicating decreased dental side effects.[5,612] In addition to the buccal tipping with expansion appliances, the decreased buccal bone thickness and vertical bone level have been described as the unwanted side-effects. It has been found that the amount of decrease in buccal bone thickness and vertical bone level with mini-screw assisted rapid palatal expansion appliances is lower or equivalent to the conventional maxillary expansion appliances.[5,12] It is important to compare these findings with control over the long-term to evaluate whether these changes are detrimental to the periodontal condition of the teeth.

7. Soft-tissue effects of rapid maxillary expansion appliances

The soft-tissue changes with bone-anchored maxillary expansion and conventional rapid maxillary expansion have shown a laterally directed movement of the nasal structures indicating an increased nasal width. In addition, to the transverse plane, Lee et al. showed that there are changes in the sagittal and vertical plane as well. The authors observed that there is a trend for inferiorly directed movement and anteriorly directed movement of the nasal soft-tissues with mini-screw assisted rapid palatal expansion.[29] However, these results showed only the immediate effects after expansion procedures. In a study by Abedini et al., it was described that there were changes in the paranasal regions and the medial aspects of the cheeks after 1 year following expansion.[30] The changes in these regions were also in the same direction, mainly laterally and anteriorly directed movements. The soft-tissue changes reported in these studies are a reflection of the hard-tissue changes observed with rapid maxillary expansion.[17]

8. Airway effects of rapid maxillary expansion appliances

The effects of expansion appliances leads to widening of nasal cavity and thus, can cause an improvement of the breathing.[31] Bone-anchored maxillary expansion has been described to cause an increased skeletal expansion of maxilla and thus, it has been a belief in orthodontic world that it may lead to a greater improvement of airway abnormalities. But, airway is not only restricted to bony structures, it is also affected by the adjacent soft-tissues. CBCT studies have evaluated the effect of mini-screw assisted rapid palatal expansion on airway dimensions and airway volume. After expansion, there is an increase in the nasal airway volume and nasopharynx airway volume.[8,32,33,34] However, the interesting observation is what happens to the airway structures in the long-term. The studies evaluating the airway structures at 1 year follow p showed that there is increase in volume of nasal cavity.[32] However, another study evaluating the airway structures at 2.5 years, showed no difference in the volume of nasal cavity between mini-screw assisted rapid maxillary expansion, conventional maxillary expansion, and controls.[8] But, the authors reported an increase in the nasopharyngeal volume 2.5 Years following expansion with min-screw assisted rapid palatal expansion.[8]

The effects of expansion appliances on airway as evaluated with computational fluid analysis has shown an upsurge in the volume of upper airway and reduction of the airflow velocity and pressure in the upper airway with mini-screw assisted rapid palatal expansion.[34] However, further studies are needed, especially with long-term follow-up to investigate the effects of expansion appliances on airway.

Conclusion:

The design and protocol of rapid palatal expansion appliances have been updated over time by orthodontists to achieve higher desired skeletal effects and reduce the unwanted dental side-effects. In particular, the recent development of mini-screw assisted rapid palatal expansion appliances have increased the scope of rapid palatal expansion appliances to late adolescents and even adults. In the current literature, there is a deficiency of studies on the long-term effects of bone-anchored maxillary expansion appliances, thus the results of the current studies should be interpreted with caution. Further studies on the long-term effects of bone-anchored maxillary expansion are required.

Conflict of Interest

The authors declare no conflict of interest.

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Citation: Yagnik N, Parikh K. "Bone-Anchored Maxillary Expansion: A Contemporary Evidence Based Review". SVOA Dentistry 2:4 (2021) Pages 143-147.