

# The Management of Transverse Maxillary Deficiency

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**Abstract:** The correction of transverse maxillary deficiency can be an important component of an orthodontic treatment plan. A number of different techniques are available for the correction of such discrepancies. The aim of this article is to review the methods available to clinicians discussing their indications, advantages and disadvantages.

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**Clinical Relevance:** The correction of transverse maxillary deficiency is a common problem faced by those carrying out orthodontic treatment.

The correction of transverse maxillary deficiency can be an important component of an orthodontic treatment plan. Implant studies have shown that growth of the mid-palatal suture is the most important factor determining the width of the maxilla.<sup>1</sup> Growth is normally complete by the age of 17 years and the mean transverse growth between the age of four years and adulthood is 6.9 mm.<sup>1</sup> As such a small amount of growth occurs in the transverse dimension of the maxilla throughout life, it is unlikely that a crossbite encountered in the permanent dentition will self correct. However, a number of orthodontic techniques exist to expand the maxillary arch. It is the aim of this article to review the techniques for maxillary expansion.

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## INDICATIONS FOR MAXILLARY EXPANSION

The clinical situations in which maxillary expansion should be considered are:

- Crossbites;
- Distal molar movement;
- Functional appliance treatment;
- Surgical cases (arch co-ordination/ bone grafts);
- To aid maxillary protraction;
- Mild crowding.

## Crossbites

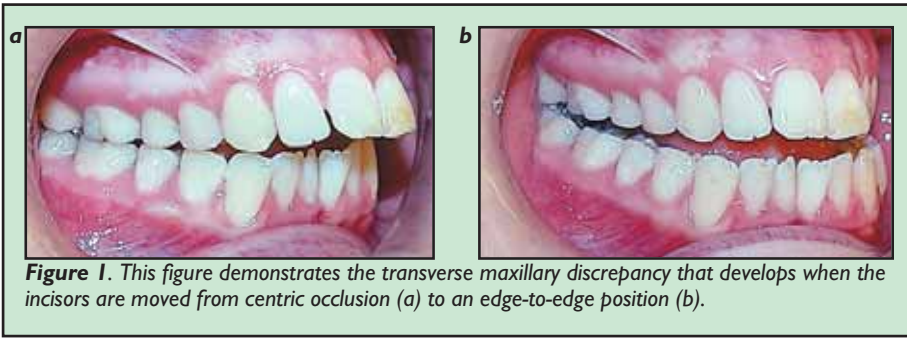
Crossbite correction is routinely undertaken during orthodontic treatment. Maxillary expansion may help to eliminate a mandibular displacement associated with a crossbite and/or be used to create space for the relief of crowding. Sometimes a patient will present with a bilateral crossbite, involving all the molar teeth, which is not associated with a mandibular displacement. If correction is attempted and relapse occurs, there is a risk of producing a unilateral crossbite associated with a mandibular displacement. It may be prudent to accept bilateral crossbites in most cases.

## Distal Molar Movement

Headgear is often used to distalize the maxillary molars in order to increase arch length for the relief of crowding and overjet reduction. During distal molar movement, it is important that the inter-molar distance is also increased, so that a crossbite is not created in the molar region as a narrower part of the upper arch is moved back against a wider part of the lower arch. Expansion in these cases can be achieved by slightly expanding the inner bow of the headgear, Kloehn bow, or by using a removable appliance with a midline expansion screw in conjunction with headgear.

## Functional Appliance Treatment

Functional appliances are commonly used in the treatment of moderate Class II malocclusion in growing patients. The overjet is reduced by a combination of maxillary incisor retroclination, mandibular incisor proclination, accelerated mandibular growth and a restraint in maxillary growth. In the majority of cases, it is important to expand the maxillary arch during treatment in order to maintain arch co-ordination as the maxillary dentition is distalized relative to the mandibular dentition. The amount of expansion required can be judged by asking the patient to bite the incisors in an edge-to-edge position and noting the size of the transverse discrepancy that develops in the buccal segments (Figure 1). A number of techniques can be used to increase inter-molar width during functional appliance treatment, including use of a midline expansion screw (e.g. the Twin Block appliance), a Coffin spring (The Bass



**Figure 1.** This figure demonstrates the transverse maxillary discrepancy that develops when the incisors are moved from centric occlusion (a) to an edge-to-edge position (b).

Appliance) and buccal shields (The Function Regulator appliances of Frankel, Figure 2).

### Surgical Cases

Arch expansion may be indicated in a number of joint orthodontic-orthognathic cases in order to maintain arch co-ordination following correction of the sagittal skeletal discrepancy. A good post-surgical occlusion is important for enhancing post-treatment stability.

### Maxillary Protraction

Maxillary protraction, using reverse pull headgear, can be used for the management of skeletal Class III malocclusion in growing patients. This technique works by a combination of proclination of the maxillary incisors, retroclination of the mandibular incisors, forward maxillary movement and a downwards and backwards redirection of mandibular growth. Rapid maxillary expansion may be used to facilitate protraction as it disrupts the circum-maxillary sutures.

### Mild Crowding

Maxillary expansion may be used in carefully selected cases for the relief of mild crowding. Evidence generally indicates that the mandibular intermolar width may be increased by 2-3 mm and remain stable.<sup>2</sup> The maxillary molar width may be increased by a similar degree to help maintain arch co-ordination.

In recent years, a number of clinicians have claimed that it may be possible to expand the arches significantly during the mixed dentition, in the absence of cross-

bites, and that stability may not be compromised because of the adaptive capability of younger patients. However, there is no scientific evidence that this form of arch development is stable in the long term and this form of treatment is not currently recommended.

### TECHNIQUES AVAILABLE FOR MAXILLARY EXPANSION

The appliances available for producing maxillary expansion are:

- Removable appliances;
- Quadhelix;
- Rapid maxillary expansion (RME);
- Fixed appliances (e.g. archwires, auxiliary archwires and cross elastics);
- Surgical methods (SARPE; Segmental Le Fort 1 Osteotomy)

### Removable Appliances

A removable appliance, with a midline expansion screw, is a popular device for achieving maxillary expansion. Expansion is produced predominately by tipping the molar teeth buccally. A very small amount of skeletal expansion, by separation of the mid-palatal suture, may be expected in prepubertal children.

To produce symmetrical expansion, the baseplate of the appliance is separated in half so that there is an equal number of anchor molars on either side of the midline. Asymmetric expansion may be produced by sectioning the baseplate so that more teeth are in contact with it on the non-expansion side. Good retention, which is essential for producing efficient expansion, can be acquired by placing Adams clasps on the first premolars and first permanent

molars. Typically, the patients should be instructed to turn the expansion screw a quarter turn (0.2 mm expansion) once a week. The rate of expansion may be monitored by measuring the distance between dimples placed into the baseplate acrylic on either side of the midline, or by measuring the intermolar distance with calipers. Following expansion, the appliance is used as a retaining appliance for at least three months.

The advantages of removable appliances are that they may be removed for cleaning and additional active components can be easily incorporated. However, they do rely on patient co-operation. It can often be difficult to achieve adequate retention in the mixed dentition. The appliance will apply relatively large forces when the screw is turned which dissipate rapidly and the overbite will almost certainly reduce as the palatal cusps of the maxillary molars drop down as the molars are tipped buccally.

### The Quadhelix Appliance

The quadhelix appliance (Figure 3) is a



**Figure 2.** The buccal shields of the functional regulator appliance relieve the molars of cheek pressure allowing the buccal segments to expand under tongue pressure.



**Figure 3.** The quadhelix appliance.

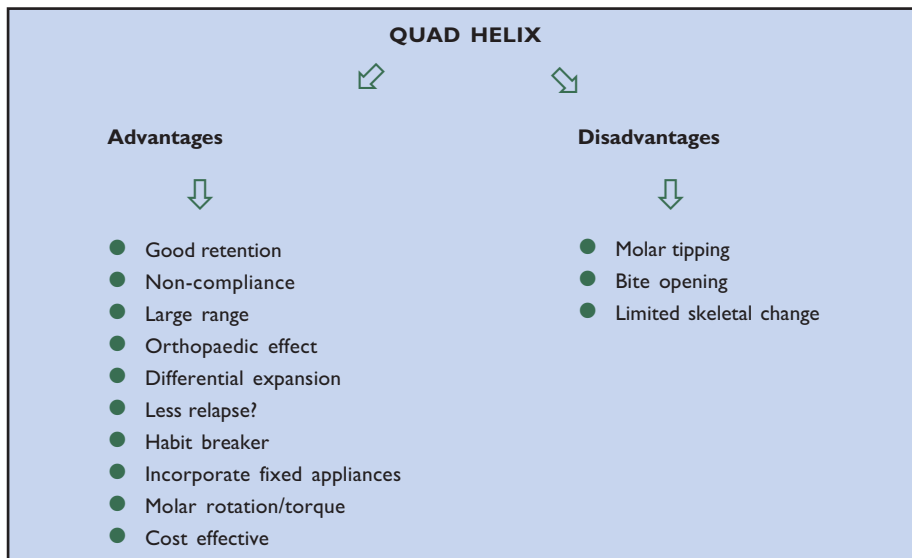


Figure 4. The advantages and disadvantages of the quadhelix appliance.

modification of Coffin's W-spring and was described by Ricketts.<sup>3</sup> 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. The appliance is retained by orthodontic bands which are cemented with glass ionomer cement onto the first permanent molars.

The quadhelix may be laboratory constructed or prefabricated and is typically made from stainless steel. The benefit of the prefabricated appliance is the ease of adjustment during treatment and the ability to torque the molars during expansion. 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 favourable force delivery characteristics due to nickel titanium's superelastic properties. This may help to produce more physiological tooth movement with more rapid correction of crossbites.

**Mode of Action**

The quadhelix appliance works by a combination of buccal tipping and skeletal expansion in a ratio of 6:1 in pre-pubertal children.<sup>4</sup> Figure 4 outlines the principle advantages and disadvantages of this appliance.

**Clinical Management**

The desirable force level of 400 g can be delivered by activating the appliance by approximately 8 mm, which equates to approximately one molar width. Patients should be reviewed on a six-weekly basis. Sometimes, the appliance can leave an imprint on the tongue, however, this will rapidly disappear following treatment. Expansion should be continued until the palatal cusps of the upper molars meet edge-to-edge with the buccal cusps of the mandibular molars. A degree of overcorrection is desirable as relapse is inevitable. A three-month retention period, with the quadhelix in place, is recommended once expansion has been achieved. If fixed appliances are being used, the quadhelix can be removed once stainless steel wires are in place.

**RAPID MAXILLARY EXPANSION**

Rapid maxillary expansion was first described by Emerson Angell in 1860<sup>5</sup> and later re-popularized by Haas. The aim of this technique is to improve the ratio of skeletal to dental movement by producing sutural expansion at the mid-palatal suture. This is achieved by using a rigid appliance, which will limit tipping of the molars, expanding the mid-palatal suture rapidly using high forces to limit the time allowed for dental movement and carrying out treatment during or before the pubertal

growth spurt.<sup>6</sup> Following puberty, there is greater interlocking of the maxillary sutures which may limit their separation.<sup>7</sup>

**Indications/Contra-indications of RME**

As a general rule, rapid maxillary expansion is indicated in cases with a transverse discrepancy equal to or greater than 4 mm, and where the maxillary molars are already buccally inclined to compensate for the transverse skeletal discrepancy. Slow expansion techniques (e.g. quadhelices and removable appliances) tend to tip the molars further, which may be detrimental to their periodontal health and causes excess extrusion and bite opening. More recently, rapid palatal expansion has been used to facilitate maxillary protraction in Class III treatment by disrupting the system of sutures which connect the maxilla to the cranial base. Rapid maxillary expansion is generally contra-indicated in patients who have passed the growth spurt, have recession on the buccal aspect of the molars and who show poor compliance.

**Types of RME Appliances**

A number of different RME appliance



Figure 5. The banded RME appliance.



Figure 6. The bonded RME appliance.

Structure	Effect of RME
Maxilla	<ul style="list-style-type: none"> <li>● Expansion of the mid-palatal suture</li> <li>● Downwards and forward maxillary movement</li> </ul>
Maxillary Dentition	<ul style="list-style-type: none"> <li>● Midline diastema between <math>I/I</math></li> <li>● Buccal molar tipping and extrusion</li> </ul>
Mandible	<ul style="list-style-type: none"> <li>● Downwards and backward rotation leading to a reduction in overbite and increase in face height</li> </ul>
Nose	<ul style="list-style-type: none"> <li>● Widening of alar base width</li> <li>● Reduced resistance to nasal air flow</li> <li>● Nasal deformity if used in very young children</li> </ul>

**Table 1.** The effects of RME.

designs have been described. The principle advantage of the banded appliance (Figure 5) is that oral hygiene is facilitated because gingival coverage is limited. The Haas appliance has palatal flanges, which contact the palatal mucosa, through which expansion forces are transmitted directly to the skeletal structures. However, the large acrylic framework makes cleaning very difficult. The bonded appliance (Figure 6) has become increasingly popular because it can be easily cemented during the mixed dentition stage, when retention from other appliances can be poor. The buccal capping is thought to limit extrusion of the molars during treatment and therefore improve overbite control. However, Reed and co-workers<sup>8</sup> found no difference in the increase in lower face height when comparing bonded and banded appliances.

**Mode of Action**

Table 1 summarizes the main short-term effects of RME. Compared to slow expansion techniques, RME produces expansion by a greater degree of skeletal movement and less tipping of the molars. Wertz<sup>9</sup> found that approximately 40% of the expansion achieved could be attributed to skeletal changes. The ratio between anterior (between the canines) to posterior (between the molars) skeletal expansion was approximately 2:1 and the greatest skeletal response was achieved when treatment was carried out before or during puberty. The posterior maxilla expands less readily because of the resistance produced by the zygomatic buttress and pterygoid plates.

In the long-term, it appears that there is continual relapse of the dental and skeletal expansion, even up to five years after initial treatment.<sup>10</sup>

**Clinical Management of RME**

Before commencing treatment, it is important to warn the patient/parent that an upper midline diastema will form during the expansion phase (Figure 7). This is likely to close spontaneously during the retention period. Patients should be instructed to turn the expansion screw one-quarter turn twice a day (am and pm). This may be associated with minor discomfort. Force levels tend to accumulate following multiple turns and can be as high as 10 kg following many turns.

The activating key should be attached to a handle or tied to a piece of dental floss to prevent swallowing or inhalation should it be dropped in the mouth (Figure

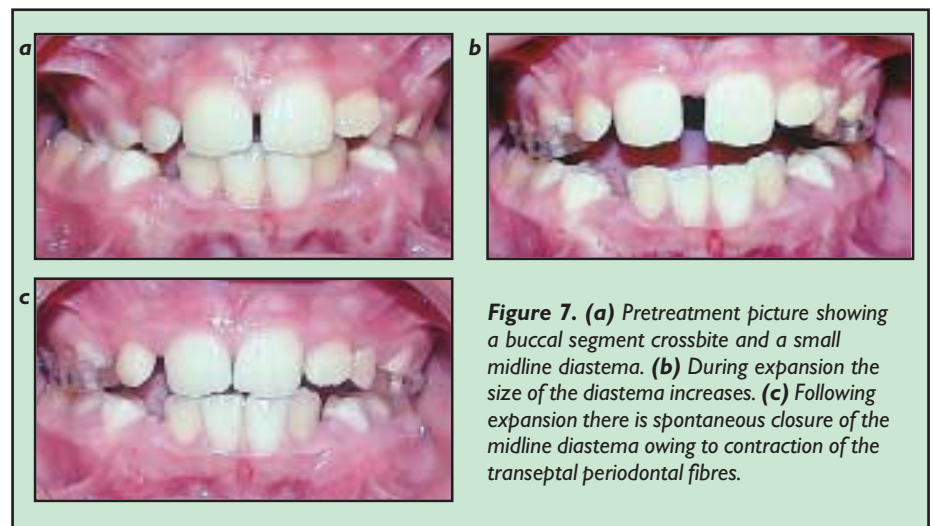
8). Patients should be reviewed on a weekly basis during expansion and some clinicians recommend that an upper occlusal radiograph be taken one week into treatment to ensure that the mid-palatal suture has separated. If there is no evidence of this, it is important to stop appliance activation as there is a risk of alveolar fracture and/or periodontal damage. Active treatment is usually required for a period of 2–3 weeks, after which a retention period of three months is recommended to allow for bony infilling of the separated suture. During retention, a wire ligature can be tied around the expansion screw to prevent it turning inadvertently.

**EXPANSION WITH FIXED APPLIANCES**

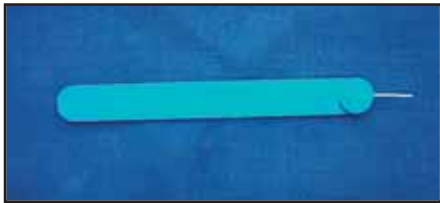
A number of different techniques can be employed using fixed appliances to expand the maxillary arch. The techniques to be discussed include expansion with archwires, use of auxiliary arches and cross elastics.

**Expansion with Archwires**

Significant expansion may be produced by using overexpanded stainless steel archwires, particularly those with a large dimension (for example, 0.021" x 0.025"). The archwire should be overexpanded by approximately 10 mm. One advantage of this technique may be that less buccal tipping of the molars occurs during



**Figure 7.** (a) Pretreatment picture showing a buccal segment crossbite and a small midline diastema. (b) During expansion the size of the diastema increases. (c) Following expansion there is spontaneous closure of the midline diastema owing to contraction of the transeptal periodontal fibres.



**Figure 8.** The activating key of an RME appliance may be attached to a handle to prevent swallowing or aspiration.

expansion as the rectangular archwire maintains torque control.

### Auxiliary Arches

Expansion arches, also known as jockey arches, are auxiliary wires that can be easily and cheaply constructed at the chairside and incorporated into a fixed appliance during treatment. They can also be used to maintain arch width after rapid maxillary expansion.

The expansion arch, which can be made from 0.019" x 0.025" rectangular stainless steel or a larger round steel wire with a diameter of 1–1.13 mm, runs over the main archwire and is inserted into the extra-oral traction tubes of the first molar bands posteriorly and secured anteriorly with a ligature (Figure 9). Some operators prefer to bend the wire into the buccal sulcus in order to reduce its visibility.

The advantages of using expansion arches are that their construction is cheap and can be carried out easily at the chairside without having to change the molar bands. Expansion is likely to be produced by a degree of molar tipping and this may be reduced by incorporating molar buccal root torque into the main rectangular archwire.

### Cross Elastics

To produce maxillary expansion, cross elastics run from the palatal aspect of one or more of the maxillary teeth to the buccal aspect of one or more of the mandibular teeth (Figure 10). In addition to producing lateral forces, a vertical force vector is also produced which tends to cause molar extrusion. This can be detrimental in patients with a reduced overbite or increased face height. To limit the degree of molar tipping, cross elastics

should only be used in conjunction with rectangular stainless steel archwires. Success with this technique is dependent on good patient compliance.

### SURGICAL TECHNIQUES

Surgically assisted expansion techniques can be considered in skeletally mature individuals with significant transverse discrepancies.

The techniques available include:

- Surgically Assisted Rapid Palatal Expansion (SARPE);
- Segmental maxillary surgery.

### SARPE

The main resistance to maxillary skeletal expansion comes from the buttressing effect of the zygomatic and sphenoid bones at their point of attachment to the maxilla and from the integrity of the mid-palatal suture. With SARPE, these attachments are surgically severed which allows expansion to be easily achieved using a conventional RME appliance. Fixed appliances can be used to move apart the roots of the central incisors before surgery so that the roots are not damaged by the midline maxillary cuts.

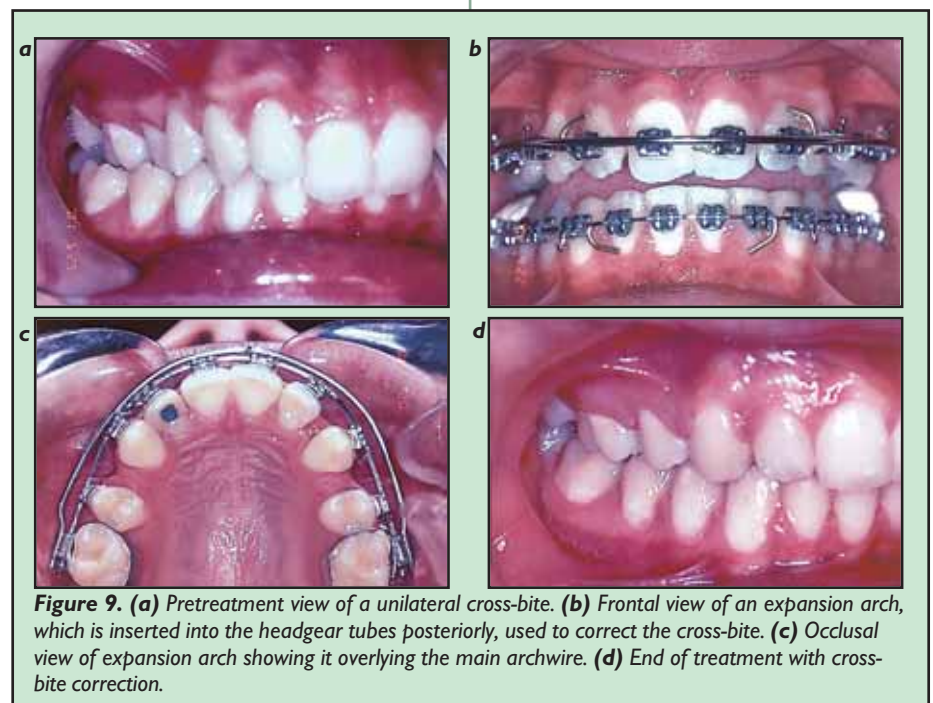
Expansion is typically carried out at a rate of 0.5 mm a day and patients develop a significant midline diastema which they must be warned about (Figure 11). Surgical expansion has a high relapse tendency, probably because of the inelasticity of the palatal mucoperiosteum, and a degree of over correction is valuable.

SARPE is the technique of choice in patients who do not have co-existing sagittal and vertical maxillary discrepancies which may require maxillary surgery at a later date.

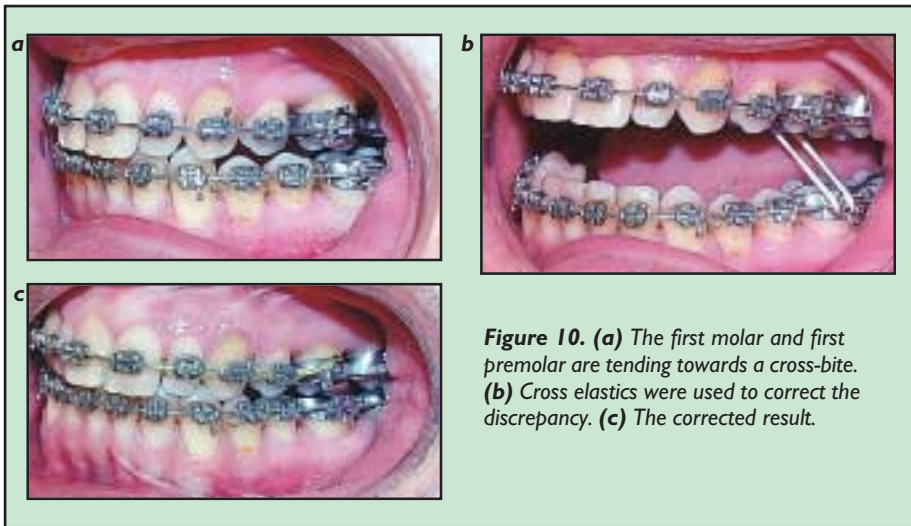
### Segmental Maxillary Surgery

Transverse expansion can be produced during a Le Fort 1 osteotomy by creating an additional surgical cut along the mid-palatal suture. The maxillary halves are then separated and retained in the new position. The relative inelasticity of the palatal mucoperiosteum limits the degree of expansion that may be achieved.

Before surgery, orthodontic treatment involves moving the roots of the maxillary central incisors apart to improve surgical access to the osteotomy site. This is the technique of choice in patients who require expansion and have co-existing sagittal and/or vertical maxillary discrepancies.



**Figure 9.** (a) Pretreatment view of a unilateral cross-bite. (b) Frontal view of an expansion arch, which is inserted into the headgear tubes posteriorly, used to correct the cross-bite. (c) Occlusal view of expansion arch showing it overlying the main archwire. (d) End of treatment with cross-bite correction.



**Figure 10.** (a) The first molar and first premolar are tending towards a cross-bite. (b) Cross elastics were used to correct the discrepancy. (c) The corrected result.

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**STABILITY OF CROSSBITE CORRECTION**

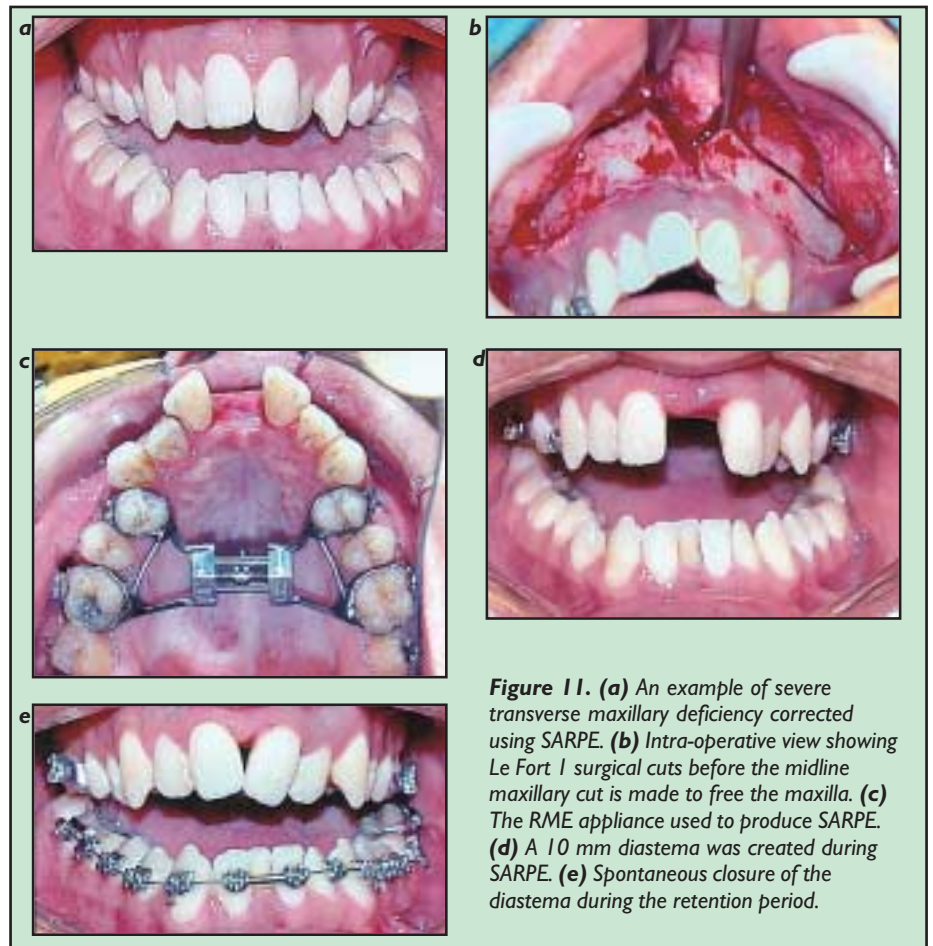
The factors which may be important in enhancing the stability of maxillary expansion include:

- Achievement of good intercuspation;
- Alteration in tongue position. Expanding the maxilla in some cases may allow the tongue to adopt a higher resting position which may help to maintain increases in transverse arch dimensions;
- Mode of respiration. Expansion may be less stable in mouth breathers because of the lower natural tongue position.
- Retention. Retainers should be constructed from acrylic and the Hawley type is recommended. The more flexible Essix type of retainer may not have adequate rigidity to counteract relapse forces.

**CONCLUSIONS**

Maxillary expansion is indicated in a variety of clinical situations and we have reviewed the different mechanisms available to clinicians. The precise method selected will depend on the nature of the crossbite (i.e. skeletal versus dental), the size of the discrepancy, the age of the patients and other factors related to the dentition (e.g. amount of dento-alveolar compensation present and the periodontal health). Before treatment is commenced, it is essential that the

prognosis for stability of correction is assessed. The main factors influencing stability have been stated. Owing to the high relapse potential of transverse expansion, it is important to achieve a degree of over correction and provide adequate retention.



**Figure 11.** (a) An example of severe transverse maxillary deficiency corrected using SARPE. (b) Intra-operative view showing Le Fort I surgical cuts before the midline maxillary cut is made to free the maxilla. (c) The RME appliance used to produce SARPE. (d) A 10 mm diastema was created during SARPE. (e) Spontaneous closure of the diastema during the retention period.