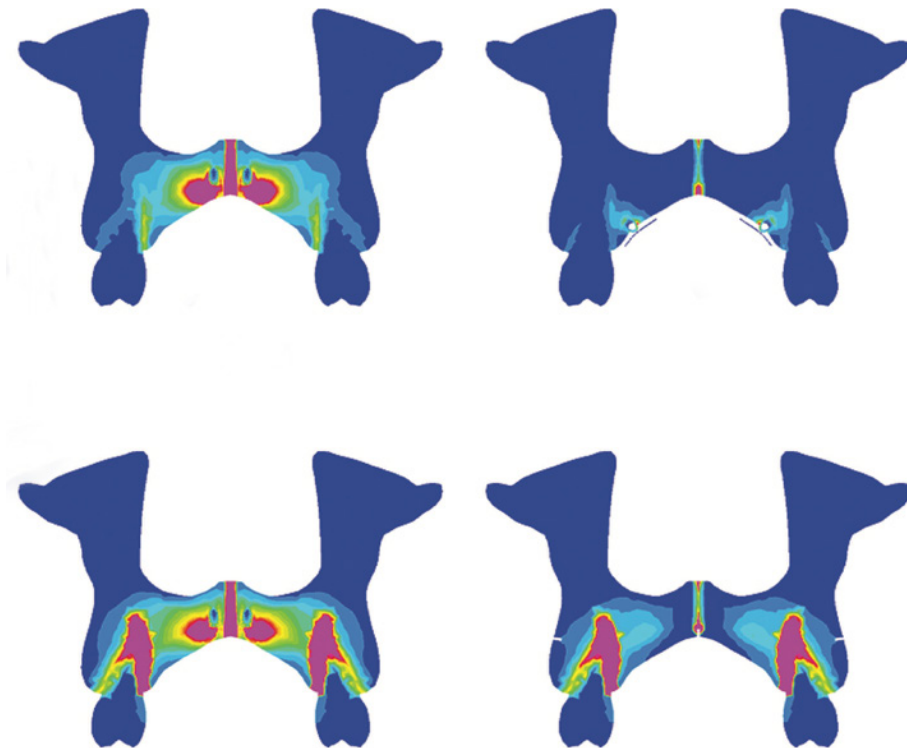


WHAT IS THE

TRANSVERSE DIMENSION

AND WHY DO WE CARE ABOUT IT?

By Rebecca Bockow, D.D.S., M.S.



WHAT IS THE TRANSVERSE DIMENSION AND WHY DO WE CARE ABOUT IT?

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WHAT IS THE

TRANSVERSE

Historically in orthodontics, treatment planning has centered around a lateral cephalometric radiograph. This two-dimensional snapshot of the patient's profile provides valuable information.

A patient's cranial base has very little changes after about age four, so we can evaluate growth and position of both the upper and lower jaws relative to the cranial base over time. A lateral cephalometric radiograph gives us specific information about vertical and anterior-posterior jaw relationships. We can also see lip and chin projection. However, the key dimension we lack in a lateral cephalometric radiograph is the transverse dimension.

The transverse dimension is critically important because it plays a key role in a patient's periodontal, occlusal and airway health.

The transverse dimension and sufficient maxillary width are important for the following reasons:

Sufficient maxillary width helps prevent dental crowding by ensuring that there is adequate bone to accommodate the erupting dentition.

Adequate maxillary width helps ensure that adequate bone surrounds the teeth and subsequently helps prevent future recession.

A wide maxilla ensures that the teeth can be positioned upright in the bone — allowing for the teeth to be loaded along their long axis in occlusion.

The roof of the mouth is the floor of the nose. A properly sized maxilla in the transverse dimension translates to opened nasal passages.

A maxilla that is sufficiently wide in the transverse dimension will allow for adequate tongue space — helping improve or ensure airway health.



E DIMENSION



The maxilla is made up of bony plates that are joined at a series of sutures. These sutures are not fused, but become more and more interdigitated as we age (Melsen, 1975). Pressure from the tongue resting in the roof of the mouth from infancy through adolescence is what drives the growth of the upper jaw.

The default position for all children should be lips together and quiet nasal breathing. This allows for an equilibrium between all soft tissue components – and includes the tongue resting high and forward in the maxilla. As the maxilla develops in the width and in the anterior/posterior dimension, this also drives the growth of the nasal cavity, including the nasal septum and floor of the nose.

If a child does not establish proper swallowing or breathing habits at a young age, this will alter the resting and functioning tongue posture. If the tongue never puts pressure on the maxilla, it will not develop in the width, in the anterior/posterior dimension, or both. This is often due to tongue tie (tethered oral tissue), asthma or allergies, premature birth and/or being tube fed in the neonatal intensive care unit, large adenoids and/or tonsils, habits such as digit or thumb sucking; late pacifier use, late bottle use, and genetics.

WHY DO WE CARE?

Orthodontic expansion can help reduce the likelihood of crowding and recession.



A tooth is centered in the medullary bone within a socket. The medullary bone is surrounded by a dense cortical plate. The cortical plates act as a scaffold to support the soft tissue complex. Soft tissue will surround a tooth as long as bone is present. If one orthodontically moves a tooth outside of the alveolar housing, one can actually push a tooth outside of the cortical plate.



Wehrbein, 1996.

Bone does not follow when one orthodontically pushes a tooth outside of the cortical plate:



Before expansion.



After expansion. (Garib, Dent Press J Orthod, 2010).

If a tooth is pushed outside of the alveolar housing and no buccal plate remains, this area will be vulnerable to recession or one will clinically see recession during orthodontic tooth movement.

In order to prevent this situation, we have the opportunity in a young child to grow and expand the bone, creating more bone for the teeth to move and grow into. This works best when we start the process early. As we open the maxillary suture with an expander, we increase the circumference of the maxillary arch – thus creating more room for the adult dentition to erupt. In fact, expansion is the ideal intervention when one sees canines headed for impaction in the mixed dentition. In the lower arch, we can use passive and active appliances to upright lower teeth, thus widening the alveolar ridge and creating more room for the erupting adult teeth.

Dental impaction is another sign of inadequate bone to accommodate the eruption of the adult dentition. If there is inadequate bone for the maxillary canines to erupt, they can either manifest as buccally displaced (ectopic) or palatally displaced (impacted) teeth. Sigler et al, in 2011 analyzed intervention strategies for palatally impacted canines. In this study, the treatment group received expansion and extraction of primary maxillary canines. In the control group, no intervention was provided. They showed that expansion led to the successful eruption of 80% of canines, whereas watchful waiting resulted in 28% eruption of palatally displaced canines.

We have the opportunity in a young child to grow and expand the bone, creating more bone for the teeth to move and grow into

PERIODONTAL HEALTH

Soft tissue integrity is dictated by the presence of alveolar bone. The bone acts as a scaffold to support the periodontium. If we have a buccal plate surrounding a tooth, we will have stable and adequate soft tissue support. In the presence of a dehiscence or fenestration, or in a case where there is clinically thin bone, a patient is more susceptible to recession. In a patient with a thin gingival periodontal phenotype, we will often see inadequate keratinized tissue and/or recession when there is no alveolar bone.

In order to help ensure adequate soft tissue support, we need to keep the teeth within the bony housing. If we inadvertently move teeth outside of the alveolar housing, we can potentially set a patient up for recurrent recession.



The patient shown above was treated orthodontically, but the transverse deficiency was neglected. The teeth were subsequently moved facially on the upper arch and tipped lingually on the lower arch. These movements in the absence of true alveolar bone support contributed to his recession.

**In order to help ensure
adequate soft tissue
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FUNCTIONAL/ BIOMECHANICAL

Functionally, we aim to have all teeth loaded on their long axis. This helps ensure even force distribution, prevents future wear and dental breakdown, and prevents aberrant occlusal forces that could lead to periodontal or joint disturbances. If the upper arch is deficient in the transverse dimension and the patient is treated orthodontically without skeletal expansion, the orthodontist makes compromises to the occlusion.

The orthodontist will roll the lower teeth to the lingual and tip the upper teeth to the facial. This leads to teeth not loaded on their long axis and uneven occlusal forces. One can see this situation in the example above by looking at the position of the posterior teeth.

This patient underwent comprehensive orthodontics without skeletal expansion. The orthodontist attempted to solve skeletal discrepancy by tipping teeth, leading to loss of periodontal support and potentially traumatic occlusion with non-working interferences.

AIRWAY

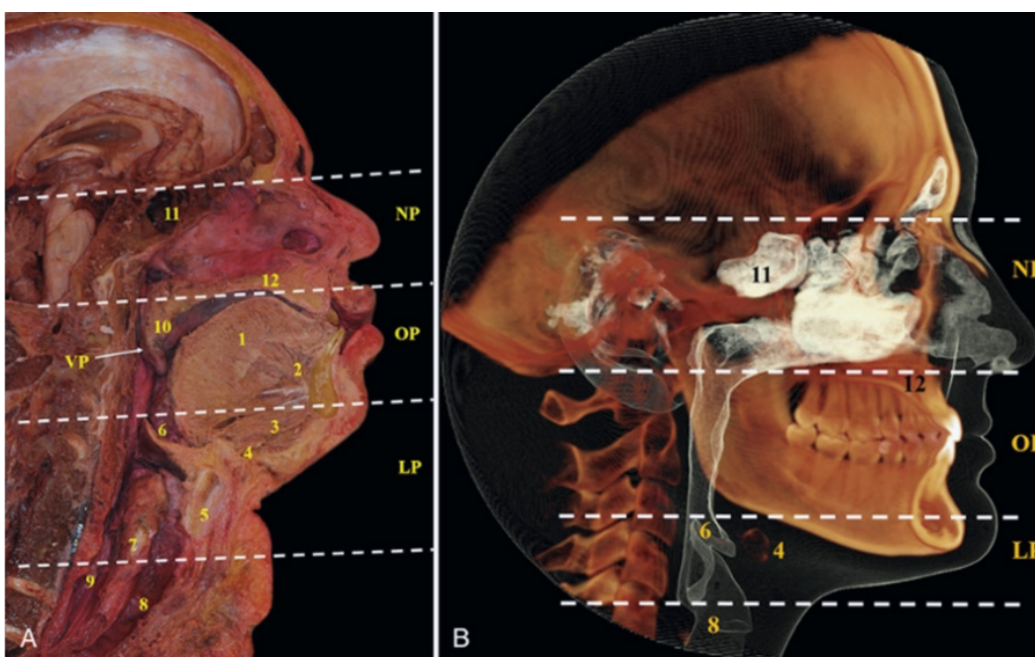
The roof of the mouth is the floor of the nose.



When the maxilla is narrow, the nasal passages are also narrow (Stefanini et al., 2012). Patients with narrow maxillae often have decreased nasal volume, a deviated septum, increased resistance to nasal breathing and a higher incidence of respiratory-related illnesses. We also know that when we expand the maxilla, resistance to nasal breathing decreases, incidences of respiratory infections improves and sleep improves (Villa et al., 2007; Gray et al., 1975). The Nasal Airway Complex (NAC) can account for up to 50% of total upper airway resistance (Georgalas, 2011). In a pediatric population, rapid maxillary expansion (RME) has been successfully used to improve nasal breathing in patients with sleep apnea (Camacho, 2017).

THE TEETH PROVIDE THE 'HOUSE' FOR THE TONGUE

The three-dimensional airway anatomy includes nasal passages (the nasopharynx), the oropharynx (the area behind the soft palate), and the laryngopharynx or hypopharynx (the area behind the base of the tongue).



A narrow maxilla and high-arched palate is a characteristic phenotype of obstructive sleep apnea (OSA). This phenotype is also associated with increased nasal resistance due to the narrow maxilla and posterior tongue displacement due to the lack of oral volume (Johal et al., 2004; Abdullatif et al., 2016). Guilleminault et al. reported a 10.9-fold increase in the occurrence of OSA with a narrow palate (Guilleminault et al., 1995).

As we open nasal passages with expansion, lip posture — and, subsequently, tongue posture — changes. As the tongue naturally comes up and forward, this opens the pharyngeal airway and improves breathing. Additionally, as we expand the arches with bimaxillary expansion, we create more three-dimensional room for the tongue. As the tongue has more room to come forward and move laterally, it repositions more anteriorly and superiorly and opens the pharyngeal airway space.

As the tongue naturally comes up and forward, this opens the pharyngeal airway and improves breathing

Other great things that can occur following RME:

Space for mild crowding (Haas, 1970; Adkins, 1990)

Interceptive treatment for palatally impacted canines (Sigler)

Treatment of choice for class III malocclusions when applied in conjunction with protraction facemask (Ngan)

Nasal airflow improvement if the nasal airway is blocked (McDonald, 1995)

Improved hearing due to the functional normalization of pharyngeal ostia of the Eustachian tube and decreased incidences of recurrent serous otitis media (Laptook, 1981; Gray, 1975)

Decreased incidences of nocturnal enuresis (Schutz-Fransson et al., 2008)

Treatment for patients suffering from primary headaches (Farronato et al., 2008)

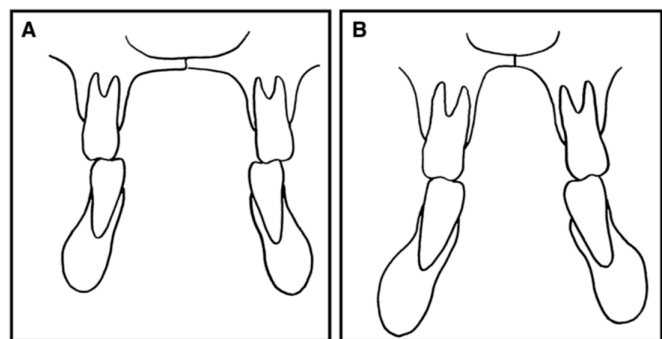
HOW DO WE DIAGNOSE A TRANSVERSE DEFICIENCY?

Clinically, a narrow palate can present in different ways. The easiest maxillary transverse discrepancies to diagnose are when a crossbite is present. When we clinically see a crossbite, it can appear unilaterally or bilaterally.

In unilateral crossbite cases, it is always a good idea to check for a functional shift. Many times, these patients will present with a mandibular midline shift, but can be repositioned into centric occlusion and midlines will align once the maxillary expansion is completed. It can also appear as dental crowding.

When we see dental crowding in the primary dentition, this is a red flag that there is inadequate bone. Crowding in the mixed dentition will signal the same thing, as will early recession. We can also look at radiographs. If the canines appear to be headed toward the roots of the lateral incisors or if they have crossed the distal aspect of the lateral incisors, this is another sign that there is insufficient bone to accommodate the eruption of the adult dentition.

A maxilla can also be narrow in the absence of a crossbite. If the lower teeth appear to be excessively lingually inclined, one must imagine what the clinical presentation would be if these teeth were upright. If the maxilla is narrow and we upright the lower teeth, this will lead to a crossbite — thus necessitating a maxillary expander.



The above diagram is from Miner et al. (2012). A is the drawing of the transverse dimension of a patient with normal-width arches. B is a patient where both arches converge. The maxillary arch in patient B is narrow, but the lower teeth are lingually inclined. Clinically, patient B is maxillary deficient in the transverse dimension, even though there is no crossbite. In order to normalize patient B, we will need to skeletally expand the maxilla, as well as dentally upright the lower teeth.

In order to diagnose a transverse discrepancy, we need to find a bony landmark for our measurements. As we can see from the illustrations provided by Miner et al., the teeth can tip and mislead the clinician. Therefore, we need a landmark that cannot be altered orthodontically, and can be an accurate reflection of the transverse dimension.

On a set of study models, the easiest landmark to measure is the muco-gingival margin. The muco-gingival margin, or MGJ (mucogingival junction), outlines the available alveolar bone. We can tip teeth in any direction, but the MGJ will remain stable. If we measure the width from mucogingival junction to mucogingival junction at the level of the first molars for both arches, the maxillary arch should be wider than the mandibular arch.

A wider maxillary arch will allow the maxillary and mandibular teeth to remain upright in the bone — surrounded by buccal and palatal plates and gingiva. If the maxilla is wider than the mandible by 5mm, this will account for about a 2.5-mm buccal overjet of the maxillary to mandibular teeth on either side of the arch. Today, we can also perform the same measurement using the pulp chambers on a CBCT. The above method of measurement only applies if the molars are in a class I dental relationship.

In order to diagnose a transverse discrepancy, we need to find a bony landmark for our measurements ... the teeth can tip and mislead the clinician ... we need a landmark that cannot be altered orthodontically, and can be an accurate reflection of the transverse dimension

WHICH TYPE OF EXPANDER SHOULD I USE?

When treatment planning these cases, we must consider treatment goals as we decide on the best appliance to use. In orthodontics, there are orthopedic appliances and orthodontic appliances. Orthopedic appliances lead to true sutural changes. Orthodontic appliances move teeth and may also include dento-alveolar bone bending. When it comes to airway changes and long-term stability, we prefer orthopedic appliances to induce true skeletal changes.

The age of the patient and the degree of skeletal maturity is of utmost importance. Younger patients have less-developed sutures. Therefore, if we anchor an appliance to the teeth of a child and we apply pressure, we have a very high probability of successfully expanding the suture and a lower likelihood of causing unwanted side effects like dental tipping. As we age, our suture becomes more and more intertwined and the bone around the maxilla grows more and more dense. In older patients, when we anchor an appliance to the teeth and apply a

force, the bone resists the force application. We therefore tend to see more dental tipping, recession, bone loss, and very little skeletal changes. Examples of orthopedic appliances include fixed expanders like a hyrax, Haas, and a bonded expander.

Orthodontic or dento-alveolar appliances tend to use light forces and work gradually over time. These appliances tend to move teeth and bend bone more than they actually open the skeletal sutures. In many cases, they can lead to dehiscences and fenestrations and bony defects because the teeth can be pushed outside of the alveolar housing. These appliances may necessitate lifetime retention. Occlusion may also be difficult to manage because of the degree of dental tipping (Digregorio et al., 2019; Corbridge et al., 2011).

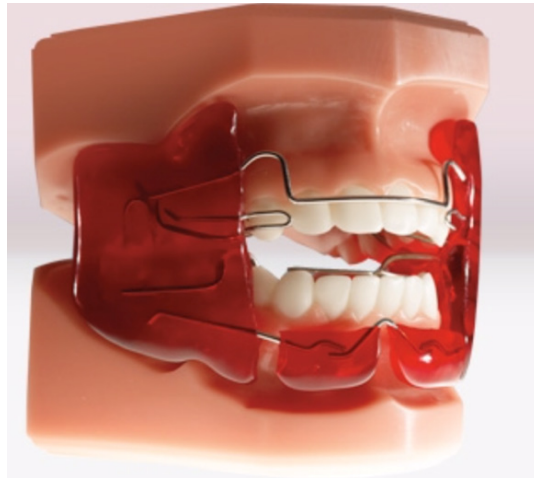
WHAT TYPES OF EXPANDERS EXIST?

HOW DO YOU KNOW WHICH TO USE?

Passive expanders:

Passive expanders shield the buccal and labial musculature from the teeth. As the muscles are held away from the teeth, more pressure is exerted from the tongue. The teeth slowly upright over time. Examples of passive appliances include the Frankel 2 appliance and a lip bumper.

Studies have shown bone deposition along the alveolus with these appliances. These results are stable over time as the alveolar bone is remodeled. These are best suited for the lower jaw, where we aim more for dental uprighting as compared to the upper jaw, where we would like to see sutural changes.



Frankel 2 appliance (courtesy of AOA Labs).

These results are stable over time as the alveolar bone is remodeled



Lip bumper – can be removable or fixed.

Orthopedic expansion:

The teeth and the craniofacial bones are constrained by the periodontium and the sutures, respectively. It requires approximately 900-4,500 grams of force in order to separate the mid-palatal suture. By contrast, it requires about 10-150 grams of force to move a tooth.

The goal and theory behind a rapid maxillary expander is to disarticulate the sutures before the teeth have a chance to respond (Provatidis et al., 2008; Chaconas et al., 1982). Rapid maxillary expansion leads to true orthopedic expansion when used in a skeletally immature patient. Fixed expanders employ heavy interrupted forces to maximize the orthopedic effects. The force application ranges from 2,700 to 7,400 grams.



Hyrax expander (courtesy of ODL Labs).



Bonded expander (courtesy of ODL Labs).

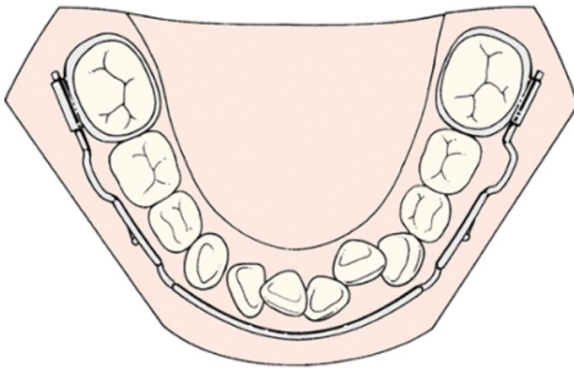
Slow maxillary expansion:

The theory behind this movement is that lighter, continuous forces will move teeth at a more “physiologic” rate. Proponents of these appliances use removable expanders, such as Schwarz expansion plates and fixed-wire appliances like a w-arch or a quad helix. The force application with a quad helix is between 180 and 667 grams. Much research now demonstrates, with the use of CBCT data, that slow expanders cause proportionally greater dental movement and less sutural changes. In many cases, the buccal plate can be lost and the risk of recession increases (Corbridge et al., 2011; and Digregorio et al., 2019).

Much research now demonstrates, with the use of CBCT data, that slow expanders cause proportionally greater dental movement and less sutural changes

Mandibular expansion:

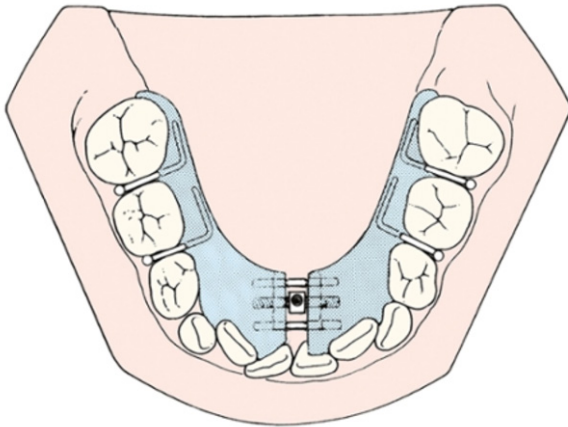
While we often say “mandibular expansion,” it is truly dental uprighting, not sutural expansion like we see in the maxilla. For mandibular expansion, we can choose between fixed and removable expanders.



A lip bumper can be fixed or removable. Bands with sheaths are cemented to the first molars. The lip bumper remains in place during adolescent growth. It holds the cheeks away from the teeth, allowing them to upright naturally. Furthermore, the appliance can be slightly expanded at each appointment, putting gentle tension on the periosteum. Vanarsdall and colleagues showed that long-term use of a lip bumper successfully grew the alveolar housing as they documented bone apposition along the mandibular alveolar ridge over time.

A lower Schwarz expander is a popular appliance because it is removable, easy to adjust, easy for parents or patients to turn, and we can make it with fun colors to keep the patients engaged. The downside to this appliance is that it is heavily dependent on compliance — it does not work if it is not worn, and it can be lost. Relapse can occur quickly if it is not worn. It also does not work well in the presence of ankylosed primary teeth.

Long-term use of a lip bumper successfully grew the alveolar housing



A Fixed Lower Expansion Appliance (FLEA) is our preferred appliance due to its simplicity and simple instructions. Upper hyrax expanders are simultaneously cemented with lower FLEAs and parents are asked to turn the appliances simultaneously. This helps ensure simultaneous arch development and posterior contact throughout the expansion process.

In some cases, the teeth on the lower arch do not respond as quickly as those on the upper arch and we need to slow down the rate of turns with this appliance. It also will not work with ankylosed lower primary teeth since the wire will no longer upright teeth as it rests along the ankylosed tooth.



WHAT TREATMENT OPTIONS EXIST FOR SKELETALLY MATURE PATIENTS?

There is a theory in some orthodontic circles that we can slowly expand the upper jaw in adults and this will lead to stable and physiologically substantive changes. Unfortunately, the literature shows us that slow adult expansion leads to bone bending and dento-alveolar changes, but not true sutural changes.

When we consider tongue space, slow adult expansion can increase tongue space. However, bone bending and dental tipping will not open nasal passages and will have less of an impact on overall breathing when compared to different treatment plans that provide the opportunity for true skeletal changes.

Cao et al. (2009) evaluated slow maxillary expansion in adults. They attempted non-surgical slow expansion on 65 adults using three different appliance designs. They compared this large treatment group of 22 adults who were treated orthodontically but with no expansion appliances. What they found was that, after expansion, there were no significant long-term transverse, sagittal or vertical skeletal maxillary changes in any of the adults who received non-surgical expansion.

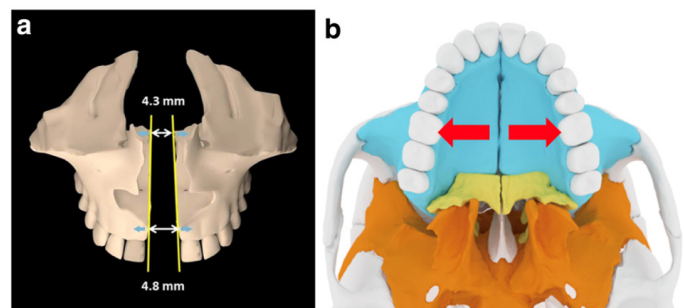
We now have predictable means of expanding a skeletally mature patient using bone borne or TAD-borne expanders. We refer to these appliances as MARPE or Miniscrew Assisted Rapid Palatal Expanders.

The advantages of using a MARPE include:

- Greater vertical control
- Greater orthopedic effects
- Lower rates of dento-alveolar side effects
- Less need for over-correction when compared to traditional expansion appliances

When we utilize MARPE, we see the following changes:

- Sutural splits in skeletally mature patients
- The split is parallel in nature, unlike tooth borne expanders, which tend to demonstrate a more pyramidal sutural opening
- The pterygopalatine suture can be split, negating the need for surgery in many patients



Cantarella et al., 2017.

MARPE appliance designs:

We can use exclusively bone borne, tissue/bone borne, and bone/tooth borne appliances. They all have strengths and weaknesses.

Two popular designs are the acrylic based TAD expander and a hybrid tooth and TAD based expander.

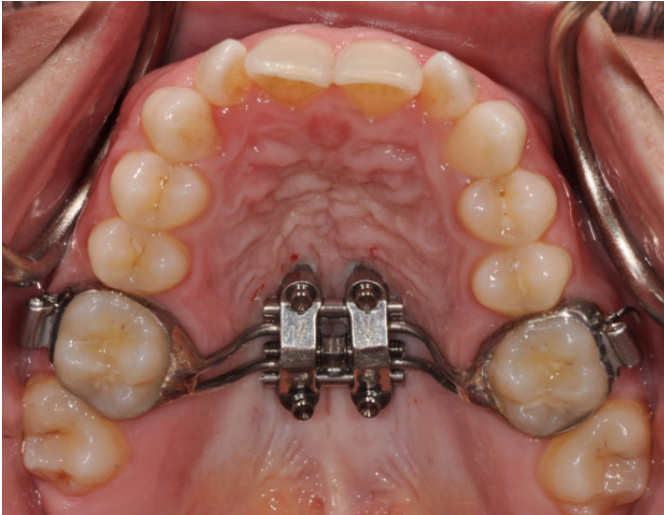


An acrylic based TAD expander is a great appliance due to its cost effectiveness. It can be inserted into a narrow maxilla and it does not involve any teeth, making it ideal for a patient who is periodontally compromised. However, it is difficult to work with because the clinician does not have access to the TADs during expansion.

If a TAD fails (as they sometimes do), one must cut the TAD out of the expander

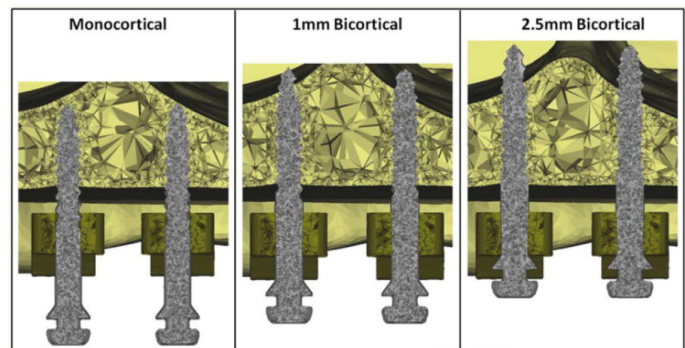
Therefore, if a TAD fails (as they sometimes do), one must cut the TAD out of the expander, sometimes forcing the patient and the clinician to abort this particular round of expansion. The acrylic can be a food trap, it can ride up on the free gingival margin of the adjacent teeth — leading to gingival recession — and there is less bony engagement of the TADs due to the thickness of the palatal tissue.

The Won Moon-designed MSE:



The MSE has many advantages. The appliance allows for easy access to the TADs, it has a high rate of success for splitting the suture in young adults, and it is easy to place and remove. Its disadvantages include that it cannot fit into narrow maxillae, the high cost of appliance and high cost of components, and the appliance design in some respects dictates the location of the TADs.

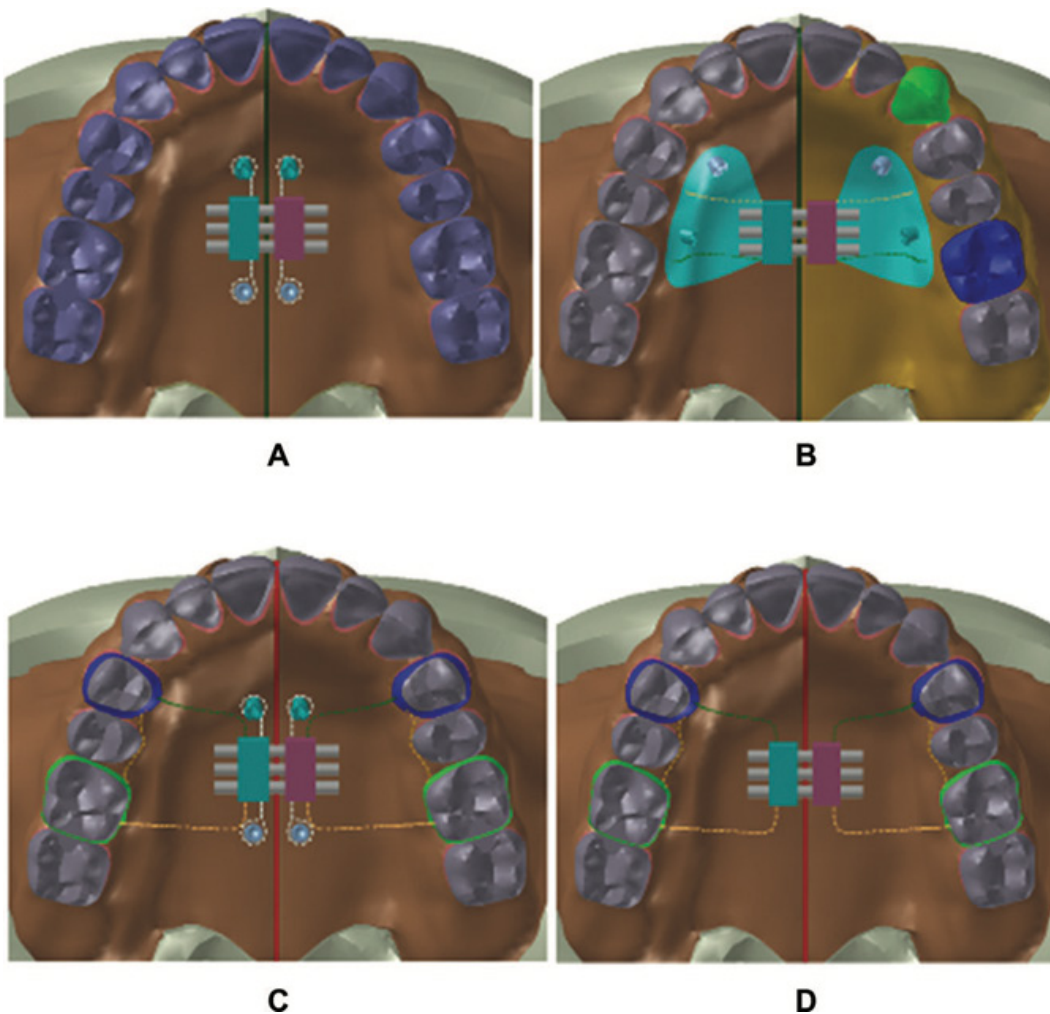
The MSE is designed so that the TADs engage both sides of palatal cortical bone. Lee completed a finite element analysis in 2008, which demonstrated that bicortical engagement of the TADs was the most effective design for sutural splitting.



Bicortical engagement ensured mini-implant stability, decreased mini-implant deformation and fracture, more parallel expansion in the coronal plane, and increased expansion in general.

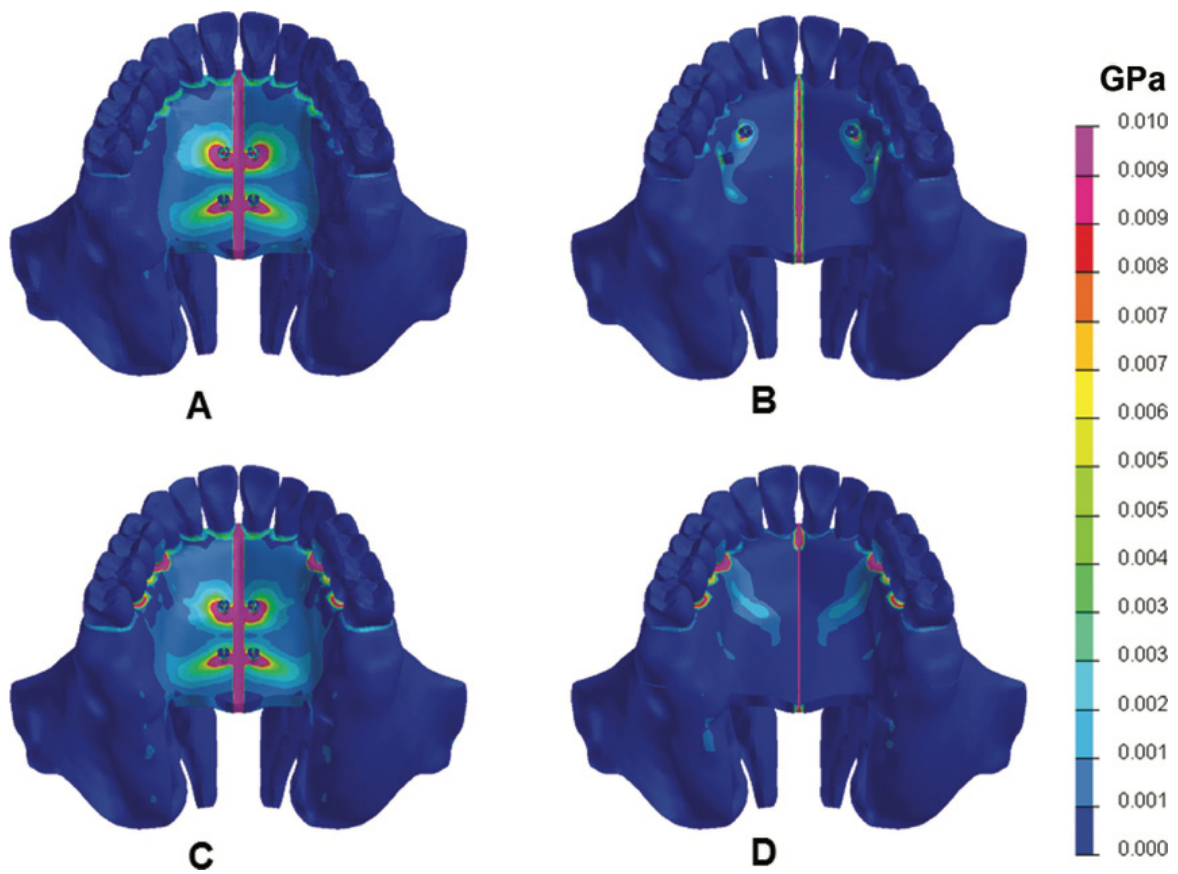
WHICH EXPANDER DESIGN IS THE BEST IN TERMS OF FORCE DISTRIBUTION ON THE SUTURE AND THE TEETH?

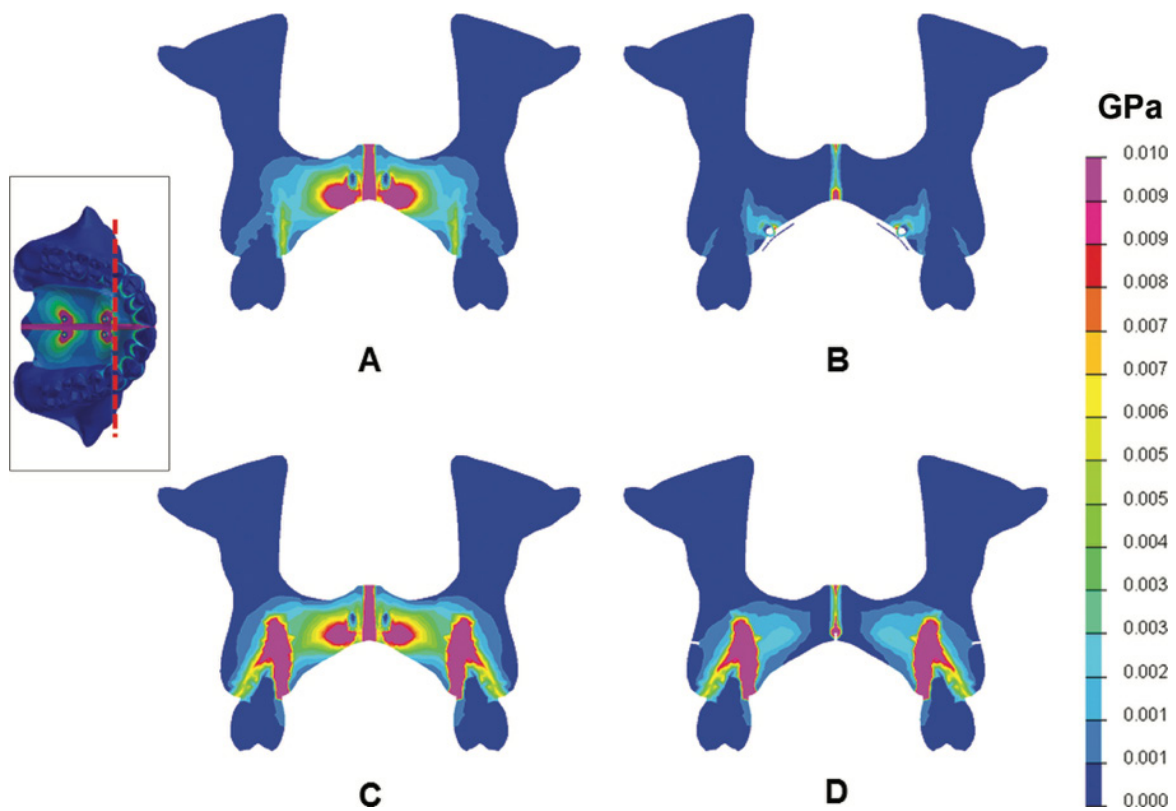
Lee et al. (2002) approached this question with a finite element analysis study.
They looked at the following designs:



They found that the TAD appliances demonstrated the greatest sutural changes.

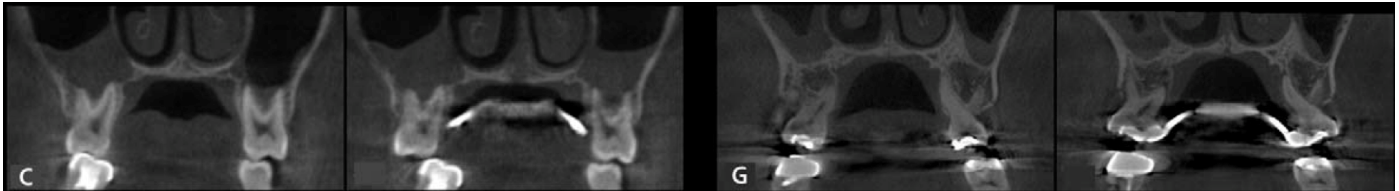
When the TADs were placed parallel to the maxillary suture, they showed a more parallel and more significant sutural opening.





They also showed that when teeth are incorporated into the design, a force will still be exerted on the teeth. In theory, design A is terrific — parallel sutural changes with no unwanted forces exerted on the teeth. However, it is difficult to work with clinically due to lack of a way to stabilize it while placing the TADs. Perhaps this will change if a company can produce a surgical guide in the future.

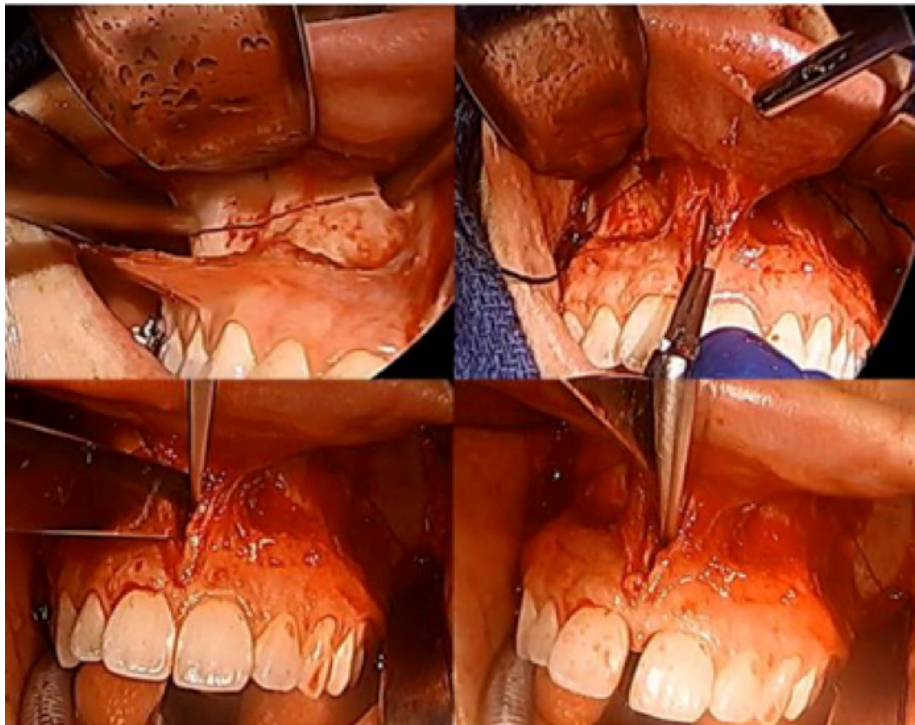
When comparing TAD expanders (MARPE) to hyrax expanders in late adolescents, the literature demonstrates that MARPEs will result in a more parallel sutural opening with less dental tipping (Lin et al., 2015).



TAD expander (left) and Hyrax expander (right).

Case selection is key to the success of TAD expansion. It works well in women. In male patients over 25 there is a high failure rate. Due to the high failure rate, Drs. Stanley Liu, Audrey Yoon and colleagues have designed a modified surgical approach to TAD expansion. They have given this modified treatment plan the acronym DOME – distraction osteogenesis maxillary expansion.

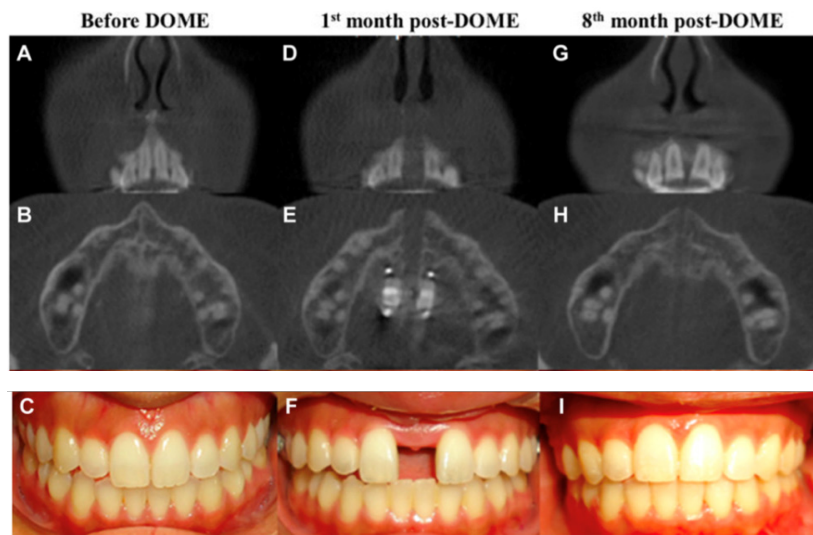
The DOME procedure utilizes a TAD expander, but adds surgical cuts to augment the maxillary split. The surgical cuts include a LeFort I level osteotomy with no down-fracture. A midline osteotomy may be necessary. Bilateral maxillary separation is confirmed in the operating room.



Images courtesy of Drs. Stanley Liu and Audrey Yoon.

Due to the less invasive nature of the cuts, the DOME procedure can be an outpatient surgery.

Drs. Stanley Liu and Audrey Yoon have shown in numerous publications that the DOME procedure can help reduce the AHI in non-obese patients with sleep apnea. The successful reduction of AHI following this procedure is likely due to the fact that the surgical maxillary expansion reduces resistance to nasal breathing and also provides more intraoral volume for the tongue.



AHI in above case dropped from 12.2 to 3.8.

In conclusion, the transverse dimension is a critical area that we should all include as a part of our diagnosis and treatment planning. Correcting transverse discrepancies can have a positive influence on the periodontium, occlusion, and airway. Appliance design depends on age, sutural maturity, and overall treatment goals based on the original diagnosis.

ABOUT THE AUTHOR

A board-certified orthodontist and periodontist, Dr. Rebecca Bockow has published articles on interdisciplinary dental treatment in various dental journals. The Spear Resident Faculty member has lectured nationally on corticotomy-facilitated orthodontic therapy and interdisciplinary treatment planning. Her practice in the Seattle area focuses on orthodontics and periodontics.

Dr. Bockow received her dental degree from the University of Washington School of Dentistry and dual training in orthodontics and periodontics from the University of Pennsylvania School of Dental Medicine, where she also earned a master's in oral biology. She has served as an affiliate assistant professor at the University of Washington in the Department of Orthodontics.



Rebecca Bockow, D.D.S., M.S.



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