Catherine A Brierley Jonathan Sandler

Managing the Transverse Dimension

Abstract: The management of transverse discrepancies is one of the most challenging aspects of high quality orthodontic treatment. There are many different methods of managing the transverse dimension. We will outline the indications, advantages and disadvantages of these methods.

CPD/Clinical Relevance: Transverse discrepancies are a common malocclusion which clinicians need to be able to manage.

Ortho Update 2017; 10: 86–94

A crossbite exists when the buccal cusps of the mandibular teeth occlude buccally to the buccal cusps of the maxillary dentition. The estimated prevalence of posterior crossbites ranges from 5% to 23% with a greater prevalence of unilateral crossbite with associated mandibular shift.[1] Most posterior crossbites (50% to 90%) persist when the permanent teeth erupt though, for a minority, the crossbite self corrects.[2] Maxillary transverse expansion is widely used in orthodontic treatment and indications for maxillary expansion include:

1. Restricted maxillary arch width;
2. Mandibular functional shift;
3. To increase arch length in the absence of a posterior crossbite;
4. To improve a Class II relationship by spontaneous mandibular growth or repositioning.[3]

Some authors report that, if left untreated, a crossbite with associated mandibular shift could increase the risk of the individual developing bruxism,[4] facial asymmetry and temporomandibular joint dysfunction (TMD). The relationship between posterior crossbites and TMD has been long debated and the link is unclear.[5] Other reported indications for maxillary expansion include improved nasal breathing, however, these changes are of questionable significance.[6] It has also been thought to have an effect on nocturnal enuresis.[7]

Agostino *et al* report an unclear aetiology to posterior crossbites, but it may be skeletal, soft tissue, dental, respiratory factors, or as a result of a habit (eg digit sucking) or pathology.[2]

Specific clinical situations in which changing the transverse dimension should be considered include:

- Crossbites – here are clear indications for correcting a unilateral crossbite with associated mandibular functional shift. The reason being it would be undesirable for the occlusion to become fully established with the mandible in a displaced position. With a bilateral crossbite without mandibular displacement, however, accepting the crossbite can often be a sensible treatment choice as effective correction of a bilateral crossbite can be extremely challenging.
- Class II functional appliance treatment. In the majority of cases, it is important to expand the maxillary arch during treatment in order to maintain arch co-ordination once the mandibular dentition is repositioned further forwards.
- Orthognathic cases. In order to achieve good post-surgical occlusion, transverse arch co-ordination is essential and maxillary expansion, with or without surgical assistance, often precedes the major orthognathic correction.
- Aid to Class III orthodontic correction. There are suggested benefits associated with rapid maxillary expansion (RME) in conjunction with maxillary protraction facemask therapy including: 1) splinting of the maxillary dentition to aid forward movement during protraction therapy; 2) backward and downward rotation of the mandible; 3) disarticulation of the circummaxillary sutures.[8] RME has been postulated to prime the sutures for more pronounced orthopaedic effects, however, a randomized clinical trial by Vaughn *et al* reported that early facemask therapy, with or without palatal expansion, is effective in correcting skeletal Class III malocclusions.[8]
- Mild crowding – expansion may be used in selected cases to help with space requirements for the relief of mild crowding. It has been reported that mandibular intermolar width increases of between 2–3 mm remain stable.[9] It has been shown that a 1 mm increase in the inter-premolar width increases the arch perimeter by 0.7 mm.[10]
- Interceptive treatment for impacted canines. A randomized clinical trial by Baccetti *et al* reported that subjects treated with rapid maxillary expansion

Catherine A Brierley, BDS(Hons), MFDS RCS, MClinDent, Orthodontic, Post-CCST, Sheffield and Chesterfield and **Jonathan Sandler**, BDS(Hons), MSc, PhD, FDS RCPS, MOrth RCS, Professor and Consultant Orthodontist, Chesterfield Royal Hospital, Chesterfield, Derbyshire, UK.

have a rate of successful eruption of palatally displaced canines (65.7%) that was almost five times greater than that of the untreated controls (13.6%), and this difference was statistically significant (P <0.001).[11]

Treatment options for managing the transverse dimension

Upper removable expansion plates

Removable expanders comprise a maxillary acrylic baseplate with a midline expansion screw which the patient is meant to turn a quarter turn once weekly (0.25 mm/week). Arch expansion, if it does occur, is mostly by buccal tipping of the molar teeth. Few clinicians believe that significant skeletal expansion is possible in pre-adolescent children. Following expansion, the removable appliance must be worn for a further 3–6 months for retention of the achieved arch width changes.

The theoretical advantages of removable expanders are that they can be removed for cleaning and other active components can be incorporated in the appliance to attempt other non-related tooth movements.

There are, however, two major limiting factors of removable plates. The first is that, for a successful outcome, it requires that patients comply with activation and wear-time prescriptions. During expansion, failure to wear the appliance will usually result in rapid relapse, thus the need for adjustment of the midline expansion screw to constrict the appliance again until it fits, so that expansion can then be resumed. Appliance fit is often severely compromised. The second problem is that the rate of expansion is necessarily slow because fast expansion with high forces results in problems with retention of the appliance. Well-adjusted Adams cribs on the first premolars and first permanent molars are often essential for success.

Other (less commonly used) removable expanders have also been described, such as the expansion and labial segment alignment appliance (ELSAA) or a removable appliance incorporating a coffin spring (1.25 mm wire). These have also been employed with varying degrees of success.

Figure 1. (a–c) Pre-treatment: sagittal correction without simultaneous transverse correction would likely result in posterior crossbites.

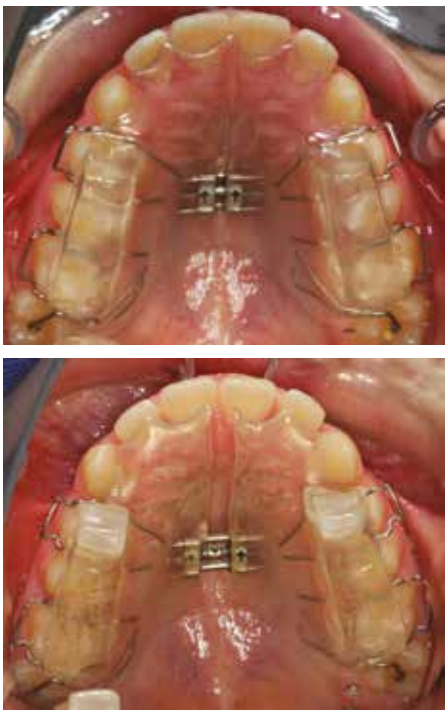

Figure 2. (a, b) Seven months of twin-block treatment. Palatal expansion achieved by once weekly turning (0.25 mm/week) of the mid-palatal screw.

Expansion as an integral part of the twin-block treatment

The twin-block appliance is commonly used in the treatment of Class II skeletal discrepancies in growing patients. The overjet is reduced by a combination of skeletal (27%) and dental change (73%).[12] In the vast majority of cases, the maxillary arch is expanded at the same time as sagittal correction in order to maintain arch co-ordination as the maxillary dentition is distalized relative to the mandibular dentition (Figures 1–3). This would usually be performed by once weekly turning (0.25mm /week) of the mid-palatal expansion

Figure 3. (a–c) Maintenance of transverse relationship alongside sagittal correction. Following twin-block treatment, the patient transitioned to a clip over bite plane (COBP) and upper and lower fixed appliances. The COBP helped to maintain the transverse and antero-posterior correction.

Advantages	Disadvantages
Can be fixed or removable. Removable quadhelices can be easily expanded or contracted without the need for removing then recementing molar bands.	Molar tipping and associated bite opening
Does not rely on patient compliance	No orthopaedic change (although some orthopaedic change has been suggested in pre-adolescent children)
Can also function as a habit breaker	Usually no more than 4 mm expansion achievable
Can be used simultaneously with a fixed appliance	Can cause transitory discomfort and a soft tissue imprint on the dorsal mucosa of the tongue which resolves on removal of the appliance
Can be used for molar derotation	If not monitored closely and adjusted properly the quadhelix can become embedded in the palatal mucosa (Figures 6 and 7)
Removable quadhelices can be used to introduce buccal root torque on the upper molars	

Table 1. Advantages and disadvantages of using a quadhelix for expansion.

Figure 4. Removable quadhelix with separators to hold quadhelix in palatal sheath.

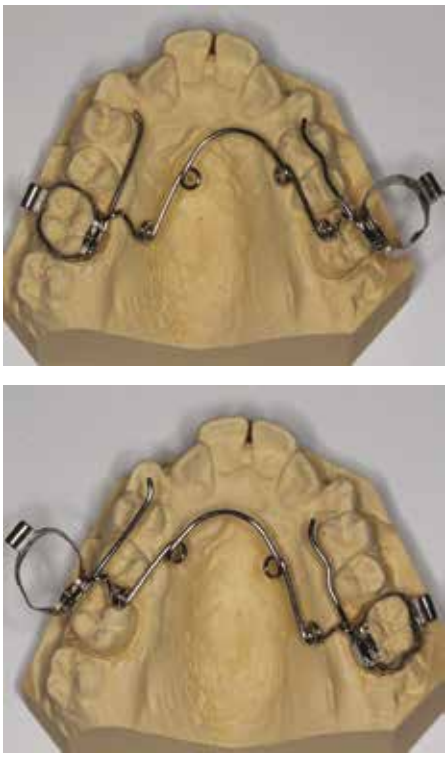

Figure 5. (a, b) Activation of quadhelix by one molar tooth width. Check the amount of expansion by placing quadhelix in turn on each first molar.

Figure 6. (a, b) Inadequate monitoring and adjustment of the quadhelix can lead to embedding of the quadhelix in the soft tissue mucosa.

Figure 7. (a–c) Technique for intra-oral adjustment of the quadhelix using triple beak pliers.

screw. The advantage to this approach is that transverse and sagittal correction are occurring simultaneously. The main limitation of this method is the same as for upper removable expansion plates; patients must comply with wear-time and activation prescriptions.

There are no studies, to our knowledge, examining the stability of transverse correction following twin-block treatment. A possible reason for the paucity of literature in this area is that clinicians do not experience significant problems with relapse. This may be because expansion occurs at a slow rate over a period of usually 9 months. Additionally, of the methods reported for transitioning from twin-block to fixed appliances,[13] two of the more common methods contribute to retention to the transverse correction: 1) use of a clip over bite plane; and 2) part-time wear.

Quadhelix

Quadhelices can be laboratory

constructed or prefabricated and adjusted chairside. They can be removable (Figure 4) or fixed and are usually made of 0.9 or 1.0 mm stainless steel with four helices which increase the flexibility and range of activation. Trihelices can be useful in patients with cleft lip and palate. The desirable force level of 300–400 g can be delivered by activating the appliance by approximately one molar width (Figure 5). The length of palatal arms can be altered to include the teeth that are in crossbite, where appropriate, though there is rarely any advantage at all in extending them forwards of first premolars. Quadhelices are usually cemented using glass-ionomer cement or compomer onto first permanent molars. Over-correction of the maxillary expansion is usually required to account for the inevitable relapse. Proffit *et al* recommend that the palatal cusps of the maxillary teeth should occlude on the lingual inclines of the buccal cusps of the mandibular molars at the end of active expansion.[14] Quadhelices are usually kept in until placement of full-sized rectangular stainless steel working archwires.

A recent Cochrane review reported that 'there is a small body of low-to-moderate quality evidence to suggest that the quadhelix appliance may be more successful than removable expansion plates at correcting posterior crossbites and expanding the inter-molar width for children in the early mixed dentition (aged 8–10 years)'. The authors reported that quadhelix appliances may: 1) be 20% more likely to correct crossbites than removable expansion plates; and 2) achieve 1.15 mm more molar expansion than expansion plates. There was insufficient evidence regarding canine expansion or the stability of crossbite correction.[2] The advantages and disadvantages of quadhelices are summarized in Table 1.

Comparing quadhelix expansion with rapid maxillary expansion, quadhelices were reportedly preferred because of lower forces and better tissue adaptation during expansion.[15,16] However, no strong conclusions regarding the dental and skeletal effects of slow expansion could be made in the systematic review by Lagravère *et al* due to the fact that the studies included did not have a control group.[17]

Rapid maxillary expansion (RME)

The theory behind RME is that the force on the teeth is transmitted to the bone causing separation at the mid-palatal suture, but before significant tooth movement can occur. Clinicians therefore aim to use RME before or during the pubertal growth spurt prior to complete fusion of the suture.

As a general rule, clinicians opt for RME when the transverse discrepancy is more than or equal to 4 mm. It is the preferred technique, especially when the maxillary molars are buccally flared. This is because a quadhelix would tip the molars even further, possibly compromising periodontal health and reducing the overbite by propping open the bite on the molar palatal cusps. Expansion with RME is differential: the maxilla expands as if on one hinge with the apex at the bridge of the nose giving more expansion at the roof of the mouth than at the nasal floor, and a second hinge from the palatal aspect with more expansion anteriorly than posteriorly. The posterior maxilla expands less readily because of the resistance produced by the zygomatic buttress and pterygoid plates.

Lagravère *et al* reported that the immediate effects of RME were 60% dental and 40% skeletal.[18] The long-term skeletal

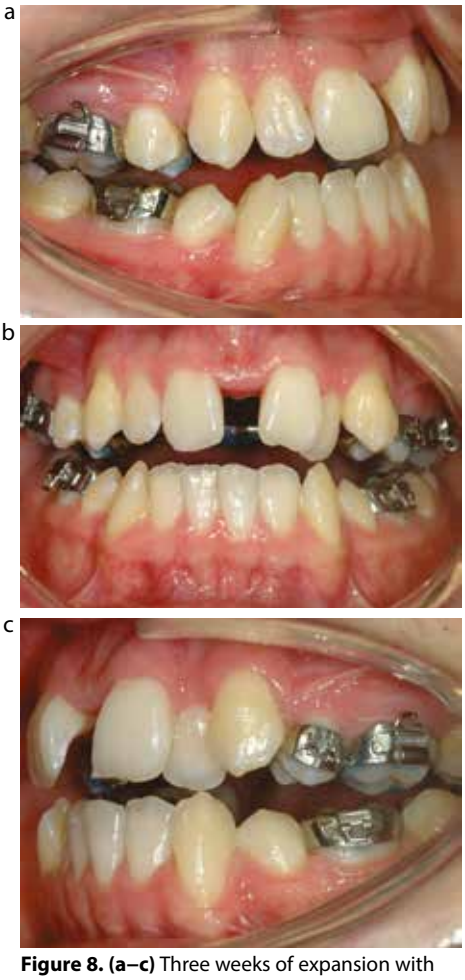

Figure 8. (a–c) Three weeks of expansion with a Hyrax RME. The mid-palatal screw was turned twice daily (0.5 mm/day) resulting in a midline diastema.

Figure 9. (a–e) Spontaneous closure of diastema observed at 3 months post sealing the mid-palatal screw.

Figure 10. (a–h) Before and after SARME using a Hyrax RME.

effects and stability of RME are less clear owing to small numbers of trials with weak methodologies. Lagravère *et al* reported no significant long-term changes in the antero-posterior or vertical dimensions following RME.[19] Although transverse correction by RME is considered by many as stable, there is a lack of strong evidence to support this.

There are two types of RME appliances. The Haas RME uses acrylic pads and heavy wires to apply pressure to both the teeth and palatal tissues. The main disadvantage of this method is that the palatal acrylic flanges impede cleaning. The Hyrax RME is an expander soldered to bands on the first molars and first premolars with a wire connecting the bands. The Cochrane review by Agostino *et al* reported that, in the correction of posterior crossbites in children (8–10 years), the Haas RME produced more expansion (0.7 mm mean difference) than the Hyrax RME, but this difference was not statistically significant.[2]

Clinical management

During consent and before starting treatment, it is important to warn the patient and parent that an upper midline diastema will form during expansion (Figures 8 and 9). The central diastema closes spontaneously from a combination of skeletal and dental relapse rather than from tooth movement alone. Patients may experience pressure or discomfort during expansion and may occasionally experience a popping sensation as the suture opens.

When choosing bands for the premolars and molars, it is prudent to choose band sizes that are 2–3 sizes slightly larger than one would usually use during fixed appliances, to account for the four paths of insertion needed when cementing the RME. It is essential that the RME fits

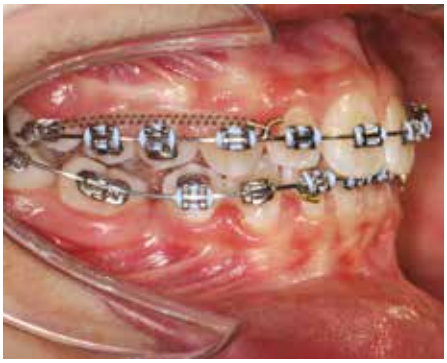

Figure 11. (a–c) During treatment a patient presented with a bilateral tendency to crossbite.

well and is cemented securely, as failure of the RME during expansion, or in the 3 months following expansion, will result in immediate loss of some of the transverse correction.

RME is usually performed by asking patients or their parents to turn a mid-palatal screw twice daily (0.5 mm/day, am and pm). The activation key should be attached to a plastic handle or a length of dental floss to prevent accidental swallowing or inhalation of the key. Patients should be reviewed on a weekly basis during rapid expansion to ensure that the appliance is not becoming loose.

The amount of inter-premolar and inter-molar changes should be measured using a pair of dividers. Palpation of the buccal mucosa can help the clinician to detect if the roots of teeth have been moved to the surface of the buccal cortex, indicating a need to stop and/or reduce the expansion. Some clinicians recommend that an upper occlusal radiograph be taken two weeks into treatment to check for separation of the mid-palatal suture. Lack of suture opening is a potential problem with RME in non-growing patients. RME in these patients can result in excessive tipping, buccal plate defects, gingival recession and asymmetric expansion.

Active screw turning is usually required for a period of three weeks, after which a retention period of three months is recommended to allow for bony infilling of the separated suture. During retention, compomer or glass-ionomer cement should be placed around the expansion screw to prevent it turning inadvertently (Figure 9).

Surgically assisted rapid maxillary expansion (SARME)

SARME is used for the correction of posterior crossbites in skeletally mature patients with fusion of the mid-palatal suture. Additionally, in cases with severe maxillary hypoplasia, the amount of expansion needed may not be attainable with traditional orthodontic expansion alone. SARME is a form of distraction osteogenesis in which a partial osteotomy or corticotomy aids expansion with a tooth- or bone-born expansion appliance (Figure 10). Opinions vary as to the best techniques and specific osteotomy sites required for stable expansion. One approach is a buccal corticotomy or effectively a Le Fort I osteotomy and/or mid-palatal split, followed by RME. The immediate effects and stability of SARME have been examined in a systematic review. Lagravère *et al* reported that the immediate intermolar width increased by 7.1–8.7 mm with a smaller intercanine width increase of 4.9–5.2 mm. They found that there were no clinically significant changes in vertical or sagittal dimensions, and that relapse of the intermolar width at one year was 0.5–1 mm.[20]

A systematic review by Verstraaten *et al* found no evidence of an advantage of a bone-borne expansion appliance over tooth-borne SARME.[21]

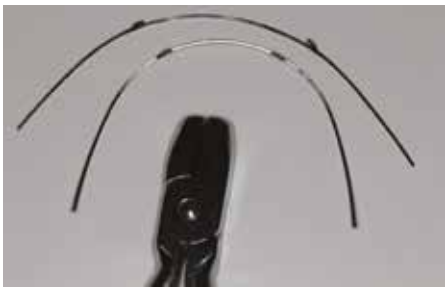

Figure 12. The upper archwire was expanded.

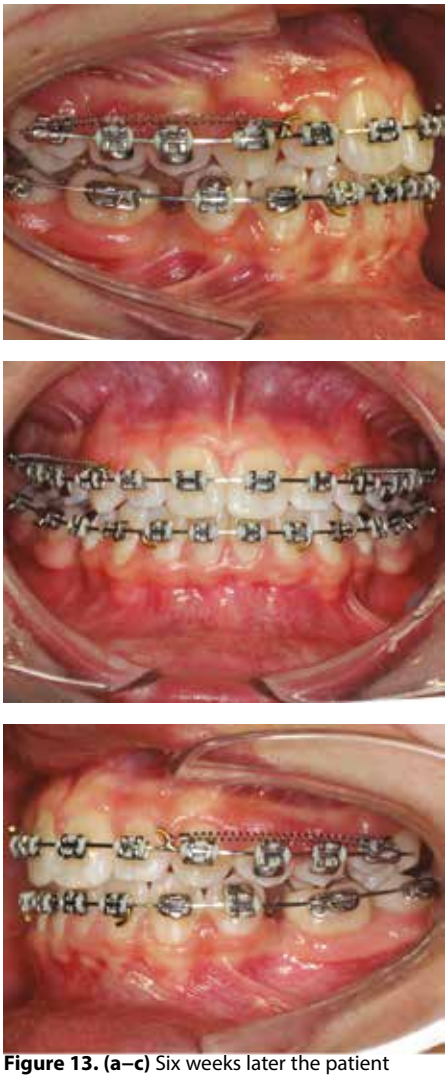

Figure 13. (a–c) Six weeks later the patient presented with a scissors bite affecting the upper molars.

Figure 14. (a–e) Cross-elastics have been started to correct a scissors bite affecting the upper left buccal segment. Kobayashi ligatures were placed on the UL4 and UL5 and lingual buttons were bonded to the LL4, LL5 and LL6.

Archwire expansion

Another method commonly used by clinicians to attempt transverse correction is by expanding the upper archwire and contracting the lower archwire (Figures 11–13). There are difficulties with this approach. The first is that the arch expansion is slow to occur and significant expansion can be difficult if not impossible to achieve predictably. Additionally, one will usually employ this method when in working rectangular 0.019" x 0.025" stainless steel archwires, which means that expansion is attempted in the later stages of treatment and any change achieved will need retaining for a significant period. Some clinicians suggest that differential expansion can be achieved with this technique by placing buccal root torque on the side that does not need expanding, however, little evidence has been presented of the success of this technique.

Figure 15. (a–c) Three months of cross-elastic wear resulted in full correction of the scissors bite.

Cross-elastics

Cross-elastics can be an extremely effective way to help correct buccal segment crossbites or indeed scissorbites. If there were a scissorbite, one would place Kobayashi ligatures on the brackets of the affected upper molar and premolar teeth and buttons on the lingual surfaces of the lower teeth when in rectangular stainless steel archwires (Figures 14–15). The opposite would be done for crossbite correction, with the elastic running between the palatal surface of the uppers, and the buccal surface of the lowers. The patient would then be instructed to wear an intra-oral elastic from the ligatures to the buttons full-time, changing the elastic once daily. The main factor limiting success with this technique is the lack of patient co-operation with elastic wear.

Self-ligating brackets

Over the past eight years, prospective clinical studies investigating the effects of self-ligating systems have been conducted. One of these effects investigated is arch dimensional changes (Figure 16). Fleming *et al* reported statistically more intermolar expansion associated with self-ligating (SmartClip, 3M Unitek, Monrovia, Calif, USA) appliances compared with the conventional pre-adjusted edgewise appliance (Victory, 3M Unitek).[22] However, the difference was only 0.91 mm, which may not be considered clinically significant, and only mandibular arch dimensional changes were assessed. Pandis *et al* also reported statistically greater intermolar expansion with Damon II (Ormco, Glendora, Calif, USA) brackets compared with the conventional edgewise group.[23] However, there was no statistically significant difference noted in intercanine expansion between the two groups. It remains to be seen whether expanded archwire forms with self-ligation promotes significantly more transverse increase than conventional edgewise systems.

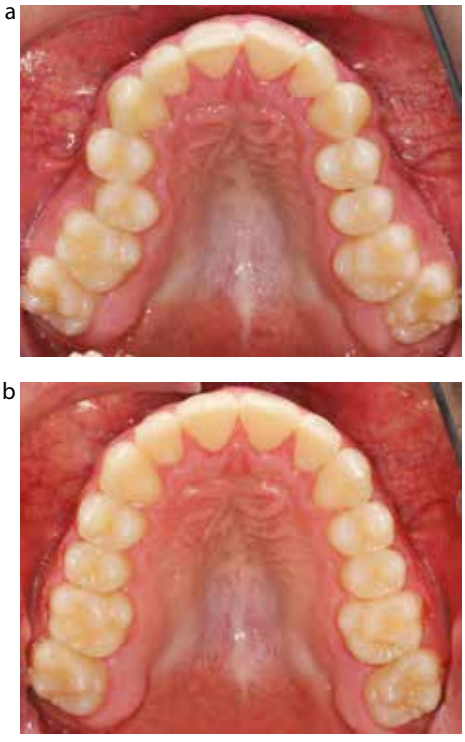

Figure 16. (a, b) Expansion post non-extraction fixed appliance treatment using Damon Q (Ormco, Glendora, California, USA).

Expansion arch

The expansion arch or auxiliary buccal arch can be made from 0.9–1.135mm round stainless steel wire bent into the shape of a dental arch and inserted into the extra-oral traction tubes on the first molar bands. A prospective randomized clinical trial by Mcnally *et al,* comparing quadhelices and expansion arches, reported that both were equally effective, but that 75% patients disliked the appearance of the expansion arch compared with 25% patients who disliked the appearance of the quadhelix. The expansion arch was, however, significantly cheaper.[24]

Conclusion

The different methods of correcting transverse discrepancies have been discussed. Clinicians need to be aware of the respective merits and limitations for each of these methods. The method chosen will depend on several factors, such as the nature of the crossbite (skeletal or dental), the degree of dento-alveolar compensation, the size of the discrepancy, and age of the patient. Consideration should also be given to the stability of the correction and to the provision of adequate retention.

References

1. Marshall S. Orthodontic treatment of the transverse dimension – assessment of the evidence. In: *Evidence-based Orthodontics*. Huang G, Richmond S, Vig K, eds. Oxford: Blackwell Publishing Ltd, 2011: pp234–235.
2. Agostino P, Ugolini A, Signori A, Silvestrini-Biavati A, Harrison JE, Riley P. Orthodontic treatment for posterior crossbites. *Cochrane Database Syst Rev* 2014 Aug 8 (8): CD000979. **www.ncbi.nlm.nih.gov/pubmed/25104166**
3. Marshall S, English JJ, Huang G *et al*. Long-term stability of maxillary expansion. *Am J Orthod Dentofacial Orthop* 2008; **87**: 584–588.
4. Malandris M, Mahoney E. Aetiology, diagnosis and treatment of posterior cross-bites in the primary dentition. *Int J Paediatr*

Dent 2004; **14**: 155–166.
5. Luther F. TMD and occlusion part II. Damned if we don't? Functional occlusal problems: TMD epidemiology in a wider context. *Br Dent J* 2007; **202**: E3.
6. Gordon J, Rosenblatt M, Witmans M, Carey J, Heo G, Major P, Fores-Mir C. Rapid palatal expansion effects on nasal airway dimensions as measured by acoustic rhinometry. A systematic review. *Angle Orthod* 2009; **79**: 1000–1007.
7. Al-Taai N, Alfatlawi F, Ransjö M, Fakhry S. Effect of rapid maxillary expansion on monosymptomatic primary nocturnal enuresis. *Angle Orthod* 2015; **85**: 102–108.
8. Vaughn GA, Mason B, Moon H-B, Turley PK. The effects of maxillary protraction therapy with or without rapid palatal expansion: a prospective, randomized clinical trial. *Am J Orthod Dentofacial Orthop* 2005; **128**: 299–309. **www.sciencedirect.com/science/article/pii/S0889540605004245**
9. Lee R. Arch width and archform: a review. *Am J Orthod* 1999; **115**: 305–313.
10. Adkins M, Nanda R, Currier G. Arch perimeter changes on rapid palatal expansion. *Am J Orthod* 1990; **97**: 10–19.
11. Baccetti T, Mucedero M, Leonardi M, Cozza P. Interceptive treatment of palatal impaction of maxillary canines with rapid maxillary expansion: a randomized clinical trial. *Am J Orthod Dentofacial Orthop* 2009; **136**: 657–661. **www.sciencedirect.com/science/article/pii/S0889540609007094**
12. O'Brien K, Wright J, Conboy F, Sanjie Y, Mandall N, Chadwick S *et al.* Effectiveness of early orthodontic treatment with the Twin-block appliance: a multicenter, randomized, controlled trial. Part 1: Dental and skeletal effects. *Am J Orthod Dentofacial Orthop* 2003; **124**: 234–243.
13. Fleming PS, Scott P, DiBiase AT. How to manage the transition from functional to fixed appliances. *J Orthod* 2007; **34**: 252–259.
14. Proffit W, Fields H, Sarver D. *Contemporary Orthodontics* 5th edn. Missouri: Elsevier Mosby, 2013: pp476–480.
15. Hicks E. Slow maxillary expansion: a clinical study of the skeletal versus dental response to low-magnitude force. *Am J Orthod* 1978; **73**: 121–141.
16. Bell R. A review of maxillary expansion in relation to rate of expansion and patient's age. *Am J Orthod* 1982; **81**: 32–37.
17. Lagravère M, Major P, Flores-Mir C. Skeletal and dental changes with fixed slow maxillary expansion: a systematic review. *Am J Orthod Dentofacial Orthop* 2005; **136**: 194–199.
18. Lagravère M, Heo G, Major P, Flores-Mir C. Meta-analysis of immediate changes with rapid maxillary expansion treatment. *Am J Orthod Dentofacial Orthop* 2006; **137**: 44–53.
19. Lagravère M, Major P, Flores-Mir C. Long term skeletal changes with rapid maxillary expansion: a systematic review. *Angle Orthod* 2005; **75**: 155–161.
20. Lagravère M, Major P, Flores-Mir C. Dental and skeletal changes following surgically assisted rapid maxillary expansion. *Int J Oral Maxillofac Surg* 2006; **35**: 481–487.
21. Verstraaten J, Kuijpers-Jagtman AM, Mommaerts M, Bergé S, Nada R, Schols J. A systematic review of the effects of bone-borne surgical assisted rapid maxillary expansion. *J Cranio-Maxillofacial Surg* 2010; **38**: 166–174.
22. Fleming PS, DiBiase AT, Sarri G, Lee RT. Comparison of mandibular arch changes during alignment and leveling with 2 preadjusted edgewise appliances. *Am J Orthod Dentofacial Orthop* 2009; **136**: 340–347.
23. Pandis N, Polychronopoulou A, Makou M, Theodore E. Mandibular dental arch changes associated with treatment of crowding using self-ligating and conventional brackets. *Eur J Orthod* 2010; **32**: 248–253.
24. Mcnally MR, Spary DJ, Rock WP. A randomized controlled trial comparing the quadhelix and the expansion arch for the correction of crossbite. *J Orthod* 2005; **32**: 29–35.