

Rapid Maxillary Expansion and Its Effects on Stomatognathic System: Review Article

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ABSTRACT

Expansion is a tempting means of gaining space, and it has been stated that crowding is due to posterior crossbite that develops early and is not self-correcting. Angle described the first use of rapid maxillary expansion (RME) in 1860, and he taught that the ideal occlusion can be achieved when all teeth are accommodated in the dental arch to get a functional efficiency and to ensure a permanent result. Since reduced transverse dimension can also be an etiologic factor for the development of arch length discrepancies, expansion can be used for alleviating the crowding in selective cases. In RME, the dental and skeletal effects have been well documented, for correcting maxillary alveolar constriction. The expansion appliances can be classified into removable, semi-fixed, or fixed appliances, and based on the mode of activation, it can be either slow or rapid. The objective of this article is to create a better understanding of expansion as an important part of orthodontic treatment modality which can be a very valid solution to many space problems during treatment, as it is one of the most frequently used methods of gaining space.

Keywords: Dental, Dentistry, Growing patient, Orthodontics.

Journal of Scientific Dentistry (2021): 10.5005/jp-journals-10083-1011

BACKGROUND

Expansion is a tempting means of gaining space, and it has been stated that crowding is due to posterior crossbite that develops early and is not self-correcting. Angle¹ described the first use of RME in 1860, and he taught that the ideal occlusion can be achieved when all teeth are accommodated in the dental arch to get a functional efficiency and to ensure a permanent result.

Since reduced transverse dimension can also be an etiologic factor for the development of arch length discrepancies,² expansion can be used for alleviating the crowding in selective cases. In RME, the dental and skeletal effects have been well documented,³ for correcting maxillary alveolar constriction. The expansion appliances can be classified into removable, semi-fixed, or fixed appliances, and based on the mode of activation, it can be either slow or rapid.

Depending on the growth status of the individual, RME produces orthodontic and/or orthopedic effect.⁴ Clinically, expansion with the use of the above appliance can be elicited by the appearance of midline diastema, and maxillary posteriors get laterally tipped. The movement and expansion of maxillary segment can occur when the applied forces are of sufficient magnitude.⁵

Cooperation of patient especially during the mixed dentition period is essential for a good result. Debate is still being done on the stability and progress of expansion since the day of expansion has been put forward. It is generally agreed that when both the upper and lower arches are simultaneously expanded, relapse may occur.⁶ With the absence of a proper retention protocol, the position of the expanded dental arches will not be stable and relapse will occur.

The objective of this article is to create a better understanding of expansion as an important part of orthodontic treatment modality which can be a very valid solution to many space problems during treatment, as it is one of the most frequently used methods of gaining space.

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How to cite this article: Arun V, Sankar H, Kumar VV, Varma AJ. Rapid Maxillary Expansion and Its Effects on Stomatognathic System: Review Article. *J Sci Den* 2021;x(x):xx-xx.

Source of support: Nil

Conflict of interest: None

GENERAL CONSIDERATION

The cranial and facial bones of vertebrae are of intramembranous region. At the periosteal surface, cranial and facial bones were reshaped by resorption and opposition of bone.⁷ The sutures in the skull perform a number of functions. They integrate bones, absorb forces, act as joints that enable relative movement between bones, and serve as growth sites in the developing skull.

Changes at Midpalatal Suture

Melsen B⁸ studied the maturation of the midpalatal suture histologically at various stages of development using autopsy material.

Infantile stages (up until the age of 10): The suture was wide, smooth, and "Y" shaped (Fig. 1).

Juvenile stages (at the age of 10–13): It had transformed into a more conventional squamous suture with overlapping segments, and was "T" shaped (Fig. 2).

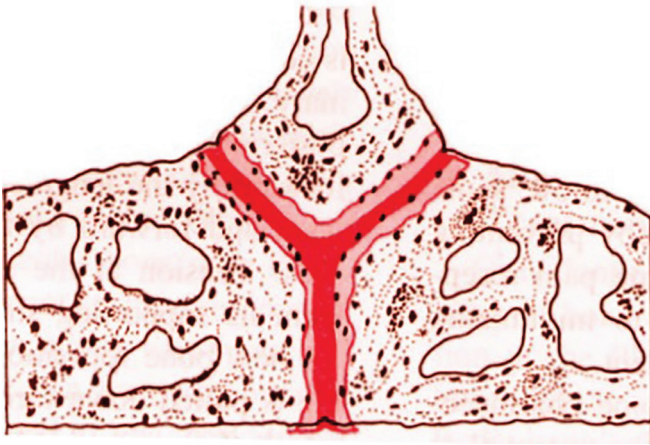


Fig. 1: Y-shaped suture



Fig. 2: T-shaped suture

Adolescent stages (at the age of 13 and 14): The suture became weaker once the pressure was increased. Interdigitations have "jigsaw puzzle" appearance (Fig. 3).

Growth takes region via way of means of sutural tissue proliferation exerting a setting apart pressure at the bony edges. Fibers connecting the bony edges run obliquely in an overlapping suture. Praha additionally claimed that shortening of those fibers at some point of the suture's bony borders may separate as the suture matures.⁹

According to Hass,¹⁰ when the suture opens, during expansion, mostly in patients who are under the age of 16 or 17, the following changes can be appreciated:

- Parallel opening of the suture superior inferiorly.
- The maxilla will move forward and downward when the suture gets open.
- Downward and backward rotation of mandible will change the posture of maxilla.
- The crown converges as the suture expands, whereas the root diverges.¹¹

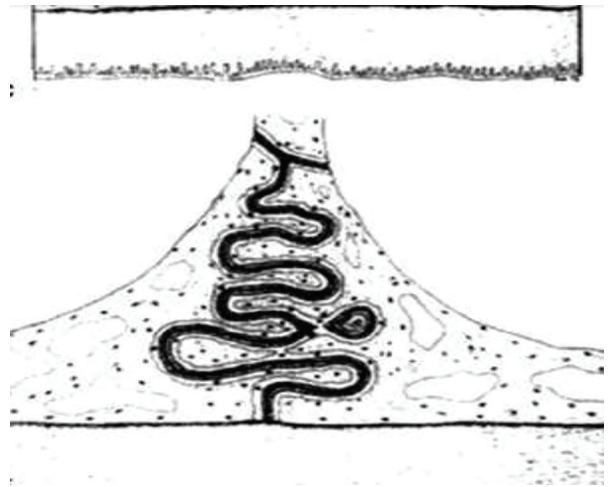


Fig. 3: Jigsaw puzzle appearance

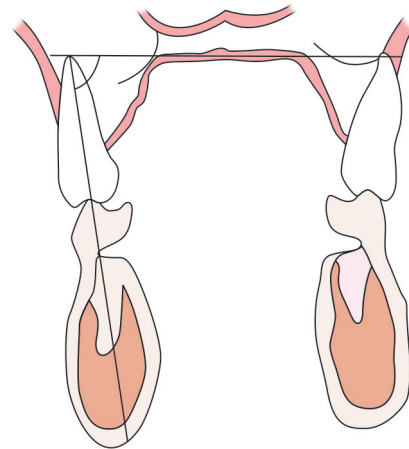


Fig. 4: Buccal axial inclination

CLINICAL EVALUATION OF SKELETAL AND DENTAL CROSSBITE

In crossbite, deficiency involving in the apical base is wider, there is a recession in the apical base, and the alveolar process is widening or lateralizing. The axial inclination of crossbite teeth can help to determine if the abnormality is skeletal or dento-alveolar in nature.¹² Buccal axial inclination (Fig. 4) of dento-alveolar origin is indicated by a deficit in the apical base width and lingual axial inclination within the apical base width.¹³

In addition to the usual diagnostic aids like study models, intra-oral and extra-oral photographs and lateral cephalograms occlusal view radiograph of the maxillary arch and PA view, cephalograms are often advised to assess the patency of the midpalatine suture and the extent of transverse discrepancy, respectively.

CLASSIFICATION OF EXPANSION (TABLE 1)

Table 1: Classification of expansion

<i>According to category</i>	<i>According to time</i>	<i>According to tissue involved</i>	<i>According to direction</i>
• Passive	• Slow	• Dental	• Unilateral, Bilateral
• Orthodontic	• Semi-rapid	• Skeletal	• Anterior, Posterior
• Orthopedic	• Rapid		• Three-dimensional
			• Individual tooth

METHODS OF EXPANSION

Slow Maxillary Expansion

SME techniques lower tissue resistance surrounding the circummaxillary structures and, as a result, promote bone development in the intermaxillary suture, obviating or reducing the limitations of RME.

Coffin Appliance

Given by Walter Coffin (1875), the coffin appliance (Fig. 5) is made up of a 1.25-mm-thick omega-shaped wire that is placed in the midpalatal area. The omega wire's free ends are placed in acrylic that covers the palate's slopes. The spring is actuated by manually pushing two apart. Patients tolerate 0.2–0.5 mm of expansion a day for 1–3 weeks in developing youngsters, depending on the amount of expansion desired and the frequency of daily activations.¹⁴

Isaacson, Ingram and Zimring¹⁵ Ohshima et al. have argued that slower rates of expansion would allow for a slow expansion in monkeys.

Quad Helix

Ricketts described the quadhelix appliance (Fig. 6), and Coffin's W-spring. The incorporation of four helices into the W-spring helped to increase the flexibility and range of activation. The length of the palatal arms of the appliance can be altered depending upon which teeth arch in crossbite. A new generation of prefabricated appliances, constructed from nickel titanium, have been introduced more recently. The advantages of using nickel titanium over stainless steel include its more favorable force delivery characteristics as it has superelastic properties.

Semi-rapid Maxillary Expansion

RME is followed by slow maxillary expansion, which occurs shortly after the separation of the midpalatal suture, namely semi-rapid maxillary expansion (SRME) suture. A modified McNamara RME device was cemented with an extension screw attaching right and left maxillary dental acrylic components to each other using a Hyrax type maxi screw (Fig. 7). The screw was turned twice a day for the first 7 days, then once a day until the palatal cusp of the upper molar made contact with the buccal cusp of the lower molar. After this initial treatment, when the maxillary arch was sufficiently over-expanded, the screw was attached with a steel ligature wire. Mew presented a review on semi-rapid palatal expansion. Although used by Fauchardin 1728, expansion appliances were probably first pioneered by Kingsley (1890). They were very popular in the early part of this century, when they were often provided for rhinological as well as dental treatment (Pollock, 1968).

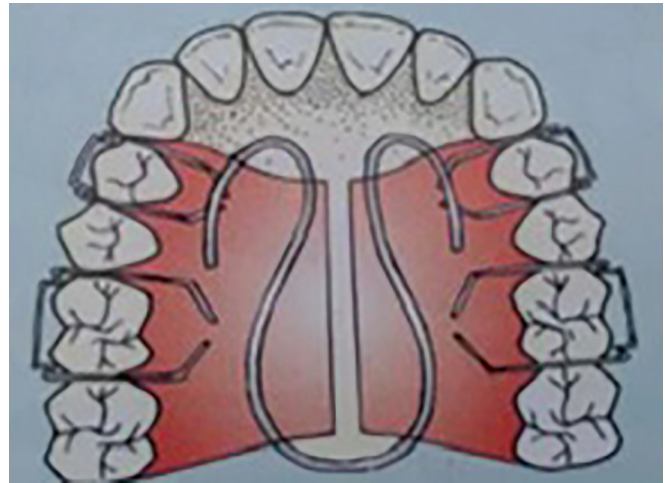


Fig. 5: Coffin appliance



Fig. 6: Quad helix



Fig. 7: Hyrax type maxi screw

Rapid Maxillary Expansion

Emerson Angell originally characterized rapid maxillary growth in 1860, and Haas popularized it subsequently. Maxillary expansion treatments have been used to treat maxillary transverse deficiency for over a century. When heavy and rapid stresses are applied to the posterior teeth, there isn't enough time for tooth movement; therefore, the forces are transferred to the sutures. Although the teeth only move significantly relative to their supporting bone, the sutures open up when the force generated by the appliance exceeds the limit required for orthodontic tooth movement and sutural resistance.

RME's Impact on the Maxillary and Mandibular Complexes¹⁶

- **Maxillary skeletal effect:** The midpalatine suture does not expand in a parallel or triangular fashion, with the maximum opening in the incisor region and gradually opening toward the posterior region.
- **Maxillary halves:** The downward and forward displacement of the maxilla was discovered by Haas and Wertz.
- **Palatal vault:** According to Haas, the lateral inclination of the maxillary part decreased the palatine process of the maxilla.
- **Alveolar process:** Early in RME, lateral bending of the alveolar processes occurs; in a few days, it will rebound.
- **Maxillary anterior teeth:** Diastema between central incisors develops.
- **Maxillary posterior teeth:** The resistance provided by the zygomatic buttress and pterygoid plates will lead the posterior maxilla to expand less due to extrusion and buccal tipping of maxillary molars, as well as the resistance produced by the zygomatic buttress and pterygoid plates.
- **Effect of RME on mandible:** Downward and backward rotation of the mandible.
- **RME and nasal airflow:** Breathing will improve as the nasal cavity widens as a result of growth. About 1.9 mm of average width gain is at nasal cavity, but can be wide as 8–10 mm.

BANDED RAPID PALATAL EXPANDER

Of the two types of appliances (banded and bonded), because there is no/limited palatal covering, banded appliances are clean. There are two types of banded RME: tooth-borne and tooth- and tissue-borne.

Tooth-borne RME

- **Isaacson expander:** The spring-loaded Minne expander is soldered to the band on first premolars and molars, and it is a tooth-borne appliance with no palatal covering.

The Minne expander (Fig. 8) is a calibrated coil spring that is compressed by rotating a nut. The abutment teeth' bands are soldered to two metal flanges that are perpendicular to the coil. The Minne expander may continue to apply expansion pressures after the expansion phase is completed unless it is completely disabled.

- **HYRAX expander:** It is a tooth-borne appliance that was first introduced in 1968 by William Biederman.

A specific screw known as HYRAX (Fig. 9) is used in this sort of equipment (Hygienic Rapid Expander).

The main advantage of this expander is that it does not irritate the palatal mucosa and is easy to clean. Each quarter turn (or 90°) of the screw provides approximately 0.2 mm of lateral expansion. Sutural separation can be obtained in a short period of time, and expansion of up to 13 mm can be done.

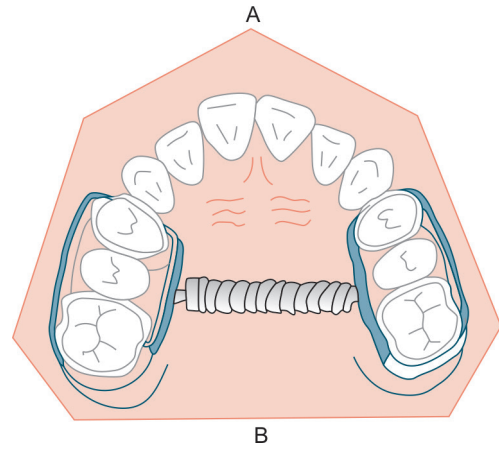


Fig. 8: Isaacson expander



Fig. 9: Hyrax expander

Tooth- and Tissue-borne RME¹⁰

The advantages of tooth- and tissue-borne RME appliances were outlined by Haas in 1970.¹⁷ Greater nasal cavity and apical base gain, more favorable connection of the denture bases in width and often in the anteroposterior plane instead of teeth, the maxilla is given significant movement.

Types of Tooth- and Tissue-borne RME

- **Haas:** The rapid expansion method is based on disrupting the sutural connective tissue to cause instantaneous midpalatal suture separation. According to Haas, a rapid palatal expander is a rigid appliance that uses a jackscrew (Fig. 10) to extend in 10–14 days for maximum dental anchoring. The forces produced by this device are said to be in the range of 3–10 pounds, which he feels will have the greatest orthopedic impact.
- **Derichsweiler:** The first premolars and molars are banded. These bands have wire tags soldered on them, which are then put into the split palatal acrylic with screws (Fig. 11).

BONDED RAPID PALATAL EXPANDER

Cohen and Silverman described the bonded RPE in 1973, posterior segments are constructed with an acrylic cap, and they are bonded directly to the teeth. The advantages of bonded appliances are as follows:¹⁸ During the mixed dentition stage, it is easy to cement the



Fig. 10: Hass-type expander

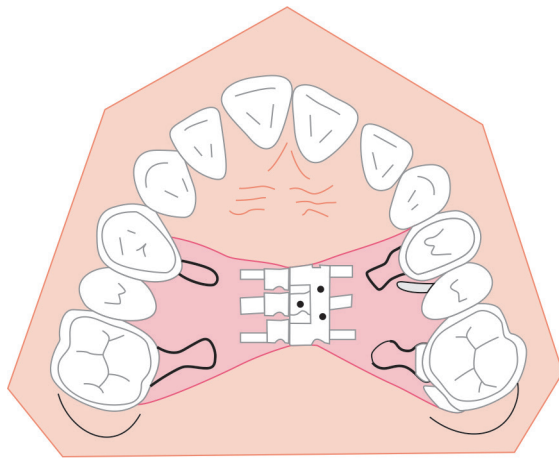


Fig. 11: Derichsweiler expander

appliance, when retention from other appliances may be inadequate. There are fewer appointments, and there is less posterior tooth tilting and extrusion, because molar extrusion would lead the mandible to autorotate backward and downward, increasing facial convexity, and the vertical dimension of the lower face. Buccal capping prevents this and enhances vertical control. This is especially effective in Class II situations, when molar extrusion would force the mandible to autorotate backward and downward, increasing facial convexity, and the lower face's vertical dimension. It has a bite block effect that helps with anterior crossbite repair (McNamara).

IPC RAPID PALATAL EXPANDER

Inman power component (IPC) (Fig. 12) is being used for incisor labial alignment and orthopedic expansion. As the IPC expands, it regulates the NiTi open coil spring force applied to the lingual surface of the anterior teeth. A wire inserted across the distal end of the lateral incisors limits the midline diastema that arises after RPE treatment.

CLINICAL MANAGEMENT OF RME

As with any appliance, proper explanation of the working and activation protocol should be provided to the patient and/or guardian, so as to achieve proper results. After fabrication of the



Fig. 12: IPC rapid palatal expander

appliance, the clinician must make sure that the appliance fits accurately and seats without causing pain or discomfort. A film of cement is applied to the dried internal fitting surface of the bands or cap splints and pressed firmly, and the excess cement is then removed and checked.

RME Activation Protocol¹⁹

Haas regimen:¹⁹ After meals, two turns every day until the desired expansion is attained.

Timms regimen for adolescents: Every day, make two turns until the necessary expansion is achieved. For adults: four quarter rotations every day until desired growth is attained.

Isaacson regimen:²⁰ Two turns per day were necessary for the first 45 days, followed by one turn per day for the remainder of the RME treatment.

Hybrid regimen: Combination of two or more of the above, as desired by the clinician.

Patients have been divided into three age groups to make instructions easier to follow (Table 2).

RETENTION AND STABILIZATION

The goal of retention is to keep the expansion that has been achieved while also keeping all of the forces created by the appliance. For the first 3 months following expansion, the appliance is left as such following sealing of the screw with composite material, and it acts as the retention appliance. During this phase, stabilization of the patent suture occurs. After this, a removable retention plate is made consisting of four Adam cribs. The time required is to allow maximum recovery and to minimize relapse.

Iron implants were employed, and it was discovered that the suture's expansion is highly stable after 3 months of retention; however, the unavoidable buccal tipping of premolars and molars was followed by a long period of uprighting (Krebs et al.²¹). After

Table 2: Classification of expansion

Up to age 15 years	Age 15–20 years	Age over 20 years
180° daily rotation—90° turn morning and evening	180° daily rotation—45° turn at four equal time lapses	45° turn morning and evening

3 months, the process of mineralization has become relatively well established in the enlarged suture (Ekstrom et al.). The retention time of RME is determined not only by the development of the midpalatal suture, but also by the establishment of a stable relationship at the articulations of the maxilla and other bones of the facial skeleton. Furthermore, it appears that the amount of residual load remained at the end of appliance activation impacted the amount of time required for skeletal modifications during retention.²²

RELAPSE

Rapid maxillary expanders have been claimed to increase stability following retention by expanding maxillary sutures. The skeletal component of arch enlargement achieved by the expansion appliance, as opposed to dental expansion achieved by edgewise appliance mechanotherapy, has been attributed to stability. The causes of relapse can be summarized (i) due to the significant stress that could accumulate between the craniofacial complex's articulations, (ii) due to the tension produced in the palatal mucosa, and (iii) as a result of maxillary expansion, there may be an imbalance between buccal and lingual forces. Thorne (1960) found that cases kept for less than 2 months showed a high rate of relapse.²³ There was no significant relapse when cases were retained for less than 2 months, while cases kept for more than 2 months showed complete stability. It has been suggested that the position of the muscle attachments and associated soft tissues changes during rapid expansion. (Starnbach H 1966)²⁴ published the results of an interesting series of experiments with animals. "The slow separation with continued growth of bone serrations within the suture provides the best form of retention with the least chance for recurrence," he declared emphatically. After all, the recommended rate of rapid expansion of 3–4 mm/week is close to the capillary network's maximal rate of expansion and so it is hardly surprising to find poor repair in the distorted tissue. It is very possible that the expansion screws used in the past were less efficient, causing the same opening to take as long as 6 months. Perhaps, this was the reason for the history of the relapses.

RECENT ADVANCES

SARPE

Surgically aided RPE (Fig. 13) is an alternate way for correcting maxillary constriction in adults by reducing the resistance of the

closed midpalatal suture. In a skeletally mature patient, it permits clinicians to achieve effective maxillary expansion.

Indications for SARPE

To provide space for a crowded maxillary dentition when extractions are not indicated, to widen maxillary hypoplasia associated with clefts of the palate, to reduce wide black buccal corridors when smiling, to overcome the resistance of the sutures when open manage essential (OME) has failed.

Surgical Technique

Bell described surgical technique:²⁵

- Before surgery, a stiff fixed tooth-borne appliance capable of delivering orthopedic forces is attached to the first molars and premolars of the maxilla.
- The operation may be performed with the patient under general anesthesia or local anesthesia.
- A paramedian incision is made under local anesthesia.
- The expansion appliance should be cemented in place immediately after surgery and activated by the surgeon three or four quarter turns after the bony cuts are made.

Retention, Stability, and Relapse

Surgical expansion, according to most assessments, is steadier than OME. According to some writers, retention is not required for SARPE, and the orthodontist can begin treatment without a waiting period. Other writers advocated a retention period of 2–12 months after expansion. Relapse rates for SARPE range from 5% to roughly 25%. These percentages are much lower than the OME relapse rate, which can be as high as 63%, 68%, or 95%. Because OME is used in skeletally advanced patients, it has a high rate of relapse. In older patients, OME is neither predictable nor stable.^{26,27}

MARPE

MARPE appliance (Fig. 14) is a novel version of the RME appliance that has evolved as a breakthrough in transverse malocclusion correction Mew J (1993).²⁸ It has shown to be a viable and effective nonsurgical treatment for young people since its beginning.

Indications for MARPE

MARPE has an effect on both respiration and occlusion. Separate evaluations of both respiration and occlusion found that both were

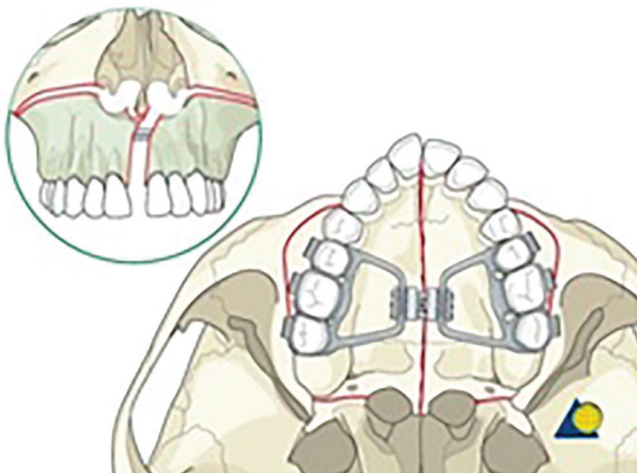


Fig. 13: SARPE



Fig. 14: MARPE

mutually supporting one another in the majority of patients. For example, buccal crossbite is connected to higher nasal resistance and mouth breathing.

Advantages of MARPE

When compared to other conventional expansion methods, which take 2–6 months to complete, treatment time is quite short, ranging from 1 to 4 weeks of active expansion. MARPE also enables for simultaneous fixed orthodontic therapy and extension because it is not dependent on any anchor teeth units. With minimum dental tipping effects, maximum skeletal displacement can be accomplished. The treatment is more stable at the end since the maxillary posterior teeth are not tipped as much buccally as in standard expansion surgery.

Respiratory Airway Effects

According to studies, addressing the nasomaxillary insufficiency with orthopedic expansion also changes the aberrant breathing pattern. The tongue posture and muscular dynamics are likely to be altered in post-MARPE individuals who prefer nasal breathing, and expiratory peak flow is improved by indirectly enlarging the nasopharyngeal airway. Nasal inspiratory peak flow, which is an indication of nasal and oral obstruction, can be enhanced immediately after expansion and maintained for up to 5 months.²⁹

The improvement in the airway is more than the area of one nostril when the nasal floor is enlarged by 1 mm (Schwartz, 1955). For bilateral crossbite with nasal stenosis, rapid expansion is only half of the treatment protocol. James et al. (1968) reported that there is an excessive narrowing of the upper arch accompanied with a unilateral or bilateral crossbite with nasal stenosis in a specific kind of Class II division 1 malocclusion. There is often impairment in the nasal airway and mouth breathing. In this situation, the nasal airway is immediately improved, and the crossbite is corrected with quick maxillary expansion. Before and after RME, nasal airflow was measured at rest and during modest exercise.³⁰ He showed that only one of the four people with breathing problems had an increase in nasal airflow, while the other three had a small decrease. A modest rise or reduction in nasal airflow was observed in the group that had no difficulty in breathing. When assessed at maximum effort, all patients showed an increase in nasal air volume capacity.

CONCLUSION

Expansion is one of the methods of gaining space in the dental arch. The great debate between the extraction- and non-extraction-based orthodontic treatments still remains to date. In the earlier days, nonextraction approach did not give stable results due to the lack of coordination between the two arches. Expansion can be considered as an alternative to extraction treatment modality in borderline cases, where the patient has a pleasing or slightly deficient soft tissue profile. With a wide variety of appliances that are available to the clinician, they should be judiciously used in order to achieve a stable result. The use of bonded appliances over banded appliances can be advantageous as they will cause symmetric advancement of maxilla and less downward and forward displacement of maxilla compared to banded appliances.

Traditionally, successful treatment with the use of RME has been limited to growing individuals. With the advent of surgical adjuncts and/or miniscrews, it has broadened the scope of expansion of maxilla even in individuals in their late teens and early 20s, as well

as adults. There is no significant difference in stability between surgically treated RME and nonsurgically treated RME.

Nothing is known in our profession by guess, and I do not believe that from the first dawn of medical science to the present moment a single correct idea has ever emanated from conjecture, it is right therefore that those who are studying their profession should be aware that there is no short cut to knowledge

-Sir Astley Paston Cooper

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