# Non-surgical management of maxillary transverse discrepancies in the orthognathic patient: a review

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**Abstract:** Adequate transverse maxillary dimension contributes to a stable and functional occlusion. Consideration of the transverse plane is a fundamental requirement when managing skeletal problems in the orthognathic patient. The presence and extent of absolute and/or relative transverse discrepancies, the degree of dento-alveolar compensation in the transverse dimension and smile aesthetics are some of the key considerations that influence treatment choices. Furthermore, the field of orthodontics has seen significant advances in techniques for non-surgical expansion over the last decade. As such, the rationale for publishing this review is to provide clinicians and surgeons with a contemporary overview of these novel developments in an evidence-based manner that aids clinical decision making and influences and shapes clinical practice when managing orthognathic patients with maxillary transverse discrepancies. This paper focusses on the importance of diagnosis in assessing and quantifying expansion requirements in the maxilla and provides a review of non-surgical expansion techniques available to manage orthognathic patients. The review provides a detailed appraisal of literature surrounding the timing and appropriateness of mid palatal expansion with non-surgical approaches which is a clinical dilemma that plagues orthodontist and surgeons routinely. Furthermore, it appraises the effectiveness and published literature surrounding the use of newer techniques to achieve expansion.

**Keywords:** Orthognathic surgery; transverse expansion; rapid maxillary expansion (RME); miniscrew-assisted rapid palatal expansion (MARPE)

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## Introduction

An adequate transverse maxillary dimension is a critical component of a stable and functional occlusion (1). Failure to consider the transverse dimension may result in a functional posterior crossbite with displacement. This may be associated with temporomandibular joint dysfunction, tooth wear, asymmetric muscular activity and resultant dentofacial deformity (2,3). Furthermore, it can have a positive impact on smile aesthetics by limiting the extent of buccal corridors and increasing display of buccal teeth

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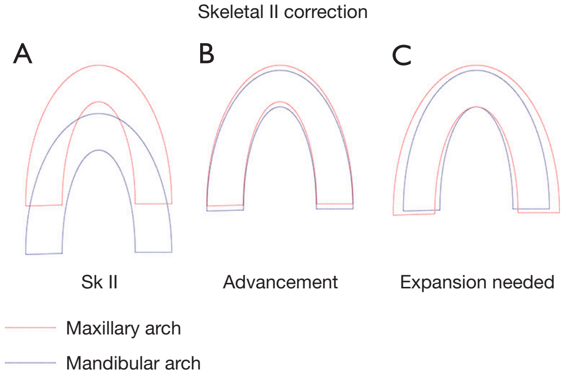


**Figure 1** Illustration of relative transverse discrepancy. The diagram shows how an anterior-posterior skeletal discrepancy will be presented as a relative transverse discrepancy (A). Advancement of the mandible will often require expansion in the maxilla due to dento-alveolar compensation of the maxillary arch (B,C). Sk, skeletal.

which is a preferred aesthetic feature in both men and women (4).

The key considerations in planning maxillary transverse discrepancy correction in orthognathic patients include; assessing whether expansion is required, evaluating the amount of expansion needed and determining how this will be achieved. These factors will now be discussed.

## Assessing the malocclusion

Consideration of the transverse plane is required when treating skeletal discrepancies of all three planes of space (1). The nature and extent of the antero-posterior and vertical discrepancy have an influence on the transverse relationship of the teeth and this must be fully evaluated pre-treatment to ensure complete correction to help achieve an aesthetic, functional, healthy and stable occlusion (5).

Adequate maxillary arch width is an important factor to be considered for orthognathic patients that present with both skeletal II and skeletal III deformity. Appropriate management relies on distinguishing between an absolute and relative transverse discrepancy in patients that present with anteroposterior discrepancies (5-7). A difference between the maxillary and mandibular transverse widths, that remains once the antero-posterior relationship has been corrected is termed an "absolute transverse discrepancy" and warrants intervention to achieve correction. In comparison, a "relative transverse discrepancy" manifests due to the relative antero-posterior positioning (with a narrower part of the maxilla opposing a wider part of the mandible) and will resolve when once the anteroposterior disharmony is corrected surgically. Malocclusions often present with a combination of absolute and relative transverse discrepancies where antero-posterior problems exist (5).

Skeletal II malocclusions result in a narrower part of the mandible occluding with a broader part of the maxilla. Whilst mandibular advancement will correct the antero-posterior skeletal discrepancy, dental expansion of the maxillary arch is often still required. The situation is similar to the upper arch expansion needed in growing patients that undergo growth modification with functional appliance therapy. This is due to dento-alveolar compensation of the upper arch to match the relative lingual position of the mandibular teeth (*Figure 1*). The resolution of this pre-surgically is required to allow full correction of the anterio-posterior skeletal discrepancy, to facilitate arch co-ordination and eliminate potential occlusal interferences (5,6).

Skeletal III malocclusions may present with both absolute and relative skeletal discrepancies and frequently both aspects need to be addressed to facilitate transverse correction. Skeletal III cases are often associated with a combination of maxillary hypoplasia and mandibular prognathism (8). If the predominant feature is antero-posterior in origin, its subsequent correction will resolve the relative transverse problem. However, a level of maxillary hypoplasia resulting in an absolute transverse discrepancy is often present and complicates the management necessitating expansion (*Figures 2,3*). Furthermore, dento-alveolar compensation presenting as lingual tipping of the mandibular teeth (*Figure 3*) and less frequently as buccal flaring of the maxillary teeth complicates the clinical picture and can lead to an underestimation of the expansion required if overlooked (5).

## Assessing the amount of expansion required

Assessing the amount of expansion needed is a critical step pre-treatment. Approximate quantification of the amount of expansion needed enables determination of whether skeletal, dental or a combination of both will be required (5,6).

Skeletal II patients may be asked to posture the mandible forward resolving any "apparent" transverse discrepancy and allowing an assessment of arch co-ordination. This is difficult to undertake in high angle cases due to the inclination of the occlusal plane and in cases of asymmetry. Moreover, the method described above for skeletal II cases cannot be used to assess the true transverse problem in skeletal III cases. In such cases, evaluating the pre-treatment study models is a useful method for assessing the amount of expansion needed as they can be hand articulated in the approximate post-operative antero-posterior position (7). This eliminates the relative transverse discrepancy allowing for the absolute transverse discrepancy to be visualised more clearly. Furthermore, simple manipulation of the pre-treatment models as described will help localise exactly where within the arch expansion is required (5). The amount of expansion required can be quantified by measuring the inter-canine (cusp tips of permanent canines) and inter-molar molar widths (mesiobuccal cusp tips of the first permanent molars) using digital callipers or a ruler (5,6,9). As a guide, the maxillary inter-canine width should exceed the mandibular inter-canine width by 8–9 mm in males and females. The maxillary inter-molar width should exceed the mandibular by 7 mm (10).

When assessing the amount of expansion required, due consideration must be given to the extent of dento-alveolar compensation present in the transverse plane as decompensation will extenuate the true discrepancy, potentially leading to underestimation of the expansion needed (*Figure 4*), in turn, compromising arch co-ordination

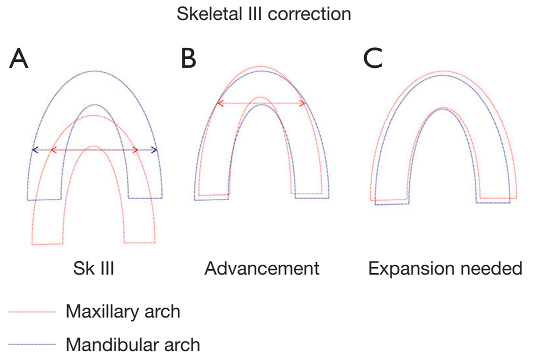


**Figure 2** Illustration of true transverse discrepancy. Despite correction of the sagittal skeletal discrepancy, expansion in the maxilla is often required due to maxillary hypoplasia in the transverse plane (A,B). As the maxilla is advanced, an absolute difference in the transverse dimensions necessitate further expansion in the maxillary arch despite resolution of the relative transverse discrepancy (C). Sk, skeletal.

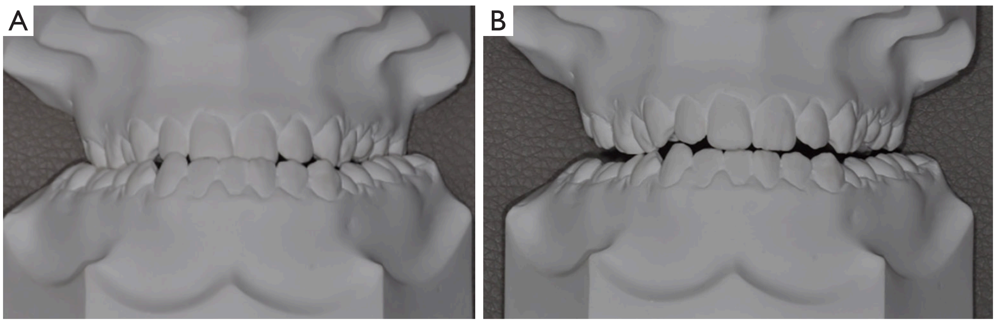


**Figure 3** Use of study models to identify a transverse discrepancy. Pre-treatment "hand-held" simulated advancement of the maxilla highlights a transverse discrepancy exists in the buccal segment despite correction of the antero-posterior relationship (A,B).

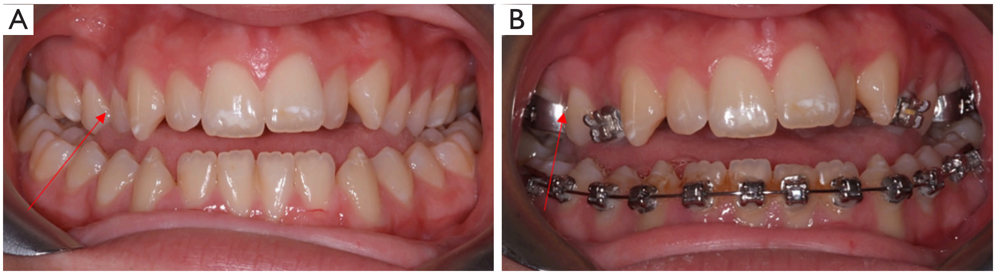


**Figure 4** Highlights the importance of assessing compensation in the mandibular arch. Illustrates the extent transverse dento-alveolar compensation in the lower arch in skeletal III cases (A). Correcting the transverse compensation in the mandibular arch (illustrated by red arrows) allow better assessment of the expansion needed in the maxillary arch (B).

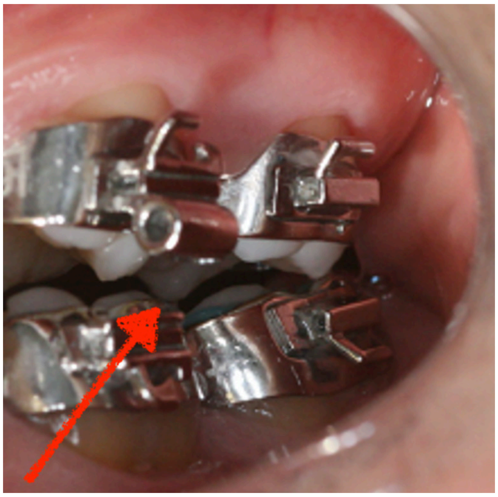

**Figure 5** Illustrates unfavourable tipping of molars. Hanging palatal cusp of maxillary right second permanent molar (indicated by red arrow).

(1,5). It can be useful in skeletal III cases with moderate to severe transverse issues and high angle cases with narrow V-shaped arches to commence pre-surgical orthodontics in the lower arch to resolve dento-alveolar compensation in the transverse plane prior to fully assessing transverse requirements in the opposing arch (5). This will aid judgment in determining the amount of expansion required as the true discrepancy can now be fully quantified through measurement of snap models or intra-orally as described above (*Figure 4*).

A bilateral buccal crossbite may be accepted and planned as a treatment outcome on some occasions, especially, if there is a concern relapse will lead to development of a unilateral crossbite with an associated mandibular displacement (9). However, the impact on facial aesthetics should also be considered as part of the process, as reduction of pre-existing buccal corridors are deemed to improve smile aesthetics in conjunction with an increased display of teeth in the buccal segment (4,5).

## Treatment options to achieve expansion

A decision as to whether surgical or orthodontic expansion is undertaken is predominantly based on the aetiological features contributing to the transverse discrepancy, the amount of expansion required and the skeletal maturity of the patient, specifically, in relation to the mid-palatal suture (9).

Non-surgical expansion can be achieved with orthodontic archwires, auxiliary expansion appliances, for example a quad helix, rapid maxillary expansion (RME) or through a relatively novel technique of miniscrew-assisted rapid palatal expansion (MARPE). Surgical expansion options include surgically assisted rapid palatal expansion (SARPE) with tooth-borne or bone-borne appliances or two or three part Le Fort I segmental surgery with expansion (5,6,9).

### *Non-surgical expansion*

Orthodontic expansion can be considered as a suitable treatment option when up to approximately 4mm of expansion is required in a skeletally mature patient (9). In situations where greater than 4 mm of expansion is required to correct an absolute transverse problem, careful consideration should be given to achieving this orthodontically to avoid compromising the stability and periodontal health, particularly, in high angle cases where buccal bone is thinner (11). Additionally, transverse correction through orthodontic means is appropriate where the inclination of the teeth is favourable, mild to moderate crowding is present and favourable smile aesthetics exist with an absence of significant buccal corridors. These factors are considered in more detail below.

The inclination of teeth in the buccal segments has an influence on the amount of expansion achievable. Palatally tipped molars are favourable, allowing buccal tipping whilst maintaining the roots buccal to the crowns and in so doing facilitating inter-digitation that will aid stability (12). Conversely, hanging palatal cusps of maxillary posterior teeth (particularly maxillary second molars) can be problematic in orthognathic cases causing interferences and preventing good inter-digitation thus hindering surgical correction (*Figure 5*). Utilising bracket prescriptions with increased buccal root torque for the molar teeth and/or addition of progressive buccal root torque can help in preventing this occurring (5). Additionally, expansion carried out later in treatment with rectangular archwires offers increased torque control helping to avoiding the problems of unfavourable tipping of teeth (5,9).

Mild to moderate maxillary arch crowding will facilitate expansion as the arch perimeter increases. Extractions should also be avoided in the maxillary arch (especially in the absence of significant crowding) as the reduction in arch perimeter makes correction of any transverse discrepancy difficult, especially, in patients with skeletal III malocclusions and in patients with increased vertical proportions that present with a narrow V-shaped arch form (5).

Another factor to assess relates to the thickness of buccal bone and associated prominence of molar roots. Prior to carrying out orthodontic expansion, periodontal assessment is advisable, particularly in adults with pre-existing periodontal issues. This is particularly important in high angle patients, given the alveolar ridge thickness is reduced and buccal bone is thinner (5,11).

Consideration should also be given to smile aesthetics and the extent of the buccal corridors. Minimal buccal corridors are a preferred aesthetic feature in both men and women (4,13). The relationship between size of the buccal corridors and perception of smile aesthetics is, however, more complex as the exposure and display of posterior teeth also has an impact (13). Accordingly, it appears minimising buccal corridors, as well as, increasing display of posterior teeth has a positive impact. Therefore, presence of excessive buccal corridors in conjunction with minimal show of posterior teeth may indicate greater expansion and arch form change is required necessitating a surgical approach (5,13).

### *RME*

RME is routinely utilised to obtain skeletal and dental expansion in children and adolescents (14). The anatomy of the maxilla in the bony anterior regions and tooth-supporting zones allow transverse force application to be accomplished separating the intermaxillary suture using fixed expansion appliances (5,14,15). However, prescribing such intervention should consider the arch form of the mandible as significant skeletal or dental expansion of the maxillary arch in the absence of posterior crossbites will necessitate complimentary expansion of the mandibular dentition which is likely to be unstable.

Significant short-term changes have been reported in maxillary skeletal (basal bone width and alveolar palatal crest width) and dental dimensions (intermolar width at the crown and root level and favourable dental tipping) following RME (15). However, skeletal relapse of 10% and palatal tipping of the dentition has been shown to occur within eight months post treatment (15). Longer-term, the skeletal effects of RME are relatively stable (16), however, when RME is carried out in post-pubertal patients an increased amount of skeletal maxillary width loss occurs (17).

Transverse development ceases around the age of sixteen with increasing mechanical interlocking of the midpalatal suture and other circum-maxillary sutures (18,19). This leads to increased rigidity of the facial skeleton and the ratio of skeletal to dental movement progressively reduces with age (20). The inability to open the suture may lead to limited expansion with lateral tipping of posterior teeth, a risk of extrusion, periodontal membrane compression, buccal root resorption, alveolar bone bending, fenestration of the buccal cortex, palatal tissue necrosis with pain and unstable expansion (14,21,22). Despite this, RME has been used successfully in adults however, its use remains contentious and it should generally be avoided to limit potential complications as detailed in the sentence above (23-25). A critical consideration, therefore, is the correlation between timing of fusion of the mid-palatal suture in relation to age and applicability of RME to achieve predominantly orthopaedic expansion.

### *Assessment of midpalatal suture maturation*

The issue of ideal timing continues to be a key consideration when clinicians deliberate orthopaedic driven therapeutic outcomes. Furthermore, opinion remains divided on the 'cut-off' age for non-surgical orthopaedic expansion and relative indication for surgical expansion which further adds to the complexity in making treatment decisions. The literature is conflicting, with an age range from anywhere between 14 to 25 recommended (26), consequently resulting in no clear agreement regarding the boundaries (in terms of age) after which orthopaedic expansion in not successful or reliable and surgical approaches are indicated.

Evidence suggests that the use of rapid palatal expansion (RPE) prior to completion of puberty is a reliable and successful technique predominantly resulting in skeletal expansion (17,27). Subsequently, as the mid-palatal suture progressively matures, resistance to expansion increases and accordingly RPE is less effective from an orthopaedic perspective. It appears, therefore, that once the growth spurt has been passed, which occurs around 12–14 years (28) the use of RPE should be carefully considered.

Accordingly, patients with moderate to severe transverse discrepancies in late adolescence or just after present a real dilemma with reference to a move from RPE to a surgical approach. In reference to this group of patients, it goes without saying, correction that avoids surgery is preferable negating the need for additional invasive intervention and associated risks (29). Conversely, use of orthopaedic expansion where resistance to palatal separation is increased may result in unsuccessful treatment and risk complications as outlined in the previous section. Conventionally, with the benefit of historical research examining mid palatal

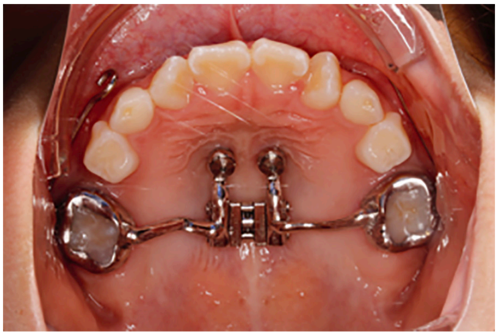

**Figure 6** Illustration of a MARPE appliance. Occlusal view of a Hybrid Hyrax MARPE appliance (courtesy of Prof. Benedict Wilmes). MARPE, miniscrew-assisted rapid palatal expansion.

fusion (18,30), a chronological age of around 16 has been used by clinicians to represent the limit for RPE (31). However, immense age variability is evident in relation to mid palatal sutural closure (28-30,32), therefore, the use of chronological age may not be dependable enough for estimating the age limit (33-36).

More recently, in an attempt to add clarity and suggest guidelines to aid treatment decisions the use of diagnostic imaging has been suggested to evaluate mid-palatal sutural closure for individual patients (36). Angelieri *et al.* 2013 proposed a novel classification method for assessment of midpalatal suture morphology using CBCT. Based on a sample of 140 patients, five stages (A–E) of sutural maturation were described. They proposed that patients presenting in stages A and B were suitable for RPE whereas stages D and E indicated a need for surgical expansion. Furthermore, they suggested that RPE may be possible in stage C but the response may be less skeletally mediated than in stages A and B (37).

Other studies, utilising this assessment method have shown stages A–C to be most prevalent in 11 to 15 years old and stages C–E in 16–20 years old (26). However, despite the interest in diagnostic technology to help decision making, there appears to be concern regarding the validity and reliability of such techniques to accurately determine palatal sutural maturation (38) and the search to find alternative methods continue (39-41).

### *MARPE*

Surgical methods of expansion are advocated to enable release of the sutures that resist expansion in adults due to the reasons outlined earlier (42,43). However, this approach requires the need for additional surgery which with the potential for adverse consequences and likely patient unacceptance has led to the search for non-surgical treatment alternatives. Over the last decade, fixed anchorage use has become prevalent in orthodontics largely due to the technical ease of insertion coupled with high reported success rates (44-47). This has led to the development of tooth/bone-borne, as well as completely bone-borne expanders, that incorporate micro-screws into the palatal jackscrew (*Figure 6*) to produce MARPE. Furthermore, this novel modification to conventional RME with the use of mini-screws has been shown to demonstrate successful maxillary skeletal expansion (48).

In the short term, MARPE can result in significant changes to the skeletal and dental maxillary components resulting in an additional 3.34 mm along the intermaxillary suture at the posterior nasal spine and 4.56 mm at the anterior nasal spine (49). Dentally, substantial increase is inter-molar width of almost 6 mm, inter-premolar width of near on 5 mm and inter-canine width of almost 4 mm have been reported (50). The proposed benefit is to allow expansion of the underlying basal bone, minimizing dento-alveolar tipping and expansion (50). Recent systematic reviews have concluded that based on the available literature mini-screw anchored RPE could lead to a decrease in loss of buccal alveolar bone and fewer undesirable periodontal side effects (51,52).

MARPE remains a relatively new technique with innovation and variation in appliance design, technique and protocols widely described (53-55). It has been shown that additional skeletally anchored force provides expansion that separates the rigid mid-palatal suture in adults without the need for surgery. This potentially has huge clinical implications by providing a means for maxillary expansion in adults through non-surgical means. Historically, a number of case reports have been published in the literature demonstrating success of MARPE in adolescents and adults (50,53-55). More recently, a robust evidence base is emerging confirming the successful use of MARPE in adults (56-60). A recently published prospective cohort study consisting of 34 patients (mean age 27.0±9.4 years) demonstrated a success rate of 94%. Significantly, a large proportion (almost 60%) of the expansion achieved in the adult subjects enrolled within this study was mediated through and at the skeletal level proving the efficacy of this technique with limited side effects in an adult population making it viable alternative to SARPE (61). Further contemporary systematic evaluation of the evidence base with respect to MARPE confirms a greater element of skeletal expansion at the intermaxillary suture with reduced buccal flaring of the first premolars and molars in comparison to RME reducing the potential adverse periodontal side effects on the periodontium (62-65). Having said this, despite a number of systematic reviews now available, very few good quality randomised controlled clinical trials exist (66). Additionally, the existing studies exhibit heterogeneity and suffer from limited long-term follow-up (67).

Not withstanding this, MARPE is associated with high success rates in adults and offers immense promise going forward in spite of the need for some robust clinical trials to further investigate these appliances and provide a stronger evidence base for the technique (65,66). Nevertheless, the use of MARPE remains an innovative addition to a clinician armamentarium to produce skeletally mediated maxillary expansion in adults especially as it appears to be generally well tolerated by patients (67).

Given the relative merits of MARPE, a fundamental consideration arises in the role such a technique may play in potentially replacing SARPE as a means of gaining expansion in adult orthognathic patients.

SARPE is recognised as form of distraction osteogenesis resulting in orthopaedic expansion of the maxilla following a partial osteotomy or corticotomy to assist the expansion with the orthopaedic force being applied through a tooth-born, hybrid or bone-born appliance (68,69). The use of SARPE has been indicated in adult cases requiring more than 5 mm of expansion (70). The perceived advantages of SARPE lie in the potential to facilitate considerable expansion of the maxilla in adults with reduced likelihood of relapse (70). The obvious downside is the need for additional surgical intervention, which for most orthognathic patients who present with more than a solitary transverse discrepancy will necessitate the need for two separate surgical episodes.

There have been numerous studies looking at the stability and skeletal/dental effects of SARPE demonstrating its effectiveness in obtaining significant transverse expansion of the maxilla which is relatively stable (69,71,72). Limited data is available directly comparing MARPE and SARPE, however, a recent study comparing the two interventions showed greater transverse midface and maxillary basal bone changes with MARPE (73). This study also demonstrated MARPE provides a more parallel form of expansion with less buccal flaring of the dentition and associated alveolus suggesting an advantage over SARME (73). More robust research through clinical trials is needed directly comparing the two interventions to increases the evidence around this subject and help inform clinical practice for the future and it is likely this will emerge in the fullness of time.

## Conclusions

The treatment of maxillary transverse deficiency in skeletally mature patients continues to be an area of interest and debate amongst clinicians, particularly as, maxillary skeletal expansion is achievable through a range of appliance designs, protocols and techniques. Much of the controversy relates to the appropriateness of using non-surgical expansion techniques or whether surgical means of expansion is indicated. Since the timing of palatal suture maturation is variable there is no definitive guidance in the literature to aid decision making. Furthermore, the reliability and validity of current techniques to fully assess maxillary palatal suture maturation remains an inexact science. This review summarises the critical considerations in managing patients requiring transverse maxillary expansion and how this may be achieved. It also discusses the emergence of newer techniques that provide a viable alternative to invasive surgical expansion in orthognathic patients through non-surgical means.

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## Footnote

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*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All clinical procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki

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