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College of Dentistry

Crossbite

A Project
Submitted to the College of Dentistry,
University of Baghdad, Department of Orthodontics
in Partial Fulfillment for the
Bachelor of Dental Surgery

By
Mina Mahdi abed

Supervised by:
Assist. Prof. Dr. Shahbaa AbdulGafoor Mohammed
B.D.S., M.Sc., Ph.D.

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Certification of the Supervisor

I certify that this project entitled "**Crossbite**" was prepared by **Mina Mahdi abed** under my Supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name: Assist. Prof. Dr. Shahbaa AbdulGafoor Mohammed
Date: 1/4/2022

Dedication

Now I'm standing in front of 17 years from my life as a hard working student getting knowledge and be effective in my way, by the end of the first journey

I dedicate this graduation project to my dear mother and father who supported me in every step of my life and be my backbone in my joys and sorrows, my companions on the path,

My sisters , thank you to be there always by my side, in my dark days and moments even before happy days

My friends , i will remember you always as my people who never let me alone , as a wonderful journey partners

We finished These steps together,

Always remember our days that pass heavily on us

But by the end , we did it together ! wishing God to protect them and protect everyone from all evil.

So finally

To my darkest day those pass

SEE ME !! I'M STRONG AND I PASS YOU !

SEE ME ! AlTHOUGHT YOU , I SUCCESS !

And now When I stand before God at the end of my life, I would hope that I would not have a single bit of talent left, and could say, " I used everything you gave me , my strengths, my patience , intelligence and all thing you put in me ,"

Mina Mahdi abed

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First and foremost, praises and thanks to **Allah** Almighty for helping me fulfill my dream, for his blessings throughout my work to complete it successfully.

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List of Abbreviations

EMG	Electromyography
UPCB	Unilateral posterior crossbite
RME	rapid maxillary expansion
SME	slow maxillary expansion
MARPE	miniscrew-assisted rapid palatal expander
MSE	maxillary skeletal expander
SARPE	Surgically Assisted Rapid Palatal Expansion
RPE	Rapid maxillary expansion
AMEX	asymmetric maxillary expansion
TADs	temporary anchorage devices
MTD	maxillary transverse deficiency
OME	orthopedic maxillary expansion

Introduction

Malocclusion is an improper or misalignment relationship between the teeth of the lower and upper dental arches, when the jaws close **(Yamany, 2019; Asgari et al., 2020)**. Malocclusion is a common disease encountered in dental care, specifically, it is the third following periodontal disease and dental caries and hence ranks third among global public health dental disease priorities **(Singh and Sharma, 2014)**.

Crossbite is a condition where one or more teeth may be abnormally malposed bucally or lingually or labially with reference to the opposing tooth or teeth. One or more of the upper teeth biting on the inside of the lower teeth characterizes a crossbite. Cross bite can involve a single tooth or a group of teeth. Cross bite can occur in the front and/or the sides of the mouth. Cross bite is an occlusal irregular condition where a lower tooth has a more buccal position than the antagonist upper tooth or vice versa. Cross bite can be classified as anterior or posterior **(Alam et al., 2012).**

Anterior cross bite is a malocclusion in which one or more of the upper anterior teeth occlude lingually to the mandibular incisors; the lingual malposition of one or more maxillary anterior teeth in relation to the mandibular anterior teeth when the teeth are in centric relation. Posterior cross bite refers to an abnormal transverse relationship between the upper and lower posterior teeth. Thus posterior cross bite occurs as a result of lack of co-ordination in the lateral dimension between the upper and the lower arches. The majority of cross bites are caused by dental factors. Arch length discrepancy, retained deciduous tooth, thumb sucking habit, nasal obstruction, narrow maxilla and mouth breathing may cause cross bite. Early correction of cross bites is recommended **(Bishara, 2001; de Sousa et al., 2014)**.

Aims of the Study

1. Determine different types of crossbite and their etiology
2. Evaluate the impact of crossbite on oral health
3. Review the literature about new techniques used for maxillary expansion

Chapter One: Review of literature

1.1 Anterior crossbite

1.1.1 Etiology

Anterior crossbite, particularly crossbite of all of the incisors, is rarely found in children who do not have a skeletal Class III jaw relationship. A crossbite relationship of one or two anterior teeth, however, may develop in a child who has good facial proportions. When racial or ethnic groups in the U.S. population are combined, about 3% of children have an anterior crossbite in the mixed dentition (Fig. 1) **(Proffit, 2019)**.

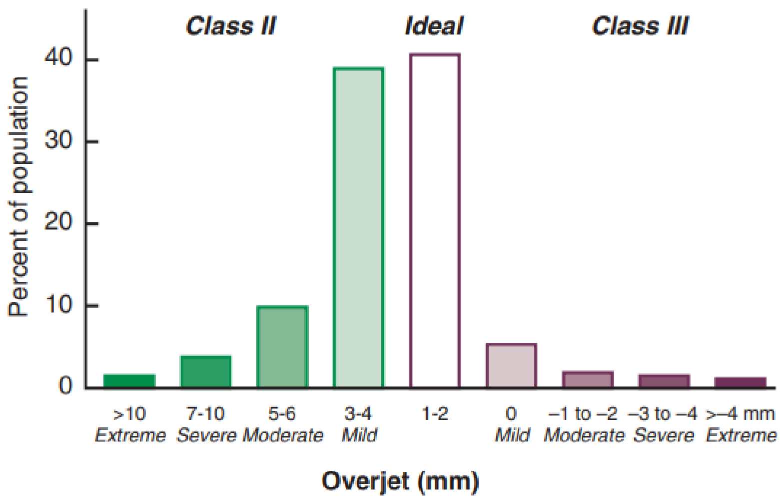

Fig. 1: Overjet (Class II) and reverse overjet (Class III) in the U.S. population, 1989 to 1994. Only one-third of the population have ideal anteroposterior incisor relationships, but overjet is only moderately increased in another one-third. Increased overjet accompanying Class II malocclusion is much more prevalent than reverse overjet accompanying Class III.

In planning treatment for anterior crossbites, it is critically important to differentiate skeletal problems of deficient maxillary or excessive mandibular growth from crossbites due only to displacement of teeth. If the problem is truly skeletal, simply changing the incisor position is inadequate treatment, especially in more severe cases **(Ceyhan et al., 2017)**.

Anterior crossbite affecting only one or two teeth almost always is due to lingually displaced maxillary central or lateral incisors. These teeth tend to erupt to the lingual because of the lingual position of the developing tooth buds and may be trapped in that location, especially if there is not enough space (Fig. 2). Sometimes, central incisors are involved because they were deflected toward a lingual eruption path by supernumerary anterior teeth or overretained primary incisors. More rarely, trauma to maxillary primary teeth reorients a permanent tooth bud or buds lingually **(Proffit, 2019)**.

Fig. 2: Although there was adequate space, this permanent maxillary right central incisor erupted into crossbite. Most likely this was caused by the lingual position of the tooth bud.

1.1.2 Treatment

Anterior cross bite is a condition which rarely self corrects, because the maxillary incisor is locked behind the mandibular incisors and the discrepancy continues to progress leading to severe malocclusion. Thus early treatment can reconstruct proper muscle balance and a well-balanced occlusal development. Early treatment is also directed towards averting dysplastic growth of both skeletal and the dentoalveolar components. **(Mahajan and Mahajan, 2015)**.

The ideal age for the correction of permanent anterior dental cross bite is between 8 to 12 years during which the roots are developing and the tooth is in the active stage of eruption. Age is not the single factor for consideration, motivation for treatment, how he or she perceives the problem also plays a role **(Kotadiya et al., 2019)**.

The clinician must first extricate cross bites of dental origin from those of skeletal origin. Dental cross bite implicates localized tipping of a tooth or teeth and does not involve the basal bone **(Bayrak and Tunc, 2008)**. Pseudo Class III malocclusion is an example of dental anterior cross bite that needs to be differentiated from sagittal skeletal discrepancies. It encompasses retroclination of maxillary incisors that cause the mandible to shift forward. That is why treatment of these cases should purpose to correct maxillary incisor inclination. Moyers has renowned pseudo-Class III malocclusion from cases with simple linguoversion. The latter involves palatal positioning of one or more maxillary anterior teeth and does not produce a positional relationship brought about by early interference **(Ulusoy and Bodru, 2013)**.

There is altered treatment methods for the correction of anterior dental cross bite which can be used in early mixed dentition period. These include tongue blade therapy, reverse stainless-steel crowns, jack screw removable Hawley retainer with anterior Z-springs, bonded resin composite slopes and fixed therapy **(Kotadiya et al., 2019)**.

The tongue blade therapy is efficacious in early developing stage and with patient cooperation and there is no precise control over the amount and direction of force applied. The reverse stainless-steel crowns have been shown to be successful but the two main drawbacks here are the unaesthetic appearance of the crown form and the limitations of working with an inclined slope that is formed. **(Ulusoy and Bodru Mlu, 2013).**

Removable orthodontic appliances represent another safe, easy and esthetically acceptable alternative for the treatment of anterior crossbite that has three major advantages: (1) The appliances are fabricated in the laboratory rather than directly in the patient's mouth, thereby reducing chair time; (2) They can be removed on socially sensitive occasions (when visible wires on the facial part of the teeth would be undesirable); and (3) They are easily cleaned, providing good oral hygiene. The amount of desired movement of the teeth can be controlled by the screw and also the base plate remains rigid despite being cut into two parts of acrylic appliances, thereby, it's management is easy and less tendency to dislodge **(Fields, 2007)**. The appliance in (Fig. 3) was fitted with a screw to achieve labial movement of multiple teeth The patient did not report any discomfort during the course of treatment. Treatment resulted in successful correction of the malocclusion and an esthetic smile **(Ulusoy and Bodrumlu, 2013)**.

Figure 3: Management of anterior dental crossbite in 8 year-old girl with removable appliance (Ulusoy and Bodrumlu, 2013)

1.2 Posterior cross bite

Posterior crossbite is one of the most prevalent malocclusions in the primary and early mixed dentition and is reported to occur in 8% to 22% of the cases.1-3 It is defined as any abnormal buccal lingual relation between opposing molars, premolars, or both in centric occlusion. The most common form is a unilateral presentation with a functional shift of the mandible toward the crossbite side, which occurs in 80% to 97% of cases (Fig. 4) **(Annicele et al., 2008)**. The prevalence of functional crossbite is 8.4% in early dentition, while it decreases to 7.2% in mixed dentition **(Caroccia et al., 2021)**.

The etiology of posterior cross bite can include any combination of dental, skeletal, and neuro muscular functional components, but the most frequent cause is reduction in width of the maxillary dental arch. Such reduction can be induced by finger sucking, certain swallowing habits, or obstruction of the upper airways caused by adenoid tissues or nasal allergies. Other etiologies of cross bites include prolonged retention or premature loss of deciduous teeth, crowding, palatal cleft, genetic control, arch deficiencies, abnormalities in tooth anatomy or eruption sequence, oral digit habits, oral respiration during critical growth periods, and malfunctioning temporomandibular joints **(David et al., 2003; Sultana et al., 2015)**.

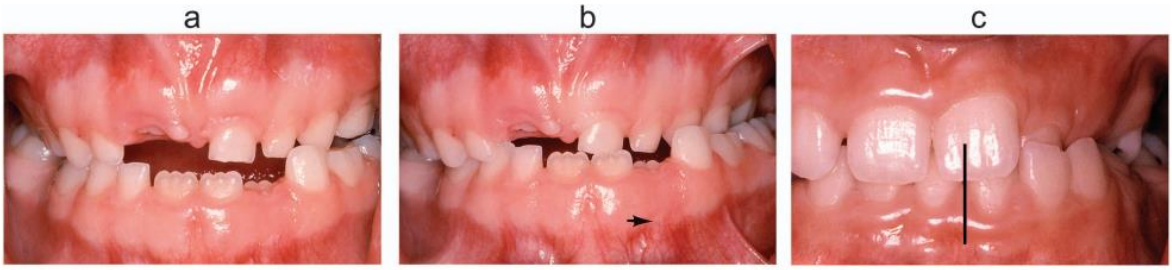

Figure 4: A 6- year- old boy with functional posterior crossbite. Arrow indicates mandibular sliding movement from retroposition (a) to intercuspal relationship and (b). The same boy 3 years later (not orthodontically treated) with increased midline deviation (c) (Thilander & Bjerklin, 2012).

1.3 Unilateral buccal crossbite with or without an associated mandibular displacement

This type of crossbite may affect only one or two teeth per quadrant, or the whole of the buccal segment. When a single tooth is affected, the problem usually arises because of the displacement of an individual tooth from the line of the arch, plus or minus the opposing tooth. This may lead to a deflecting contact on closure into the crossbite **(Simon and Laura, 2020)**.

When the whole of the buccal segment is involved, the underlying aetiology is usually that the maxillary arch is of a similar width to the mandibular arch (i.e. it is too narrow) with the result that on closure from the rest position into maximum occlusion the buccal segment teeth initially meet cusp to cusp and, in order to achieve a more comfortable and efficient intercuspation, the patient displaces their mandible to the left or right. It is often difficult to detect this displacement on closure as the patient soon learns to close straight into the position of maximal interdigitation. This type of crossbite may be associated with a centreline shift in the lower arch in the direction of the mandibular displacement (Fig. 5) **(Agostino rt al., 2014)**.

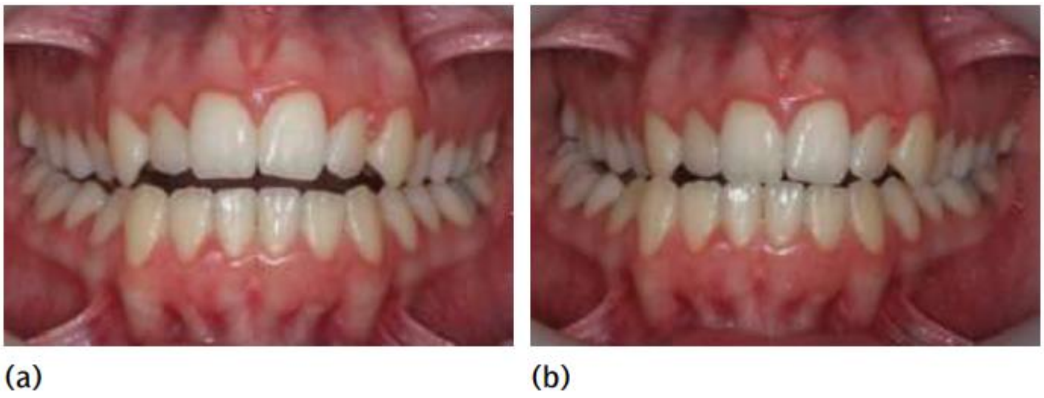

Figure 5: Unilateral crossbite with displacement. (a) Initial contact of the teeth in a cusp to-cusp relationship—note that the centrelines are coincident. (b) Mandibular displacement to the right to achieve maximum intercuspation—note lower centreline has also moved to the right (Proffit, 2019).

Occasionally, a patient may present with the buccal segment teeth in unilateral crossbite with no associated mandibular displacement. This category of crossbite is less common and can arise as a result of a deflection of two (or more) opposing teeth during eruption, but the greater the number of teeth in a segment that are involved, the greater the likelihood that there is an underlying skeletal asymmetry **(Simon and Laura, 2020)**.

Many studies analyzed the association between unilateral posterior crossbite and craniomandibular asymmetry **(Talapaneni and Nuvvula, 2012)**, and several authors have suggested that early treatment of unilateral posterior crossbite is necessary to avoid long-term effects on normal growth of jaws and teeth. Treatment of unilateral posterior crossbite induced favorable changes in the kinematics of the mandible and normalized asymmetric functional aberrations as well as stomatognathic muscle activity. Otherwise, failure to treat unilateral posterior crossbite caused activity alterations of some chewing muscles (i.e., masseter and temporal muscles) in children and promoted craniomandibular disorders in adolescents **(Venancio et al., 2014)**.

1.4 Crossbite and Skeletal Asymmetry

The existing relationship between posterior crossbite and skeletal asymmetries is still unresolved, with contrasting findings **(Kilic et al., 2008; Primozic et al., 2009; Uysal., 2009)**. Indeed, a positive association between unilateral posterior crossbite and skeletal asymmetries was supported by many studies (Fig. 6). It has been hypothesized that the altered dental transversal relationship results in alteration of the glenoid fossa–disc–condyle relationship, which in turn could be responsible for skeletal asymmetric growth. An animal study on rats supported this hypothesis, showing that an experimentally induced unilateral posterior crossbite leads to an increase in cartilage thickness on the contralateral side and a decrease in the lateral region on the ipsilateral side, these alterations being normalized to the values of the control group after the removal of the artificial unilateral posterior crossbite **(Sato et al., 2010)**.

The higher association between crossbite and skeletal asymmetry in adults than in adolescents could be speculatively explained by the fact that adolescents are still growing and the potential alteration due to posterior crossbite did not yet occur. This consideration justified the suggestion of making an early orthodontic correction of a posterior crossbite in order to reduce the adaptation demands of the stomatognathic system **(Thilander et al., 2012; Primozic et al., 2013)**. This chain of events represents only an undemonstrated hypothesis because long-term controlled studies are still lacking, and the cause/effect is merely speculative **(Tsanidis et al., 2016)**.

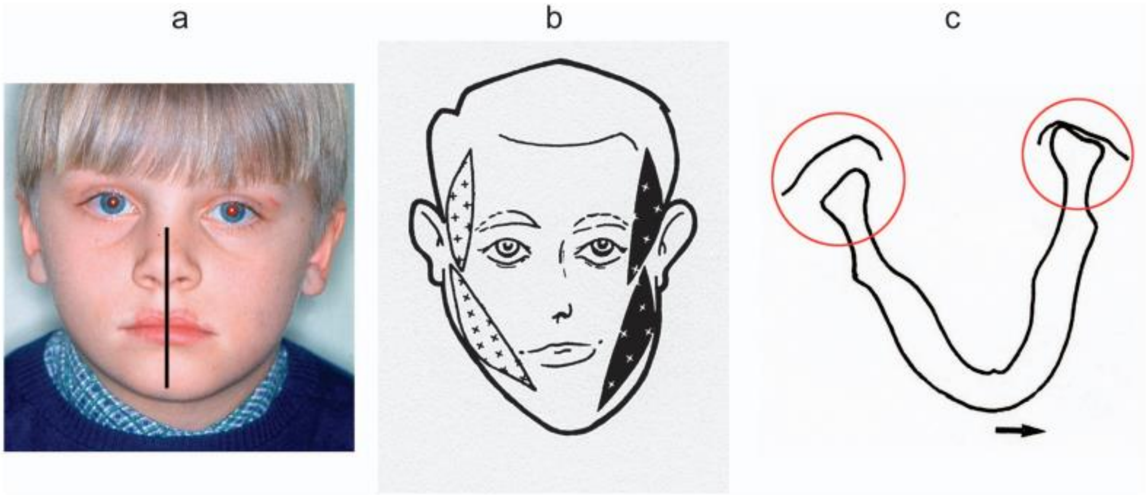

Figure 6: A 9- year- old boy showing facial asymmetry (a) and asymmetric activity of the temporal masseter muscles at the mandibular sliding to intercuspal relationship (b). Drawing illustrating the changed condylar position in relation to the temporal bony component (c) (Thilander & Bjerklin, 2012).

1.4.1 Crossbite and EMG Activity

Many articles evaluated the association between posterior cross - bite and EMG activity, all reporting a positive association. Hence, according to the currently available scientific data, unilateral posterior crossbite is associated to masticatory muscle EMG asymmetric activity. In particular, **Alarcon et al. (2000)** found that in posterior crossbite subjects, the contralateral posterior temporalis showed higher EMG activity than the ipsilateral one, possibly as a consequence of functional mandibular shift in order to reach an occlusal stability **(Andrade et al., 2009)**. Nevertheless, it must be stressed that asymmetric EMG activity does not mean pathology. Indeed, the same authors found that the right anterior temporal demonstrated a higher EMG activity than the left anterior temporal in the normocclusive group, suggesting that muscular asymmetry could be considered physiological and compatible with normal function. Furthermore, the lack of consistency also in the studies reporting an association between posterior crossbite and EMG asymmetry has to be stressed. Indeed, **Alarcon et al. (2000)** even reporting the crossbite side to be less active than in normocclusive subjects, did not find any difference between the crossbite side and non-crossbite side. Instead, **Andrade et al. (2009)** found that the masseter of the crossbite side was more active than that of the non-crossbite side in the UPCB group during maximal clenching. Conversely, **Piancino et al. (2009)** reported a reduced masseter activity on the crossbite side and unaltered or increased on the non-crossbite side.

All the studies used surface EMG measurements to evaluate muscle activity. Some studies reported good reproducibility and sufficient accuracy in young subjects. Nevertheless, several authors reported very large standard deviations in EMG activity, both in subjects with and without crossbite. This wide inter-individual variability should be taken into account when interpreting the results. Finally, surface EMG does not allow the activity of a single muscle to be recorded due to the so-called cross-talking of the neighbouring muscles **(Giorgio et al., 2016).**

1.4.2 Crossbite and Bite Force

Four articles evaluated the association between posterior crossbite and bite force. A positive association is supported by 75% of the analyzed studies. It must be stressed that three out of four studies were published by the same research group, with samples of similar age, but opposite results **(Castelo et al., 2007; Castelo et al., 2010a)**. Interestingly, the only study reporting ‘no association’ **(Rentes, 2002)** is older than the others and of low scientific and methodological quality. All studies analyzed children/adolescents, ranging from 3.5 to 13 years, using a pressure transducer to record bite force. No information is available on adults on this topic.

According to these data, unilateral posterior crossbite might lead to a significantly smaller bite force compared with non-crossbite subjects, and this difference does not decrease with age and development. Nevertheless, no definitive conclusion can be drawn on this topic, as a consequence of the insufficient evidence available **(Giorgio et al., 2016).**

1.4.3 Crossbite and Masticatory Muscle Thickness

Four studies analyzed the association between unilateral posterior crossbite and masticatory muscle thickness, half of them reporting a significant association and half of them not **(Castelo et al., 2007; Andrade et al., 2009; Kiliaridis et al. 2007; Castelo et al., 2010b)**. Indeed, **Kiliaridis et al. (2007)** reported that in unilateral posterior crossbite subjects the thickness of the masseter muscle was significantly thinner on the crossbite side, with no significant differences in the non-crossbite group. On the other hand, **Andrade et al. (2009)** found no differences either between sides or between unilateral posterior crossbite and no- unilateral posterior crossbite groups. Interestingly, the opposite findings were reported by the same authors in different studies in a three-year time lapse. This could be ascribed to the different sample size of the studies. Hence, no conclusions can currently be drawn on UPCB and muscle thickness **(Giorgio et al., 2016)**.

1.4.4 Crossbite and Chewing Cycle

Several articles evaluated the association between posterior crossbite and chewing cycle. According to most of the studies **(Nie et al., 2010; Sever et al., 2010)**, subjects with unilateral posterior crossbite present different kinematics of the mandible during mastication when chewing on the affected side, compared with no- unilateral posterior crossbite subjects (Figure 6). Indeed, during chewing, the mandible deviates laterally towards the bolus side and then medially during closure **(Piancino et al., 2009)**. Sometimes, the mandible can first deviate medially and then laterally, thus ensuring overlap of opposing dental occlusal surfaces. This is called a 'reverse chewing cycle'. Reverse chewing cycles show an abnormal, narrow pattern characterized by smaller lateral displacement and slower velocity of the mandible in comparison with normal chewing. In a patient with unilateral crossbite, reverse cycles occur mainly on the crossbite side, although not all cycles are reverse when chewing from the crossbite side (Fig. 7). Nevertheless, the reverse chewing cycle is very common in children with a normal occlusion, who present a smaller lateral component during opening and closing than adults. According to the authors, the reverse cycle is not abnormal because normal children with primary dentition have a smaller lateral component and difficulty in controlling asymmetric muscle activity. Hence, reverse chewing cycles cannot be considered pathologic but could be a physiologic and common feature of the chewing cycle in children **(Saitoh et al., 2010)**.

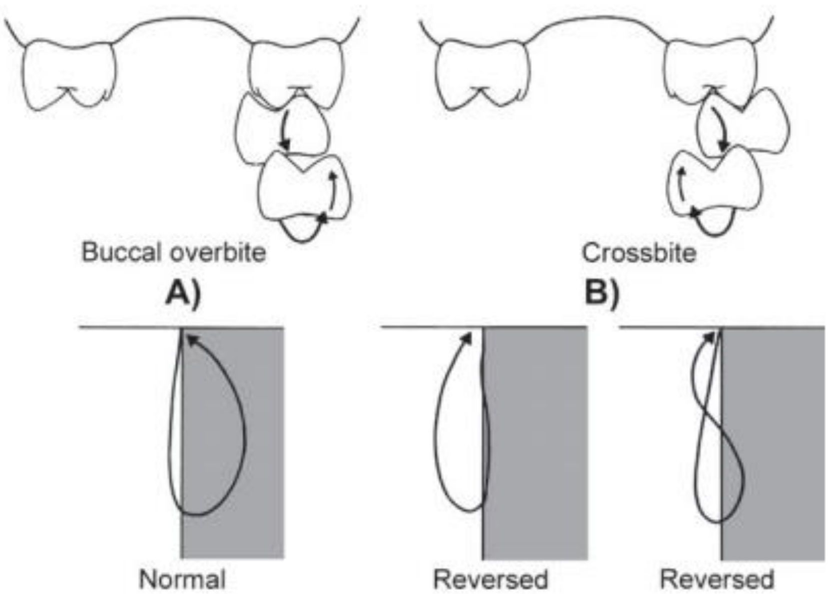

Figure 7: In subjects without a crossbite, the mandible, in the majority of chewing cycles, deviates to the bolus side on opening, especially if the bolus is known to offer resistance. It then moves medially on closure to approximate and traverse the opposing

occlusal tooth surfaces during the close – open transition (above left). In subjects with a unilateral posterior crossbite, the sequence is reversed on the bolus side in order to facilitate opposition of the tooth surfaces during the close – open transition (above right) (Piancino et al., 2006).

1.4.5 Crossbite and speech sound production

The dental arches (dentition and skeletal arch), acting as structural boundaries for placement of the tongue and lips, are inherently involved in the production of sounds for meaningful communication. A deviation in dental structure or alignment may interfere with the normal process of air flow and pressure, as well as proper lip and tongue placement and contouring, thereby affecting the integrity of speech sound production **(Jesus et al., 2014)**.

A bilateral posterior crossbite has a noteworthy effect on sound production. As compered to unilateral posterior crossbite Interestingly, no significant association was found between sound production errors and other variables: eg, overjet, positive overbite, anterior crossbite, and maxillary and mandibular spacing and crowding **(Leavy et al., 2016)**.

1.5 Maxillary expansion

Arch expansion is one of the methods of gaining space in orthodontics. The concept of arch expansion was explained for the first time by Emerson C Angel. Hence, he is considered as the father of expansion appliances**.** Correction of the transverse discrepancy usually requires expansion of the palate by a combination of orthopedic and orthodontic tooth movements. Three expansion treatment modalities are used today: rapid maxillary expansion (RME), slow maxillary expansion (SME) and surgically assisted maxillary expansion**. (phulari, 2011).**

Under normal circumstances the maxillary arch overlaps the mandibular arch both labially and buccally. But when the mandibular teeth, single tooth or a segment of teeth, overlap the opposing maxillary teeth labially or buccally, depending upon their location in the arch, a cross bite is said to exist **(Singh, 2015)**.

The clinical conditions indicating maxillary expansion include (Anirudh & Rinku, 2010):

1. crossbites, 2. distal molar movement, 3. functional appliance treatment, 4. surgical cases.

1.5.1 Slow Arch Expansion

Slow arch expansion is also known as dento-alveolar expansion. The changes produced are primarily of dental changes with very minimum or negligible amount of skeletal changes when used in older adults. But can produce skeletal changes along with dental changes when used in either deciduous or early mixed dentition. Slow arch expansion uses mild force of 2-4 pounds as compared to 10-20 pounds used in rapid maxillary expansion. The expansion produced with slow expansion is more physiologic with greater stability of having least relapse tendency as compared to that of rapid maxillary expansion **(phullari, 2011)**.

McAndrews demonstrated that the application of light continuous forces in the areas of perisoteal growth allows normal arch dimensions to develop at any age without undue tipping of abutment teeth. Increased fibroblastic, osteoclastic and osteoblastic activity seems to occur when the maxilla is widened slowly. The neuromuscular adaptation of the mandible to the maxilla in slow expansion allows a normal vertical closure **(Pereira et al., 2017)**.

Table 1: Difference between slow and rapid maxillary expansion (phullari, 2011):

Features	Slow maxillary expansion	Rapid maxillary expansion
Rate of expansion	Slow	Rapid
Duration of treatment	Prolonged	Short
Force	Mild	Heavy
Tissue response	Physiologic	Pathologic
Frequency of activations	Less frequent	More frequent
Fabrication	Easy	Difficult
Type of appliance	Can be removable or fixed appliances	Mainly fixed appliance
Adjustment required	Minimal	More
Repair response	Greater	Less
Loss of attachment	Not seen	Seen to some extent
Post-expansion stability	Greater	Lesser
Trauma	Less	More
Relapse	Less chances	More chances

1.5.2 Appliances Used for Slow Arch Expansion

1. **Jackscrew:** The standard jackscrew consists of four primary components: (1) a perforated cylinder, (2) a leadscrew, (3) guide pins, and (4) the platform (Fig. 8). most orthodontists only prescribe the customary 30 turns of the jackscrew in patients with moderate to severe crowding. But is this amount of expansion adequate? Thirty turns provides 6 mm of arch width, which equates to 4.2 mm of arch perimeter (ratio of arch perimeter to arch width = 0.7)[7] **(Kravitz, 2019)**

Figure 8: Jackscrew removable appliance (phullari, 2011)

2. Coffin Spring

This is a strong spring made of a thick gauge wire (1.25 mm) and is used for transverse arch expansion, for example to treat a unilateral crossbite with lateral mandibular displacement (Fig. 9). It has the advantage over a screw that differential expansion can be obtained in the premolar and molar regions, but the appliance tends to be unstable unless it is expertly made and adjusted. For this reason, a screw may be preferred unless differential expansion of the arch is required **(Isaacson et al., 2012)**.

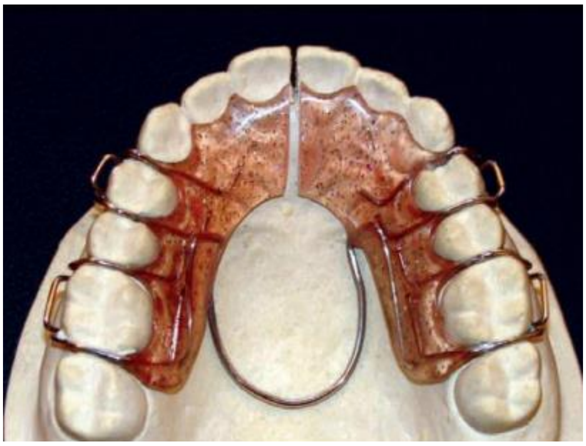

Figure 9: Coffin spring (phullari, 2011)

3. A NiTi expander brings about slow expansion

To overcome the limitations of various slow expanders, like Quad helix and W arch, Arndt in 1993, developed an NiTi expander and this was the expander of choice for our patient. The NiTi expander is a tandem loop temperature-activated palatal expander with the ability to produce light, continuous pressure on the midpalatal suture. This appliance is capable of correcting posterior crossbite and molar rotation and requires little patient cooperation and laboratory work. **Karaman (2002)** showed an increase in intermolar distance of 8.5 mm. Expansion is noted not only at the molar region but also at the intercanine and premolar regions which was 11 mm and 14 mm, respectively, which can be attributed to stainless steel palatal extension of an NiTi expander **(Ferrario et al., 2003; Katti et al., 2013)**.

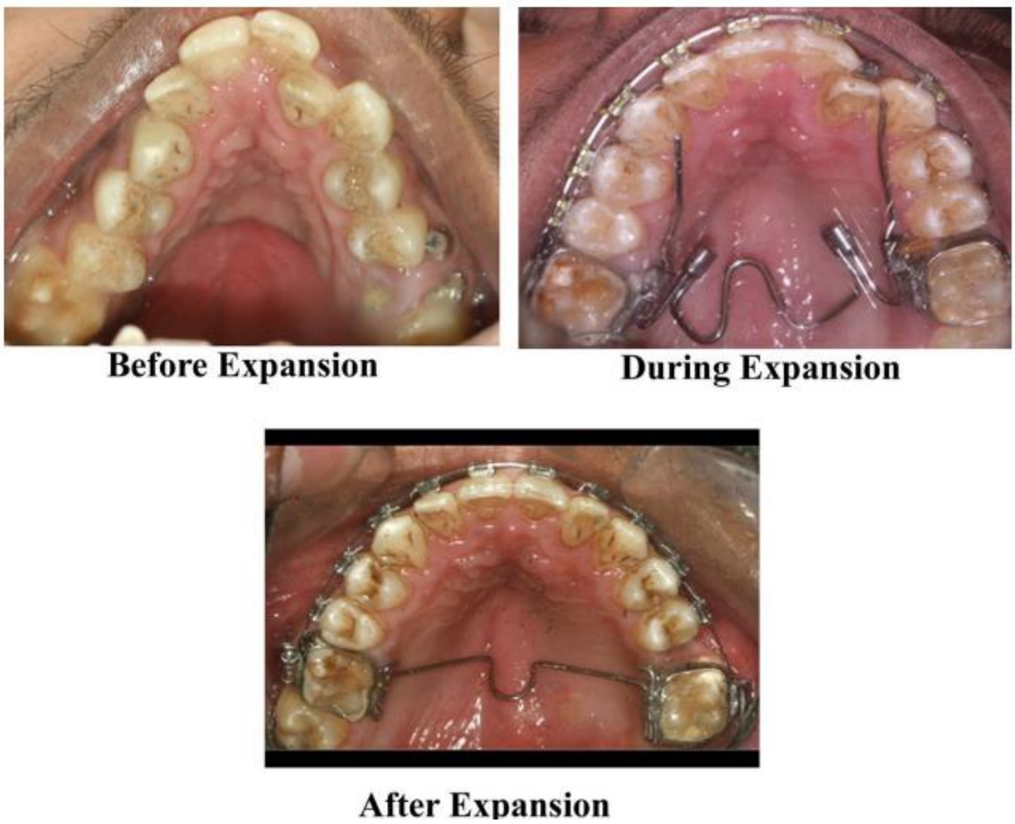

Figure 10: Before and after photographs after NITi expander (Katti et al., 2013

4. Quad Helix Appliance

A quad helix used to correct bilateral maxillary constriction. The appliance is fabricated from 38-mil wire and soldered to the bands. The lingual wire should contact the teeth involved in the crossbite and extend no more than 1 to 2 mm distal to the banded molars to eliminate soft tissue irritation. Activation at point 1 produces posterior expansion, whereas activation at point 2 produces anterior expansion. The lingual wire should remain 1 to 1.5 mm away from the marginal gingiva and palatal tissue. This quad helix is being used to correct a bilateral maxillary constriction in the primary dentition **(proffit, 2019)**.

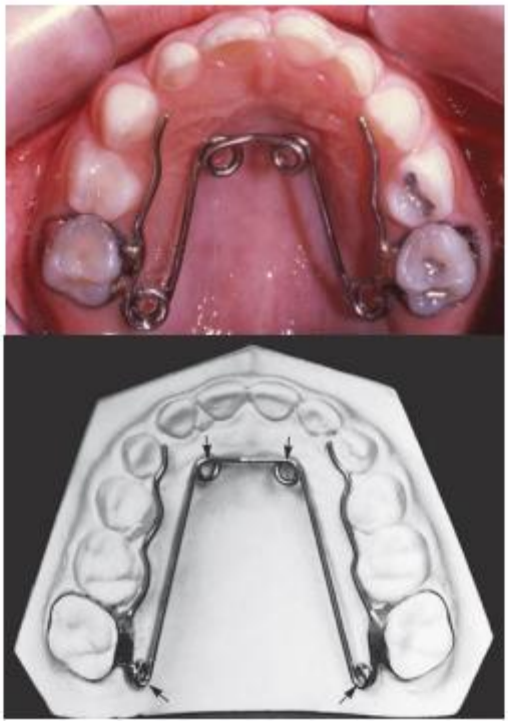

Figure 11: Quad helix appliance (Proffit, 2019)

1.5.3 Rapid Maxillary Expansion (RME)

Rapid maxillary expansion appliances are the best appliances for the orthopedic expansion, the changes are produced mainly in the underlying skeletal structures rather than by the movement of teeth through the alveolar bone. Rapid maxillary expansion not only separates the mid palatal suture but also affects the circumzygomatic and circummaxillary sutural systems. Rapid maxillary expansion device was first used by Emerson C Angel in the year 1860. He used a jack screw type of rapid maxillary expansion device between two premolars in maxillary arch on palatal side in a 14 years old girl and achieved arch expansion by 1/4 inch in 14 days **(phullari, 2011; Graber, 2017)**. Retention period after maxillary expansion is six months of retention with either fixed or removable appliances seem to be enough to avoid relapse or to guarantee minimal changes in a short-term follow-up **(Costa et al., 2017)**.

1.5.4 Miniscrew assisted raped maxillary expansion (MARPE)

Bone screw can be placed in the maxilla to serve as temporary skeletal attachments, force can be applied directly to the maxilla instead of teeth to transfer force to the bone, to expand the maxilla even if no teeth are present, to avoid tooth movement and produce skeletal change (Fig. 12),

Figure 12: MARPE appliance (de Oliveira et al, 2021)

In order to increasingly enhance the procedure of palatal expansion, one seeks to improve or innovate the appliances used. In 2010, **Lee et al, (2010)** treated a 20-year-old patient with severe transverse discrepancy and mandibular prognathism. Before orthognathic surgery, the patient used an expansion appliance secured to the palate by means of miniscrews (miniscrew-assisted rapid palatal expander, or MARPE). Expansion was achieved with minimal damage to teeth and periodontium, with stable outcomes confirmed by clinical and radiographic examination. The authors concluded that it is an effective treatment modality used for transverse correction and which might eliminate the need for a few surgical procedures in patients with craniofacial discrepancies, thus taking advantage of the possibilities offered by the sutures.

Recently, based on Lee's studies, **Park and Hwang (2010)**, **Moon (2003)** and **MacGinnis et al, (2014)** developed the maxillary skeletal expander (MSE, Biomaterial Korea, Seoul, South Korea) with four miniscrews installed into the expansion screw body, parallel to the midpalatal suture and to itself. Even more recently, **Suzuki et al (2016)** changed the rapid maxillary expansion appliance, securing it by means of miniscrews (MARPE); however, with a different design (Peclab, Belo Horizonte, Brazil) (Fig. 13). MARPE's new design has been used in a number of patients with atrophic maxilla, both young, growing patients and adult ones.

Figure 13: MARPE appliance in which miniscrews are incorporated to the screw support design, with measures determined on the basis of morphology of the palatal region parallel to the midpalatal suture: A) MSE expansion appliance; B) MARPE appliance modified by Suzuki. C) computed tomography after expansion (in B).

In the appliance developed by **Lee et al, (2010)** the miniscrews are secured to the turn-key by means of extensions welded to the expansion screw, and joined with light-curing resin. With miniscrews kept away from the midpalatal suture, there is an increase in the risk of perforating underlying structures (such as canals and nerves in both anterior and posterior regions), as well as on the sides, which is even more serious, as there would be four sites to be chosen individually. **Alves et al, (2012)** mapped the areas of risk implied in securing miniscrews onto the human palate. In **MSE (2013)** and **MARPE (2015)** appliances, miniscrews are used as a support for the expansion screw and would be secured in a more even manner parallel to the suture, with a view to aiming at a thicker bone area, so as to increase primary stability and provide a more efficient propagation of forces to the nasomaxillary complex.

The midpalatal suture is located right behind the incisive foramen, which represents the mouth of a canal that goes up in posterior direction. It might have an opening at the nasal cavity, as high as the line tangent to the distal surfaces of both maxillary canines (Fig. 14). The risk of screws affecting this structure is little, although this might occasionally happen **(Suzuki et al., 2016)**.

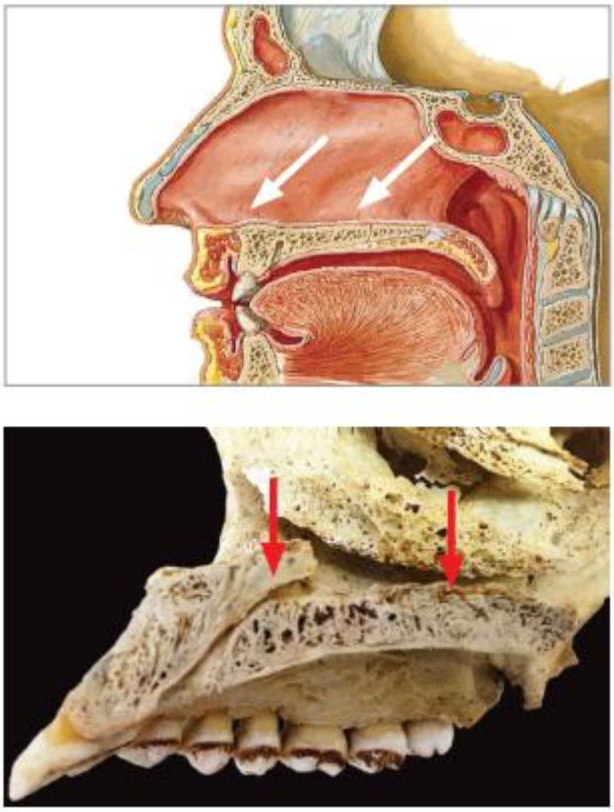

Figure 14: Midpalatal suture: note that the incisive canal distinguishes the anterior and middle segments. It goes in posterior and upward direction. The incisive canal has got vessels, nerves, salivary glands and nasopalatine canal remnants. The posterior segment is relative to the suture transversal to the palatal bone (Susuki, 2016).

Indications for MARPE (Kumar et al., 2021)

• Maxillary deficiency is Class III Cases: MARPE is of value in the Class III malocclusions with maxillary deficiency and also with flattened profile in the middle third of the face, crowding of maxillary arch and cross bite which maybe either unilateral or bilateral and the teeth are often inclinedbuccally.

- Bilateral or severe unilateral expansion in class I cases:
- Certain Class 2 div 1 malocclusion cases which in which there is an extreme narrowing of the upper arch associated with a unilateral or bilateral crossbite.
- Selected arch length discrepancy cases: Borderline case with good facial patterns.
- True maxillary deficiency case: Cases in which mandible is normal with under developed maxilla with a straight profile in a midface region and are also associated with crossbite.
- Relative Maxillary deficiency case: A case in which a larger size of mandible with a normal maxilla.
- Asymmetries of condylar position: Skeletal response during MARPE redirects the developing posterior teeth into normal occlusion and corrects asymmetries of condylar functional shifts and possible temporomandibular joint dysfunction.
- Class II cases with mouth breathing: A narrow nasal aperture literally filled by concha, with deviated nasal septum, is often seen in these patients increasing the internasal capacity to facilitate nasal respiration.

Appliance activation

The activation protocol varies based on the treatment objective and patient biotype. Activation schedule guidelines [Table 3] should be followed for better treatment progress. On an average, 0.2mm of separation is achieved per turn. Activation is terminated when an edge to edge contact is achieved between the lingual cusps of maxillary first molars and the buccal cusps of the mandibular first molar **(Brunetto et al., 2017)**. If the activations exceed the permissible limits, the expander loses rigidity and undergoes deformation. [Table 2].

Table 2: activation limits

MSE size	MAXIMUM NUMBER OF ACTIVATIONS
8mm	40
10mm	50
12mm	60

Table 3: activation schedule

AGE GROUP	INITIAL EXPANSION RATE	EXPANSION AFTER OPENING MPS (DIASTEMA FORMATION)
Beginning of adolescence (13- 16 years)	3-4 turns /week	3 turns/week
End of adolescence (16- 19 years)	1 turn / day	1 turn/ day
Young adults (19- 25 years)	2 turns per day	1 turn/ day
Adults (Older than 25 years)	2 or more turns per day	1 turn/ day

1.5.5 Post expansion assessment

The total expansion achieved is a combination of skeletal (orthopedic) expansion and dentoalveolar (orthodontic) expansion which includes the alveolar bone bending and dental tipping. In conventional hybrid bone-borne RPE appliances, center of rotation of maxilla is much higher than the miniscrew placement position, leading to torque generation in two maxillae resulting in alveolar bone bending **(MacGinnis et al., 2014)**. Though the relative position of anchored teeth was not changed dental tipping could be observed due to alveolar bone bending. By exerting the expansion forces pointing closer to the maxilla's center of resistance, a more lateral translation of the complex could be achieved with reduced dental tipping **(Kumar et al., 2021)**.

Since the greatest resistance against sutural opening is the pterygomaxillary complex, the body of MARPE should be positioned close to the junction of hard and soft palate **(MacGinnis et al., 2014)**. If the forces are applied to the center of resistance of maxilla through appropriate microimplant positioning using customized MARPE appliances, the force system becomes more favorable which would practically eliminate the inclined forces due to homogenous force dissipation on the posterior teeth facilitating more parallel midpalatal sutural opening coronally. Pterygoid plate separation with MARPE results in a parallel expansion in comparison to SARPE which gives a ”V” expansion, as there is an absence of pterygoid plate separation at the mid palatal suture **(American Journal of Orthodontics and Dentofacial Orthopedics, 2017)**. Bony resistance of maxillary expansion would be less in children and adolescents as their pterygomaxillary and zygomaticomaxillary sutures are less matured. In adult patients due to greater bony resistance offered, a substantial amount of orthopedic force will be experienced on the anchor teeth too resulting in dental tipping and alveolar bone bending **(Cantarella et al., 2020)**.

1.5.6 Correction of Unilateral Posterior Crossbite with U-MARPE

In a true unilateral posterior crossbite, it is very important that the appliance design and load system are such that unilateral expansion occurs only on the affected side and not on the side without crossbite. U-MARPE can be used to correct unilateral crossbite without undesirable movement on the unaffected side (Fig. 15). The occlusion of the side without crossbite was maintained very well after the expansion was done. Instead of using conventional RPE and Surgically Assisted Rapid Palatal Expansion (SARPE), the U-MARPE demonstrated a decent amount of expansion without additional surgery **(Dzingle et al., 2020)**.

The objective of the U-MARPE is to allow expansion of the crossbite side without clinical side effects on the opposite side. Use of the conventional RPE procedure to correct unilateral posterior crossbite needs an asymmetric relapse after bilateral expansion. To avoid this undesirable movement, previous studies support the use of an RPE with an acrylic plate having locked mechanics on the side without crossbite to produce asymmetric orthopedic and orthodontic effects **(Marshall et al., 2005; Ileri and Basciftci, 2015)**. Appliances such as an asymmetric maxillary expansion (AMEX) appliance have also been used for the correction of unilateral crossbite **(Toroglu et al., 2002)**. It has been reported to show increased expansion on the crossbite side and relatively less expansion on the side without crossbite. However, the activation of the appliance is done extra-orally, which requires removal and recementation of the appliance and, thus, increase the clinical chair time. In addition, some side effects might be observed on the maxillary and mandibular premolars and molars on the side without crossbite because they are used as anchorage units. In our design, the activation of the screw was done intraorally by the patient and does not use mandibular teeth as an anchor unit and therefore does not lead to expansion of the mandibular teeth. However, the results of the AMEX appliance imply that it can be used as an alternative in patients who do not wish to use temporary anchorage devices (TADs) **(Toroglu et al., 2002)**.

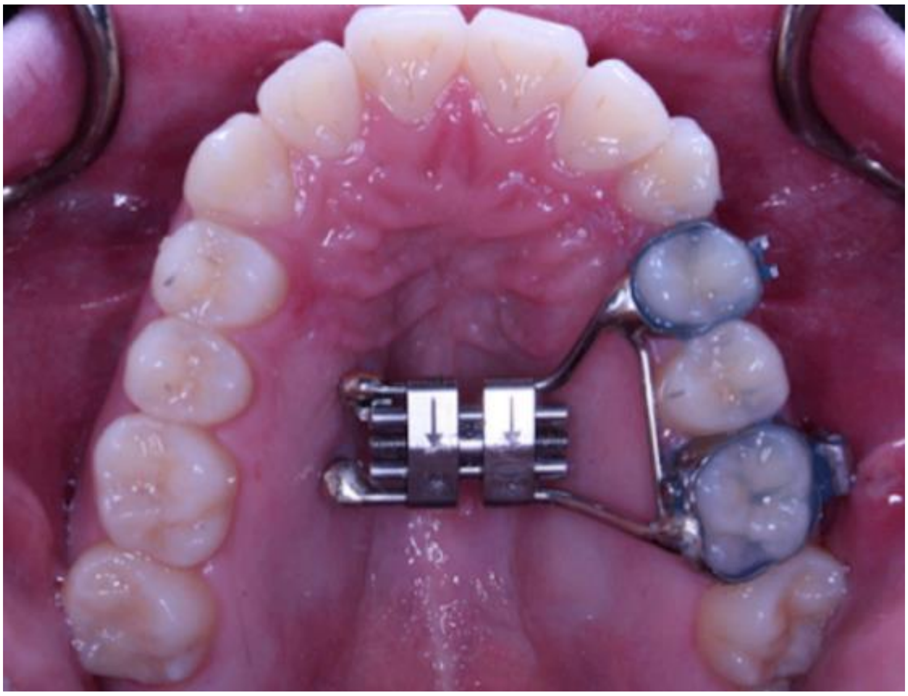

Figure 15: U-MARPE appliance applied with 2 mini-implants and bands on the maxillary first premolar and maxillary first molar (Dzingle et al., 2020)

As unilateral expansion has been reported with SARPE in adults, it was an alternative treatment plan for some patients **(Dzingle et al., 2020)**. The results from the study by **Karabiber et al, (2019)** showed that there was more expansion on the osteotomy side with unilateral SARPE, which helped in the correction of the transverse discrepancy. Thus, unilateral SARPE is an effective technique for the correction of unilateral crossbite. However, they found that there were no significant skeletal changes except for apertura piriformis. In addition, the SARPE technique requires the patient to undergo surgery under general anesthesia and adds supplementary financial cost to the treatment. Complications like epistaxis, postoperative pain, asymmetric expansion, or inadequate expansion have been reported with SARPE **(Carvalho et al., 2020)**. Unilateral expansion with the U-MARPE design enabled us to correct the transverse discrepancy without surgery. The design of the U-MARPE appliance was such that the expansion force was felt by the TADs on the side without crossbite (right side) and the molars and premolars on the crossbite side (left side) (Fig. 16). This design provided better control over the force distribution than a regular expander. This enabled to expand the molars and premolars on the left side without affecting the right side and get results comparable to those shown by unilateral SARPE **(Karabiber et al., 2019)**.

1.5.7 Surgically assisted rapid palatal expansion (SARPE)

Because of more complications after attempts to orthopedically alter the transverse dimension of the maxilla with advancing age, surgical procedures have been recommended to facilitate correction of transverse discrepancies. These procedures have conventionally been grouped into 2 categories: segmenting the maxilla during a LeFort osteotomy to reposition the individual segments in a widened transverse dimension, and surgically assisted rapid palatal expansion (SARPE) **(Suri and Taneja, 2008)**.

Surgical correction of maxillary transverse deficiency (MTD) may be achieved by either segmental osteotomy or SARPE. Segmental osteotomy is the preferred choice for correction of MTD when a single surgical procedure is planned to correct all maxillo-mandibular discrepancies. Vertical and sagittal repositioning of the maxilla and the mandible can be done at the same time when correction of MTD is done with segmental osteotomy. On the other hand, correction of MTD is done as a first step with SARPE and a separate second surgery is necessary for discrepancies of the maxilla and the mandible in the other planes of space. **Bailey et al, (2007)** have recommended that SARPE should be used for patients with an isolated transverse deficiency when orthopedic maxillary expansion (OME) is not indicated, or with unilateral or asymmetric narrowing of the maxilla.

Although it might seem that the use of SARPE is limited, it is essential to compare the long-term stability, morbidity of a 2-stage vs a 1-stage procedure, and the psychological impact of 2 procedures on the patient rather than 1 procedure. Proponents of SARPE have also hypothesized that post-SARPE orthopedic forces can be applied to the maxilla, since the 2 halves of the maxilla have been loosened. These forces might be valuable in correcting sagittal or vertical discrepancies without additional surgery. This, however, has not been used routinely because the prognosis is uncertain Comparison of dental and skeletal outcomes between MARPE and SARPE is shown in (Table 4) **(Koudstaal et al., 2005)**.

Indications for SARPE

The following have been reported in the literature as indications for SARPE, all applying to a skeletally mature patient with a constricted maxillary arch **(Koudstaal et al., 2005)**.

1. To increase maxillary arch perimeter, to correct posterior crossbite, and when no additional surgical jaw movements are planned.

2. To widen the maxillary arch as a preliminary procedure, even if further orthognathic surgery is planned. This is to avoid increased risks, inaccuracy, and instability associated with segmental maxillary osteotomy. To provide space for a crowded maxillary dentition when extractions are not indicated.

4. To widen maxillary hypoplasia associated with clefts of the palate.

5. To reduce wide black buccal corridors when smiling.

6. To overcome the resistance of the sutures when OME has failed.

Table 4: Comparison dental and skeletal out come between MARPE and SARPE (de Oliveira et al, 2021)

MARPE	SARPE
1. MARPE appliances designed with miniscrews placed close to the midpalatal suture are more favorable for obtaining greater expansion in the midface because the force is applied closer to the center of resistance of the maxilla. Therefore, The parallel pattern found in the MARPE patients indicated a greater chance of disarticulation of the sutures located at the pyramidal process of the palatine bone and the pterygoid process of the sphenoid bone. that observed the opening of the midpalatal suture almost perfectly parallel anteroposteriorly, the lateral and media plates of the pterygoid process detached in 53% of the sutures, displacement of the zygomatic bone in a lateral direction after treatment with an MSE. significant increase in the width at the anterior and posterior region of the maxilla and the level of the maxillary base, nasal cavity, and alveolar process	1. SARPE the position of the hyrax expander, more downward but also more forward than MARPE. Therefore, the pterygopalatine suture, had an insignificant posterior maxillary base expansion, an evident triangular opening pattern was observed in the SARPE, whereas MARPE produced an almost parallel expansion of the maxilla when evaluated occlusally. that showed a consistent pattern of triangular separation of the maxilla in the coronal plane, with the apex facing the nasal cavity and the base at the level of the palatal process. Tooth-borne expanders such as hyrax produce a Vshaped opening in the anteroposterior direction, with a greater opening in the anterior region and the absence of posterior suture disarticulation, especially pterygopalatine suture
2. Higher the line of force action provided by MARPE.	2. Lower line of force action produced by the hyrax expander used in the SARPE group.
3. showed minimal inclination of the posterior teeth with MARPE, which may lead to better vertical control, suggesting that MARPE may be beneficial for adults and patients with dolichofacial abnormalities.	3.Higher inclination of the posterior teeth with SARPE
4.less periodontal problems.	4.compression of the periodontal ligament, which may lead to negative periodontal impact of this appliance.
5. Widens the upper airway space and decreases airway resistance, increasing expiratory and inspiratory flow.	5. Increase Nasal air way volume.

1.6 Clear aligners

Due to the perceived shortcomings of alternative approaches, the use of clear aligners for correcting anterior crossbite in mixed dentition should be considered as a comfortable and well tolerated appliance for young patients. This new technique allows young patients to participate in all their school and social activities without any aesthetic limitation. In fact, a removable device allows optimal oral hygiene, together with rigorous oral care. The use of clear aligners prevents the deterioration of periodontal status, the dental decalcifications during orthodontic treatment, and speech impairment due to the bulkiness of the removable appliance **(Li et al., 2016; Wiedel et al., 2016)**.

The duration of therapy is in line with conventional approaches. **Li et al. (2016)** showed that the amount of activation force imparted by the aligner slowly decreases and plateaued within 5 days; therefore, the aligner change protocol was optimized, stressing out that a prolonged treatment may lead to a loss of compliance, especially in young patients. The effectiveness and efficiency of this treatment lie in its ability to achieve dental torque movements with precision. Furthermore, the occlusal vertical dimension is increased by aligners' thickness, which prevents contacts and provides an adequate vertical clearance for a feasible crossbite correction. To avoid the use of an additional retention appliance, the final aligner can be used for three months after the end of the treatment to retain the corrected tooth positions **(Patini et al., 2018; Staderini et al., 2020)**.

Chapter Two: Conclusions

Crossbite is a condition where one or more teeth may be abnormally malposed buccally or lingually or labially with reference to the opposing tooth or teeth. Different techniques have been used to correct cross bite.

Transverse maxillomandibular discrepancies are a major component of several malocclusions. Orthopedic and orthodontic forces are used routinely to correct a maxillary transverse deficiency (MTD) in a young patient. Correction of MTD in a skeletally mature patient is more challenging because of changes in the osseous articulations of the maxilla with the adjoining bones. Surgically assisted rapid palatal expansion (SARPE) has gradually gained popularity as a treatment option to correct MTD. It allows clinicians to achieve effective maxillary expansion in a skeletally mature patient.

The MARPE technique has an increase in skeletal transverse maxillary expansion at the midface and basal bone compared with SARPE, especially at the posterior palatal region; however, There is no difference in the expansion of the alveolar process between the 2 methods. MARPE presented a more parallel expansion in both a coronal and axial view, whereas SARPE led to a V-shaped opening. The greater buccal inclination of the alveolar process and supporting teeth is observed with SARPE.

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