Principals for placement and expansion protocol for the bone-first Quadexpander in adolescents and adults

Nour Eldin Tarraf, Maximilian Küffer, Oronzo de Gabriele, Benedict Wilmes

Article - Version of Record

Seminars in Orthodontics 31 (2025) 197–206

Contents lists available at ScienceDirect

Seminars in Orthodontics

journal homepage:

Principals for placement and expansion protocol for the bone-first Quadexpander in adolescents and adults

Nour Eldin Tarraf[a,b], Maximilian Küffer[c], Oronzo de Gabriele[d], Benedict Wilmes[c,*]

[a] Private Practice Sydney, Australia
[b] Honorary Lecturer, Discipline of Orthodontics, The University of Sydney School of Dentistry, Faculty of Medicine and Health, Australia
[c] University of Duesseldorf, Germany
[d] Private Practice, Lecce, Italy

ARTICLE INFO

Keywords:
RME
MARPE
Quadexpander
MSE
Hybrid hyrax

ABSTRACT

Transverse maxillary deficiency is a common malocclusion in orthodontics, particularly challenging to treat in adults due to increased resistance from the midpalatal suture and circummaxillary sutures. Traditional tooth-borne expansion methods are effective in children but cause significant dental side effects in older patients. Surgically assisted rapid maxillary expansion (SARME) is invasive, leading to the development of minimally invasive, miniscrew-supported devices like the Quadexpander. The Quadexpander is a purely bone-borne appliance anchored by four miniscrews, designed using the "Bone First" principle, which prioritizes optimal bone quality for screw placement. This custom-designed appliance avoids the negative side effects on teeth associated with hybrid devices and allows for effective skeletal expansion in adults. The article discusses the TAD insertion sites, design, placement, and activation protocols of the Quadexpander, emphasizing its advantages in achieving non-surgical maxillary expansion with minimal complications.

Introduction

Transverse maxillary deficiency is one of the most encountered malocclusions in orthodontics.[1] While tooth borne maxillary expansion is very effective at managing this malocclusion in children with immature sutures,[2] treatment becomes more challenging with older patients such as late adolescents and even more difficult in adults. The resistance to maxillary expansion increases with age, not only due to the increased interdigitation of the midpalatal suture (MPS)[3] but also the circummaxillary sutures and the reduced elasticity of the surrounding bones.[4] When tooth borne expansion is attempted in those groups it can lead to severe dental tipping, root resorption, alveolar bone fenestration and gingival recession with little or no skeletal expansion achieved.[5-8]

For decades surgically assisted rapid maxillary expansion SARME has been recommended to facilitate expansion by reducing the load on the anchorage teeth to minimize the negative side effects on the anchorage teeth.[9] However, surgery for SARME is quite invasive and not without the potential for serious complications.[10] Recently, miniscrews have been used to support maxillary expansion such as the tooth-bone borne Hybrid Hyrax[11] and the maxillary skeletal expander (MSE)[12] which share the load of the expansion between two or four miniscrews in the palate and two first molars. This greatly reduces the unwanted dental side effects of expansion [13-16] and the procedure is minimally invasive.[17] However, when non-surgical skeletal expansion is desired in mature individuals it seems preferable to avoid any loading of the teeth as the forces transmitted to the anchoring teeth would become extremely high in case of an undetected miniscrew failure during expansion or during retention and so a purely bone borne appliance such as the Quadexpander[18,19] or the Micro-4[20] C-expander, or Atoz,[21] is advocated. These appliances have been shown achieve pure skeletal maxillary expansion in adults without the need for surgery and without any negative side effects on the teeth. The aim of this paper is to describe the procedures and protocols for miniscrew placement, design and activation of the purely bone borne Quadexpander.

The principals behind the Quadexpander

The Quadexpander is a purely bone borne appliance supported by 4 miniscrews and no tooth attachments. For a purely bone borne appliance to be successful the stability of the miniscrews is crucial and so the miniscrews need to be placed in areas with the best cortical bone quality and quantity to resist the expansion forces (“Bone First” principal). The Bone First principal[18,22] aims to place the miniscrews in areas of the best available cortical bone and then to custom design the appliance around them. This is opposite to the appliance first or appliance driven miniscrew placement in which a prefabricated expansion device with

* Corresponding author at: Universitätsklinikum Düsseldorf, Germany.
E-mail address: wilmes@med.uni-duesseldorf.de (B. Wilmes).

https://doi.org/10.1053/j.sodo.2024.09.003

fixed channels for miniscrew placement, dictates where the miniscrews will be placed, which may or may not be in an area of good bone quality and quantity.

Miniscrew placement following the bone first principal for the Quadexpander, free hand insertion

Under local anaesthesia, four orthodontic palatal miniscrews (Benefit, PSM Medical, Gunningen, Germany) are inserted (Fig 1A), The two anterior mini-implants are placed paramedian in the anterior palate usually around the third Rugae line. The anterior palate has been shown, in several cone beam computed tomography (CBCT) studies,[23,24] to have the best quality cortical bone in the maxilla in the area commonly described as the T-Zone[25]. Further posteriorly the palatal bone becomes very thin especially in the molar region so for the two posterior miniscrews there are three possible insertion locations:

- The first location is where they are inserted in the alveolar process between the second premolar and first molar roots at approximately 8–9 mm from the gingival margin[18,26] (Fig 1). Ideally in this case a CBCT should be used to verify the availability of space between the roots, however, clinically it is possible to assess the available space between the palatal roots in most cases.
- The second position is to place them in the bony wall between the nasal cavity and the maxillary sinus[19] (Fig 2), this location is harder to do free hand, and an insertion guide based on a CBCT image is mandatory.
- The third option is to place them distally in the molar region very close to the MPS (Fig 3), since there is typically sufficient bone in the MPS, verifying the available bone with a CBCT scan is not mandatory.

The length of the miniscrews varies from 9, 11 and 13 mm, with a 2 mm diameter, the aim is to choose a miniscrew long enough to achieve bi-cortical engagement to provide the best support for expansion[27] with minimal miniscrew tipping. This means the miniscrews engage both palatal cortex and that of the floor of the nose. It is recommended that a CBCT is used in the planning process to select the correct length miniscrews.

After placement of the miniscrews, an intraoral scanner (such as Trios Pod Version, 3Shape, Copenhagen, Denmark) can be used to create a stereolithography (STL) file of the maxillary arch and then sent to the technical laboratory for design and appliance construction. The framework can be digitally designed using 3Shape Appliance Designer software (Fig 1B) (3Shape, Copenhagen, Denmark) or similar, to ensure the framework conforms well to the palatal contours and provides sufficient rigidity for expansion forces. The appliance design is then exported to a laser melting machine (Concept Laser, Lichtenfels, Germany) and printed using the alloy Remanium (Dentaurum, Ispringen, Germany). Once printed, a PowerScrew expansion mechanism (Tiger Dental, Bregenz, Austria) is laser-welded to the bedding prepared in the framework. The finished appliance is then inserted into the patients' mouth and secured to the miniscrews with four fixation screws (Benefit, PSM Medical, Gunningen, Germany). The final expander design can be seen in (Fig 1). Appliance fabrication is carried out as per Graf et al.[28]

Miniscrew placement following the bone first principal for the Quadexpander using an insertion guide[19]

Although in most cases free hand placement of the miniscrews is possible, the use of insertion guides for the placement of the miniscrews can be useful in achieving accurate placement in the best possible bone. This

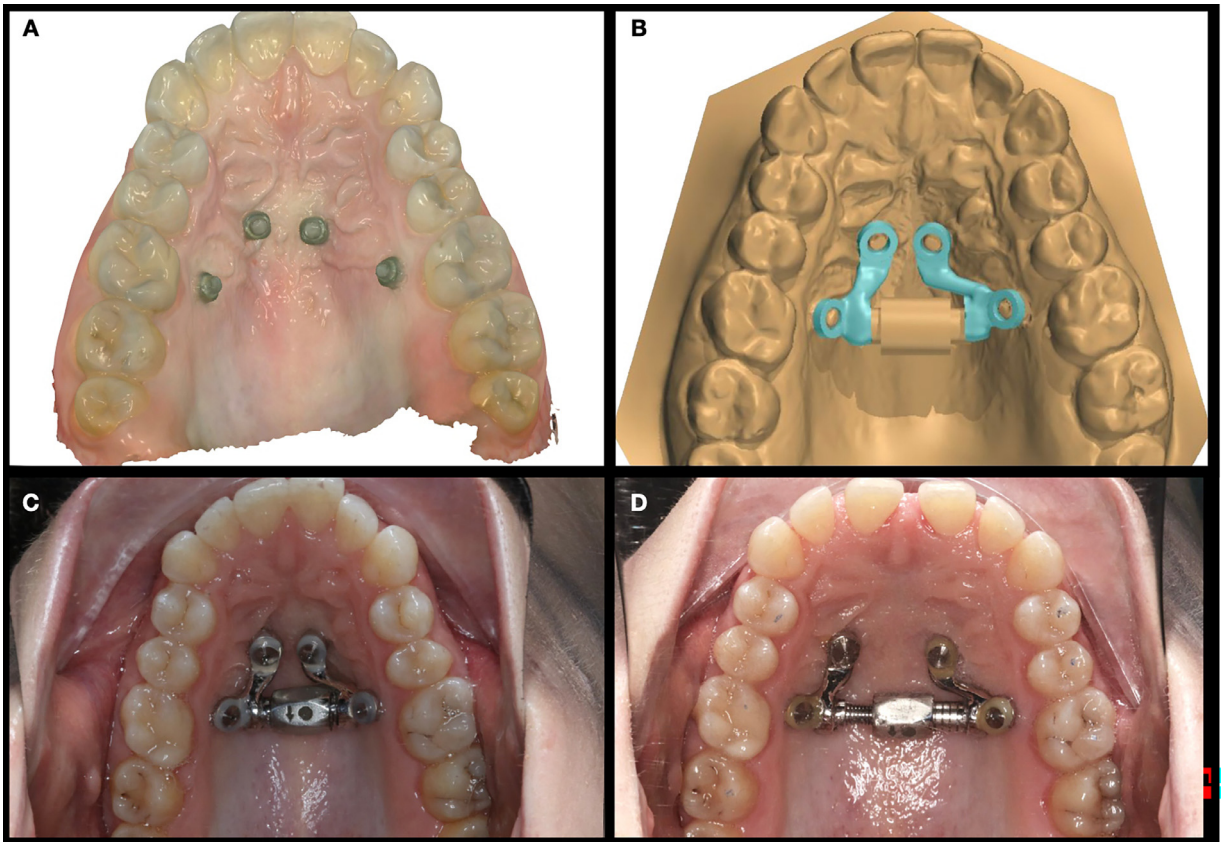

Fig. 1. First position of the posterior TADs in the alveolar process: A. Four Benefit miniscrews placed based on the bone first principal. B. The computer design of the appliance. C. The appliance in place secured with four fixation screws to the miniscrews. D. After expansion

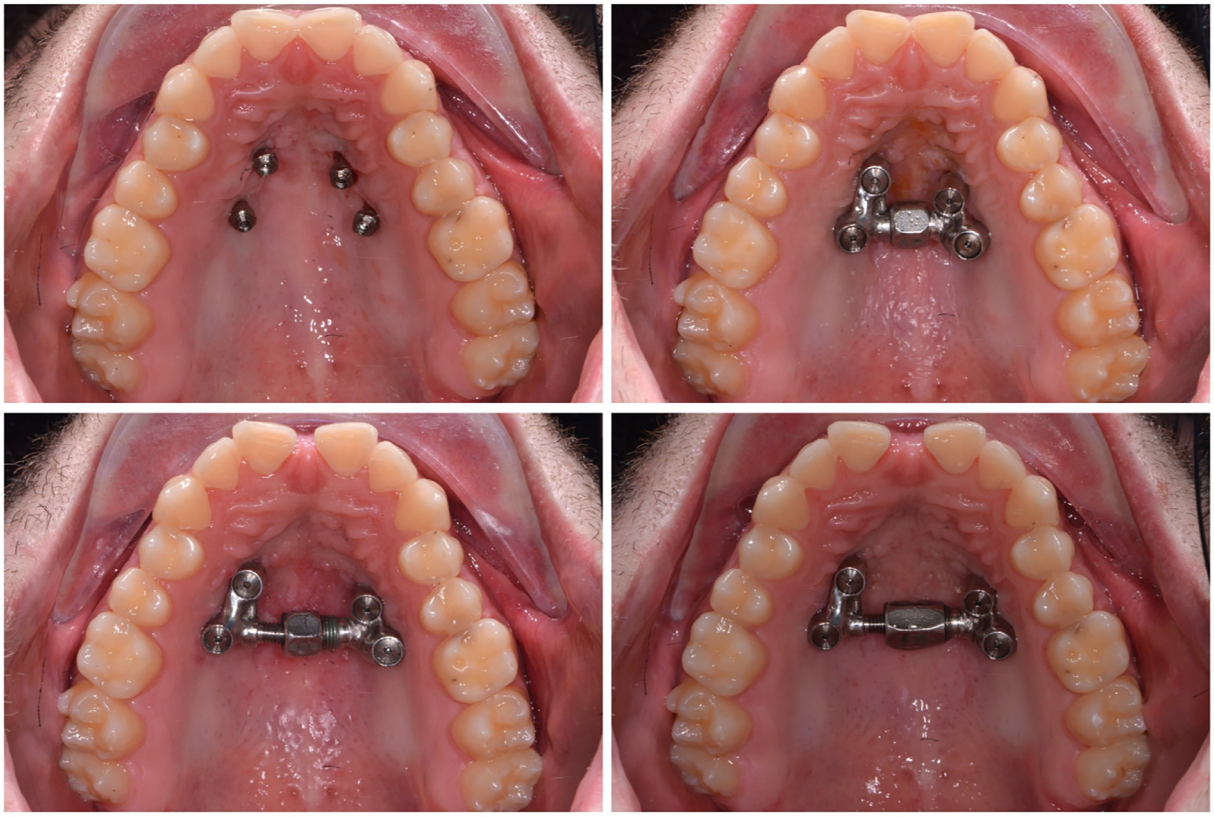

Fig. 2. The second position for placement of the posterior miniscrews for the Quadexpander: The posterior miniscrews are placed in the bony wall between the nasal cavity and the maxillary sinus. The anterior miniscrews are placed in the anterior palate in the T-Zone.

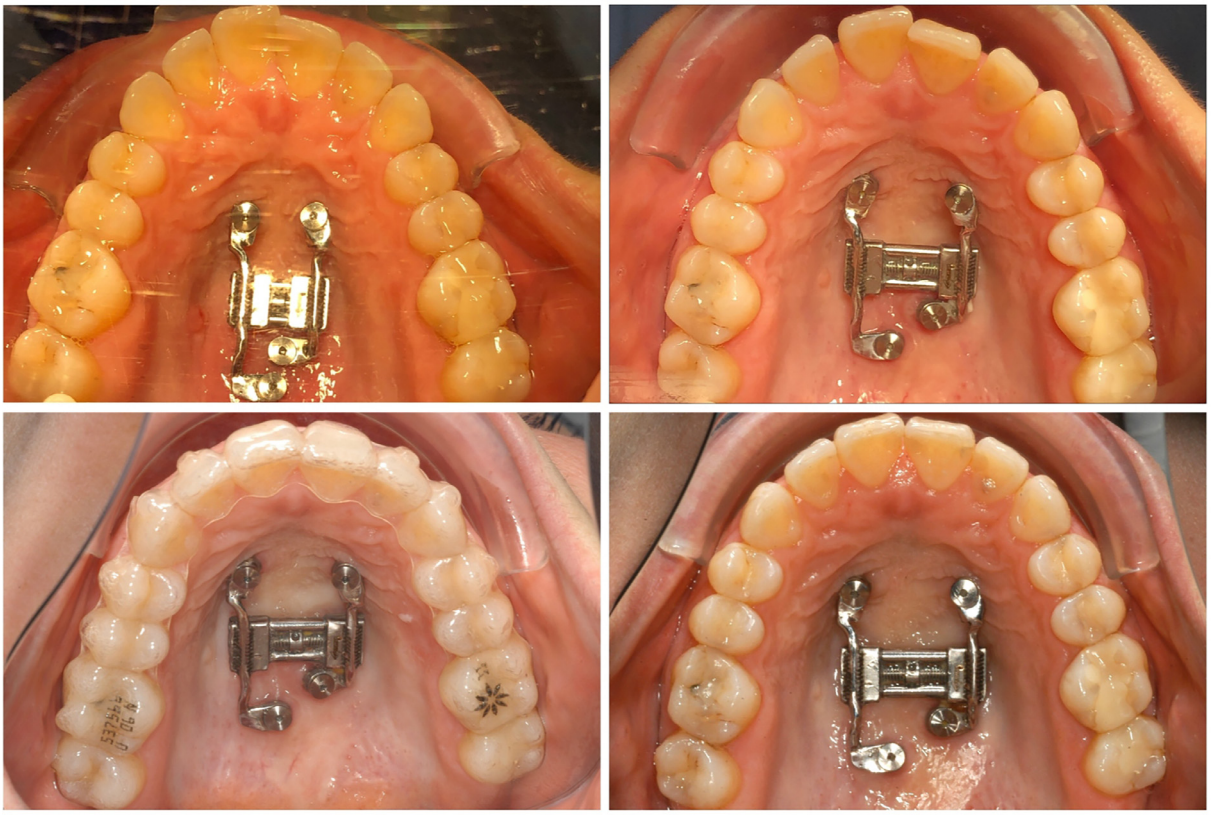

Fig. 3. The third position for placement of the posterior miniscrews for the Quadexpander: The posterior miniscrews are placed paramedian in the first molar or second premolar region close to the MPS. The anterior miniscrews are placed in the anterior palate in the T-Zone.

is particularly useful in cases where there are impacted teeth, there is root proximity, very narrow palates, and in cleft lip and palate cases. Guides can also be useful for doctors starting out with the procedure or for those who may choose to refer to a surgeon to place the miniscrews thus insuring the miniscrews are ideally positioned for orthodontic use. The orthodontist can use the guide to insert the miniscrews and then scan or take an impression as discussed above for the appliance manufacturing or alternatively the appliance can be prefabricated based on the planned miniscrew position using the virtual model and thus the miniscrew insertion and appliance placement can be done in the same visit.

Virtual planning of the miniscrew position and manufacturing of the insertion guide and Quadexpander[19]

Step 1: An STL file of the upper jaw is obtained either via an intraoral scan or a scan of a study model produced using a high-quality impression. The STL file is then superimposed with a CBCT image to identify an optimal site for mini-implant placement.

Step 2: Virtual planning software is then used to plan the precise positioning of the miniscrews as well as the correct length and diameter based on the bone available and insuring a safe distance to the roots.[18] Several software applications are available such as the Easy Driver software[18] (Easy Driver V2.0.2021, Uniontech Orthodontic Lab, Parma, Italy) or Blender (Blender Foundation, Amsterdam, The Netherlands) (Fig 4).

Step 3: Once the position of the miniscrews is finalized, a 3D printed or virtual model is created with the planned miniscrew positions represented by laboratory or digital miniscrew analogues. The Quadexpander can also be manufactured on this model.

Step 4: The insertion guide is virtually designed around the miniscrew positions and then printed from a biocompatible resin using a 3D printer.

Step 5: The miniscrews are inserted through the insertion guide using a contra-angle screwdriver. A special miniscrew insertions kit is usually used, which is designed to precisely fit into the insertion guide cylinders to ensure correct transfer of the planned miniscrew position.

Step 6: At the same appointment, if the Quadexpander has been prefabricated it is fitted to the four miniscrews using four fixation screws and expansion can commence. Alternatively, a scan or impression can be taken for appliance fabrication.

Appliance design

With the Quadexpander it is preferred to use the PowerScrew (Tiger Dental, Bregenz, Austria) as opposed to the Hyrax type screws for the following reasons. Firstly, the PowerScrew is turned with a wrench/spanner and so the patients can perform the turns on their own. This is particularly important for adult patients as they prefer not to rely on anyone to do the turns for them. Secondly, the PowerScrew (Tiger Dental, Bregenz, Austria) is easier to wind back, to contract or undo some of the expansion, when necessary, as for example when using a polycyclic expansion and contraction protocol.[20,26] It is quite difficult for a patient to wind back a Hyrax screw on their own. Thirdly, in adult expansion the force required to turn the screw can be significantly higher than in children and the pin used in the Hyrax screws can be get bent in the process while the wrench allows for a greater force to be applied. Fourthly, the PowerScrew (Tiger Dental, Bregenz, Austria) has been shown to be stiffer after expansion than the Hyrax screw[29] which is essential for force transmission to the miniscrews and for maintaining the expansion once achieved. Lastly, with PowerScrew (Tiger Dental, Bregenz, Austria) the

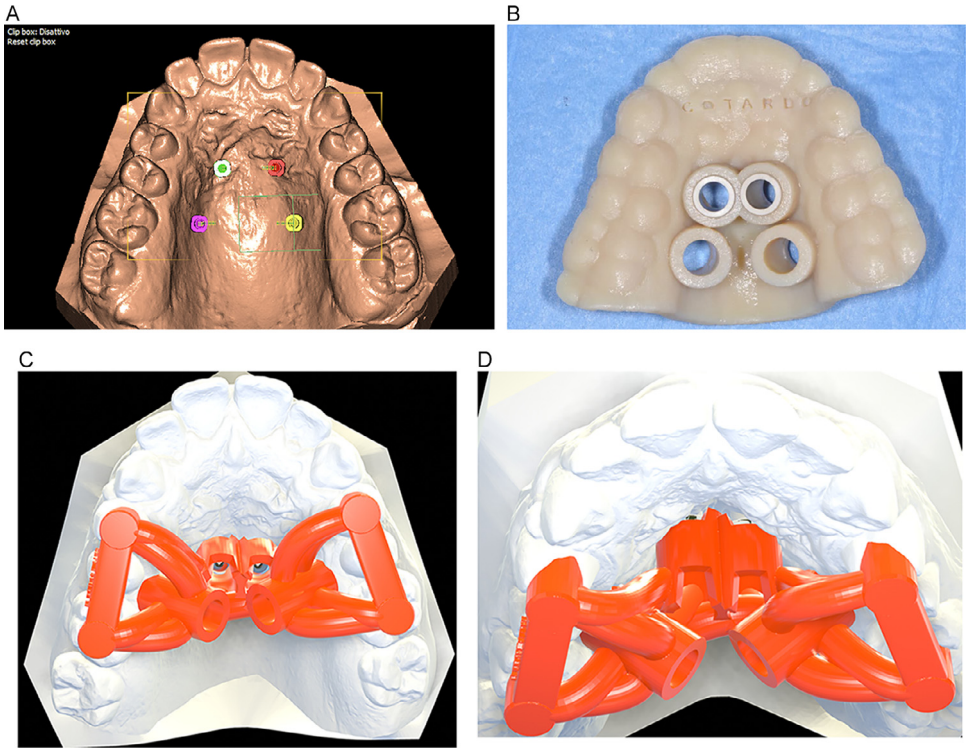

Fig. 4. Virtual design of the miniscrew placement site (a) and 3D printing of the guide (b) using Easy Driver Software. Recent guide design using Blender software (c) (Blender Foundation, Amsterdam, The Netherlands). The Guide is supported by four pillars on the dentition and the cylinders for the implant placement holder have vertical cut-outs to allow the miniscrew to slide into the channel without the patient having to excessively open their mouth (d).

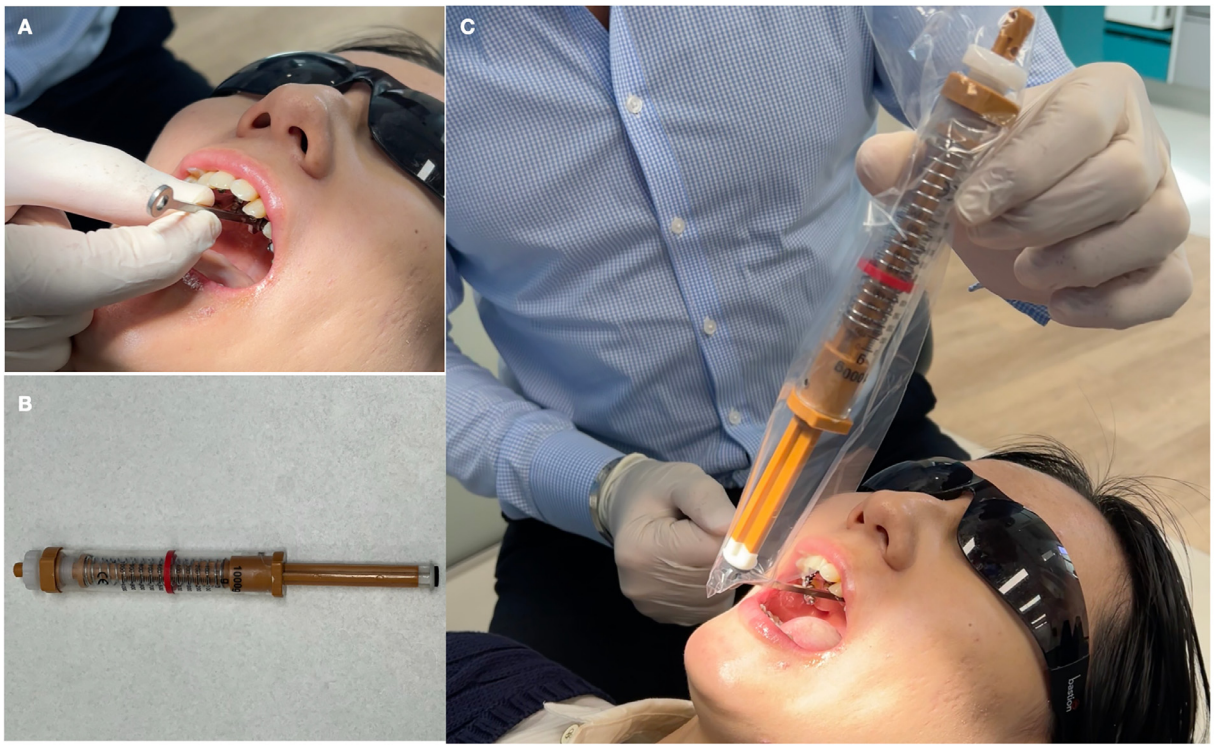

Fig. 5. Measurement of the expansion force using the force gauge (Push–Pull Spring Scale 10N, Arbour Scientific, Ann Arbor, USA). A. The expansion wrench is put into position, B. The Force Gauge (Push–Pull Spring Scale 10N, Arbour Scientific, Ann Arbor, USA). C. The Force Gauge is placed on the end of the wrench at 90 degrees and the turn is performed and the force is recorded.

expansion mechanism can be changed to increase the range of activation chair side (Fig 6), so in cases with a narrow palate the expansion can start with a small PowerScrew (Tiger Dental, Bregenz, Austria) and then once it reaches its limits the hexagonal nut can be changed over to a larger hexagonal nut thus giving the expansion appliance a greater range of expansion. This can be done chair side without having to fabricate a new appliance, which saves time and cost.

Positioning of the expansion screw should be done in such a way so that the hexagonal screw is as centred as possible between the four miniscrews (Fig 7). Placement of the barrel too far distal from the miniscrews should be avoided as this can create a large moment of force and lead to suboptimal loading and uneven force distribution between the miniscrews as well as overloading of the welding joints that hold the metal framework to the PowerScrew (Tiger Dental, Bregenz, Austria) and increase the chance of failures.

The framework should be as rigid and compact as possible to ensure that there is no flex in the appliance and forces are transmitted directly to the miniscrews and thus to the sutures. Metal printing is recommended for that reason. When conventional expansion screws are used the prefabricated wires can be flexible and thus bend under the forces of expansion and impinge on the palate. This also means that the expansion forces may dissipate and not be fully transmitted to the bone.

Activation protocols

In younger patients, such as late adolescents, a continuous expansion protocol of one turn a day 0.17 mm can be successful and with minimal side effects due to the more elastic nature of the bones. However, in adults this may be problematic and lead to unwanted complications. Winsauer *et al*[20] suggested that when a continuous expansion protocol is used in MARPE with adults, frequently two activations per day, it can overload the hardware, leading to breakage or loosening of the appliance and /or the miniscrews as well as undesirable effects on the neighbouring anatomical structures[30]. In adults the reduced elasticity of the

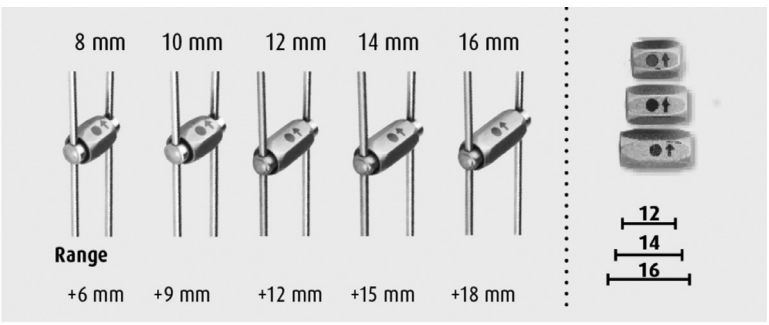

Fig. 6. The PowerScrew (Tiger Dental, Bregenz, Austria) with the interchangeable hexagonal nut, this allows for the nut to be changed chair side to increase the range of the expander without having to fabricate a new appliance.

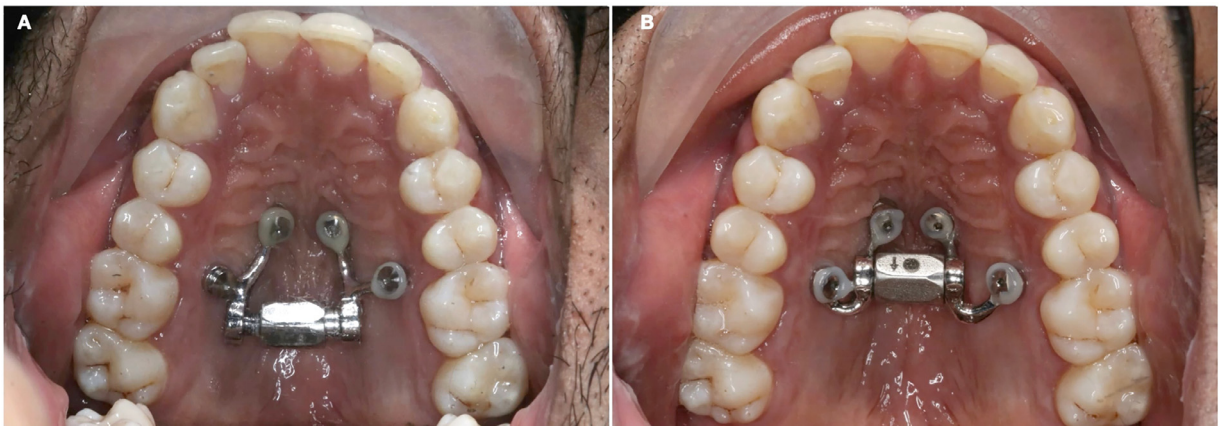

Fig. 7. A. Showing distal placement of the PowerScrew (Tiger Dental, Bregenz, Austria) which is not ideal for the loading of the miniscrew and the framework. B. same patient after redesign of the appliance to place the PowerScrew (Tiger Dental, Bregenz, Austria) in a more cantered position between the miniscrews.

facial bones[4] and the increased interdigitation of the MPS with potential fusion can lead to undesired fractures, asymmetric expansion and micro-fractures in the bones around the cranial base, resulting in injury to nervous and vascular structures. Thus, Winsauer developed a two-staged protocol for miniscrew assisted palatal expansion in adults called the force-controlled polycyclic protocol (FCPC).[20] The aim of this protocol is to weaken the circum-maxillary sutures and enable a more physiological expansion of the MPS. The activation protocol advocated here was put forward by Ponna et al[26] and is a variation of the Winsauer force-controlled polycyclic (FCPC) activation protocol of expansion.

Modified FCPC

After placement of the appliance the expansion screw is turned once daily (0.17 mm) for 1 week with a wrench turning the hex nut of the expansion screw. After 1 week of expansion, the subject visits the orthodontist who assesses for the development of a diastema and measures the amount of force required to turn the expansion screw using a spring scale (Push–Pull Spring Scale 10N, Arbour Scientific, Ann Arbor, USA) or similar (Fig 5). The ideal force required to turn the screw is selected to be between 150 and 400 cN.

- If the spring scale measures under 400 cN the subject is instructed to turn the expansion screw once daily (0.17 mm) for another week and the force is then reassessed again. If it stays under 400 cN and a diastema is evident the patient is asked to continue for another two weeks, and force is reassessed again. If it remains under 400cN the patient is then asked to continue until the desired expansion is achieved. It is possible at that stage reduce the rate of expansion to once every second day to avoid the diastema becoming too large, which some patients find aesthetically unappealing.
- If the force, however, exceeds 400 cN after the first or the second week, the expansion screw is turned back at least 1 mm or until the spring scale reads well under 400 cN, ideally less than 200 cN. Then, to weaken the circum-maxillary sutures, patients are instructed to apply the following cyclic expansion and contraction protocol: turn the expansion screw forward twice in the morning (expansion of 0.34 mm), wait for 10min, then close the screw back twice (constriction of 0.34 mm) and leave for the rest of the day. In the evening, patients were instructed to turn the screw once forward (expansion of 0.17 mm) and leave it. Patients are then to follow this daily FCPC protocol for 1 week. After 1 week, the subjects visit the orthodontic practice again to assess the force of expansion with the spring scale. This protocol is followed until the weekly spring scale measurement reads under 400 cN, indicating no high resistance to expansion, and at this point, patients are instructed to turn the expansion screw once daily until adequate expansion is achieved as assessed by the treating orthodontist. All patients should exhibit a visible diastema at their review appointments indicating MPS separation and that skeletal expansion is achieved.

Retention

Once the desired expansion is achieved it is recommended to leave the passive appliance in place for at least 12 months to allow adequate time for bone remodelling. The expander can then be removed and replaced with rigid skeletal retainer between the anterior miniscrews for a further 9 months. The retainer is secured to the miniscrews with two fixation screws (Fig 8). Extended retention is recommended midpalatal suture repair can take in excess of 16 months.[31]

Discussion

Maxillary expansion for transverse maxillary deficiency is one of the most performed treatments in orthodontics.[32] In young children, during the mixed dentition, conventional tooth borne maxillary expansion is effective. However, in older patients, even in young adolescents, there are many unwanted side effects such as dental tipping, root resorption

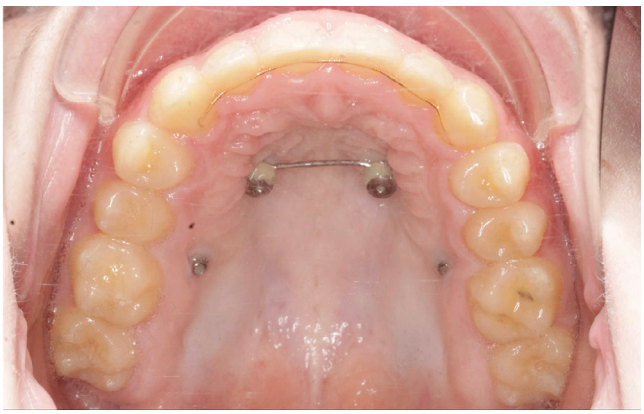

Fig. 8. The skeletal retainer, 0.8mm Stainless Steel wire placed between the two anterior Benefit miniscrews to serve as a skeletal retainer after the removal of the appliance.

of the anchorage teeth, fenestrations of the alveolar bone and gum recession.[6-8,33] This is due to increased resistance to expansion from the increased interdigitation of the MPS as well as the circummaxillary sutures. The use miniscrews to support maxillary expansion MARPE such as with the Hybrid Hyrax[11] and other hybrid appliances such as MSE[12] reduces those the negative dental side effects while increasing the skeletal effects of the expansion. In late adolescents and in adults, however, the increased resistance to expansion is much higher and can be attributed not only to the increased interdigitation of the midpalatal and circummaxillary sutures but also to the reduced elasticity of the facial bones[4]. Surgery to reduce the resistance such in SARME is commonly used,[9] however, in addition to the risks and invasiveness of surgery there are still negative side effects on the anchorage teeth, such as increased buccal tipping and reduction in the skeletal expansion when these appliances are tooth borne,[34] The bone borne transpalatal distractor[35] aimed to overcome these limitations, however, the procedure is invasive and has many possible post operative complications.[36]

Why a purely bone borne appliance is preferred

The Quadexpander offers a non-surgical alternative for the late adolescents and adults. The appliance is purely bone borne and supported by 4 miniscrews. While it is possible in children to achieve good expansion with 2 miniscrews alone,[37] with more mature patients this would not be sufficient. It is also in some cases undesirable to use Hybrid appliances such as the Hyrbrid Hyrax and the MSE which share the load of the expansion between miniscrews and the teeth. One of the main reasons is that when teeth are included in the appliances, even when supported by miniscrews, there might still be negative side effects on the engaged teeth such as buccal tipping, buccal bone loss and alveolar fenestrations,[33] Kayalar et al showed that even when using a Hybrid Hyrax combined with SARME to reduce the resistance to expansion the anchorage teeth demonstrated some buccal tipping and loss of buccal bone.[34] When the effects of a Hyrbid Hyrax using SARME were compared to the non-surgical expansion with a Quadexpander, on the other hand, there was no notable buccal tipping of the anchorage teeth and no loss of buccal bone with the Quadexpander, since the appliance does not engage any teeth.

Another reason to avoid including teeth in the appliance is that in adult patients a modified force controlled polycyclic expansion and contraction protocol is advocated[26] to reduce the resistance to expansion. This type of expansion and contraction might be damaging to any anchorage teeth with increased risk of root resorption and bone loss due to the cyclic heavy loading of the teeth this would entail. Moreover, even once expansion has been achieved the relapse forces are significant, and it is recommended to leave the appliance in place for retention for an extended period 9 to 24 months. During this period undetected miniscrew failure would mean these forces would be transmitted to the anchorage teeth and might cause significant damage while with a purely bone borne appliance any miniscrew failure would become immediately evident.

The bone first philosophy[18,22]

For successful bone borne expansion the success of the miniscrews is pivotal. This is why the bone first principal is followed. The principal dictates that the aim should be to place all 4 miniscrews in areas with adequate bone support and custom design the appliance to follow. In the Quadexpander the anterior miniscrews are placed in the best possible bone in the maxilla, in the T-Zone (Fig. 9).[23,25] Several studies have shown this area to have the best available bone. While further posteriorly the palatal bone becomes thin. For the posterior miniscrews the placement must consider the individual anatomy of the patient. With three possible placement locations, the alveolar process between the first molar and second premolar, the bony wall between the maxillay sinus and the nasal cavity or paramedian to the MPS in some patients where the palatal bone is quite thick (Fig. 10). The insure the best possible bone is used a CBCT is usually recommended for the planning, and the use of an insertion guide can be very helpful.[19] This approach contrasts with the use of prefabricated appliances such as the MSE[12] where the appliance is prefabricated with four channels for miniscrew insertion. The appliance here dictates where miniscrews will be placed which may not, at least not for all four miniscrews, coincide with an area of sufficient bone thus not insuring pure skeletal anchorage. Furthermore, in patients with very narrow palates the prefabricated appliances may not fit, while with bone first approach and a customised appliance the appliance can be adapted to very narrow palates.

Force controlled polycyclic expansion protocols (FCPC)

Overcoming the resistance to expansion in adults can be a challenge. Although the increased interdigitation of the MPS is considered a major obstacle it has been found to be patent even in mature adults.[38] A large part of the resistance to expansion comes from the cricummaxillary sutures, which do not fall perpendicular to the line of the expansion force, as well as the reduced elasticity of the surrounding bones.[4] While many authors advocate for a continuous expansion protocol with MARPE,[12,33] this is not recommended here. The continuous expansion may well work in adolescents and some young adults due to elasticity of their bones, however, it can become problematic with more mature patients. Winsauer et al[20] highlighted that in adults a continuous expansion protocol of one or two turns a day can lead to accumulation of stress which can lead to failure of the appliances or the miniscrews. More seriously, it can lead to fractures of the facial or nasal bones, asymmetric expansion and microfractures near the cranial base, which may compromise sensitive anatomical vessels and nerves.[30] Winsauer et al advocated the FCPC to help gradually loosen or weaken the MPS and the cricummaxillary sutures thus making them more responsive to expansion without inducing fractures or overloading the appliances.[20] In the case of Winsauer's protocol, the patients are given the force gauge and instructed not to exceed 500cN force for expansion. While Ponna et al[26] used a modified version of this protocol, where the assessment of the force was done by the clinician every week or two chairside at the start of treatment. There is merit to both approaches, and while Ponna et al found 100 % success in achieving expansion in their sample Winsauer et al. reported an 84 %, this difference can be explained by the difference in the mean age of the groups studied, 24.14 years and 29.1 years respectively. In both those protocols once the expansion force appears to be excessive 500 cN and 400 cN respectively the expansion appliance is reversed to reduce the stresses and then a polycyclic expansion and contraction protocol is applied to gradually disarticulate the sutures. Although the theoretical principal behind these protocols may be sound the upper limit to the expansion force allowed by both authors is purely empirical and was mainly derived from clinical experience. Further research into this is required.

Skeletal and dental effects of the Quadexpander

Few studies have examined the effects of purely bone borne non-surgical maxillary expansion in adults.[20,26,39] Ponna et al[26] looked at 27 consecutively treated cases with the Quadexpander using CBCT with a mean age of 24 years old ranging from 18-39 years old. They observed that significant skeletal expansion can be achieved while avoiding any negative dental side effects. The expansion took a pyramidal shaped pattern with greater transverse expansion at the level of the maxillary dental arch than at the skeletal level. There was evidence of expansion at the level of the lower level of zygomatic arch while there was no significant expansion at the higher level of the zygomatic arch and the fronto-

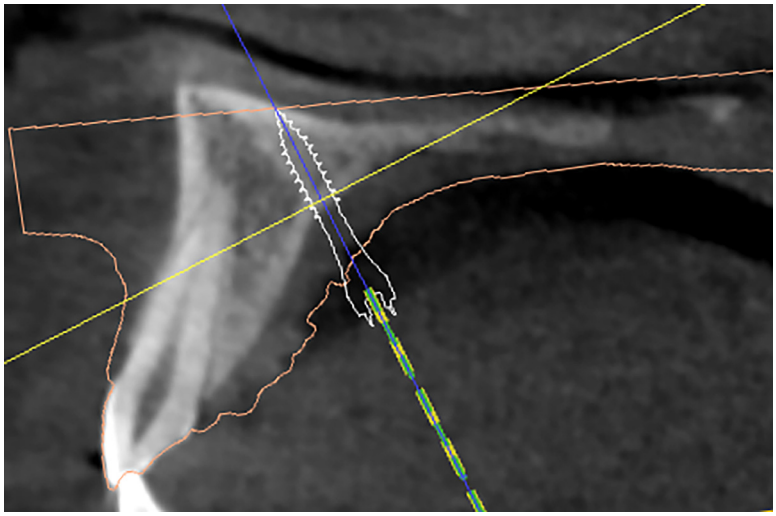

Fig. 9. Anterior insertion site: Bone availability is consistently excellent in the anterior palate, distal to the rugae (T-zone). The default angulation is 20 degrees relative to a vertical line on the occlusal plane.

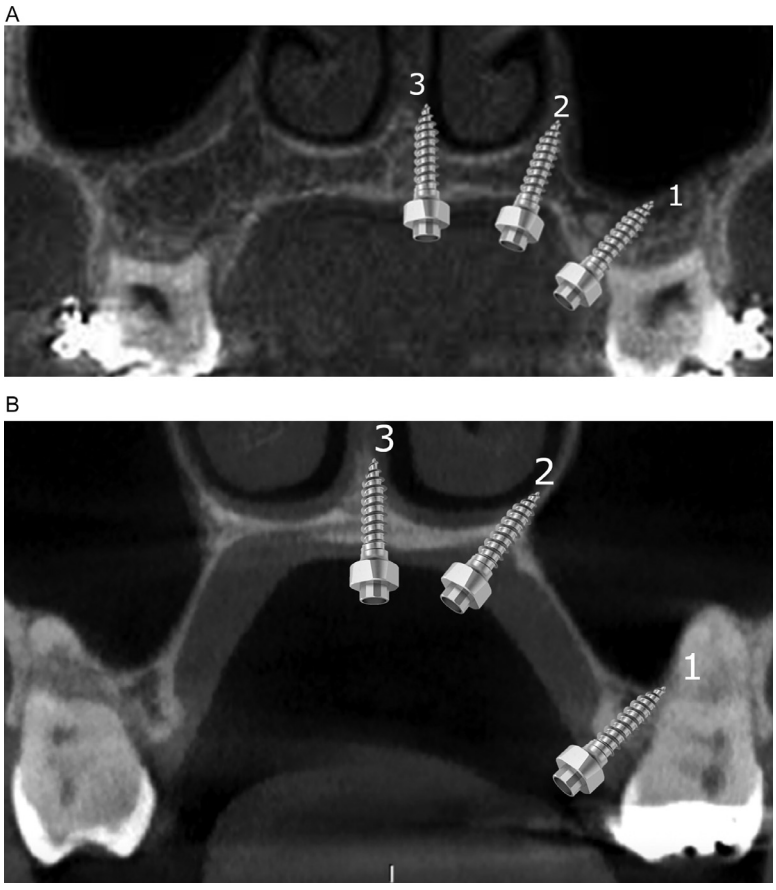

Fig. 10. Posterior insertion sites: Schematic illustrations of the three different posterior insertion sites in two different morphological situations (a,b): 1: Alveolar process, 2: Bony wall between the nasal cavity and the sinus, 3: Close to the MPS

nasal suture demonstrating the appliance is effective at midfacial expansion without affecting the cranial structures. This pattern of expansion was also seen in other studies using the MSE appliance. This is because, despite being purely bone borne, the appliances are still below to the centre of resistance of the maxilla thus rotating the maxillary halves with the centre of rotation near the frontonasal suture. With a mean activation of the expansion of 7.7 mm the mean expansion was 5.46 mm SD 1.87 at the level of dentition and 2.56 mm SD 1.8 at the maxilla while the increase in nasal width was 3.5 mm SD 1.39 (Fig 9). The expansion also took a fan shaped pattern (Fig 11) in the axial plane with more expansion anteriorly 5.34 mm at ANS than posteriorly 3.27 mm at PNS. This is similar to what was reported by Winsauer et al.[20] This pattern is different to the more parallel pattern expansion observed with the MSE[12] appliance and is likely due to the more posterior placement of the MSE overcoming the resistance posed by the zygomatic arches.

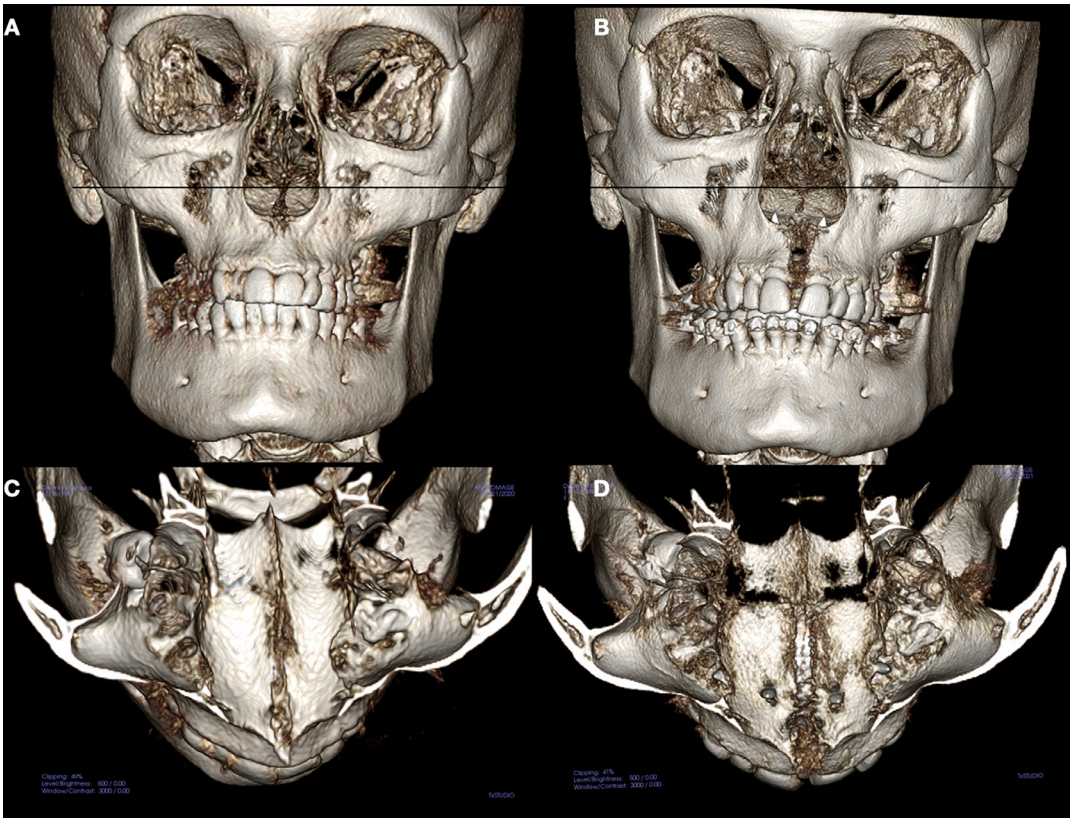

Fig. 11. A. CBCT frontal view before expansion. B. CBCT frontal view after expansion showing the split of the midpalatal suture with typical pyramidal shape of expansion. C. CBCT axial view of the palatal bone from inside the nasal cavity before expansion. D. CBCT axial view of the palatal bone from inside the nasal cavity after expansion showing the complete disarticulation of the two halves of the maxilla and the palatal bones with more expansion anteriorly at the anterior nasal spine and slightly less expansion posteriorly.

There were minimal changes in the angulation of the teeth with the Quadexpander demonstrating that appliance has a purely skeletal effect while eliminating the dental side effects and there were no serious complications reported.[26] The Quadexpander appears to be well tolerated and most of the complication were related to failure of the hardware or were quite mild such as mild to moderate discomfort during expansion.

Conclusion

The Quadexpander offers a new avenue for adult expansion without surgery. It is a purely bone borne maxillary expansion appliance mounted on 4 miniscrews placed with the bone first principal and can produce significant skeletal expansion in mature non-growing patients without the unwanted dental side effects. More research is required to further understand the best expansion protocols and the limits of its applications.

Patient consent

Patient consent was obtained.

Funding

No funding or grant support received.

Author contributions

All authors attest that they meet the current ICMJE criteria for authorship.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. da Silva Filho OG, Santamaria M. Capelozza Filho L. Epidemiology of posterior crossbite in the primary dentition. *J Clin Pediatr Dent*. 2007;32:73–78.
2. Haas A. Rapid expansion of the maxillary dental arch and nasal cavity by opening the midpalatal suture. *Angle Orthodontist*. 1961;31:73–90.
3. Angelieri F, Ruellas AC, Yatabe MS, Cevidanes LHS, Franchi L, Toyama-Hino C, et al. Zygomaticomaxillary suture maturation: Part II-The influence of sutural maturation on the response to maxillary protraction. *Orthod Craniofac Res*. 2017;20:152–163.
4. Shetty V, Caridad JM, Caputo AA, Chaconas SJ. Biomechanical rationale for surgical-orthodontic expansion of the adult maxilla. *J Oral Maxillofac Surg*. 1994;52:742–749. discussion 750-741.
5. Akyalcin S, Alexander SP, Silva RM, English JD. Evaluation of three-dimensional root surface changes and resorption following rapid maxillary expansion: a cone beam computed tomography investigation. *Orthod Craniofac Res*. 2015;18(1):117–126. Suppl.
6. Barber AF, Sims MR. Rapid maxillary expansion and external root resorption in man: a scanning electron microscope study. *Am J Orthod*. 1981;79:630–652.
7. Carmen M, Marcella P, Giuseppe C, Roberto A. Periodontal evaluation in patients undergoing maxillary expansion. *J Craniofac Surg*. 2000;11:491–494.
8. Schuster G, Borel-Scherf I, Schopf PM. Frequency of and complications in the use of RPE appliances—results of a survey in the Federal State of Hesse, Germany. *J Orofac Orthop*. 2005;66:148–161.
9. Pogrel MA, Kaban LB, Vargervik K, Baumrind S, Pogrel MA, Kaban LB, et al. Surgically assisted rapid maxillary expansion in adults. *International Journal of Adult Orthodontics & Orthognathic Surgery*. 1992;7:37–41.
10. Pereira MD, Koga AF, Prado GPR, Ferreira LM. Complications From Surgically Assisted Rapid Maxillary Expansion With HAAS and HYRAX Expanders. *J Craniofac Surg*. 2018;29:275–278.

11. Wilmes B, Nienkemper M, Drescher D. Application and effectiveness of a mini-implant- and tooth-borne rapid palatal expansion device: the hybrid hyrax. *World J Orthod*. 2010;11:323–330.
12. Brunetto DP, Sant'Anna EF, Machado AW, Moon W. Non-surgical treatment of transverse deficiency in adults using Microimplant-assisted Rapid Palatal Expansion (MARPE). *Dental Press J Orthod*. 2017;22:110–125.
13. Wilmes B, Nienkemper M, Ludwig B, Kau CH, Drescher D. Early Class III Treatment with a Hybrid Hyrax-Mentoplate Combination. *J Clin Orthod*. 2011;45:1–7.
14. Nienkemper M, Wilmes B, Pauls A, Drescher D. Maxillary protraction using a hybrid hyrax - facemask combination. *Prog Orthod*. 2013;14:1–8.
15. Wilmes B, Ngan P, Liou EJ, Franchi L, Drescher D. Early class III facemask treatment with the hybrid hyrax and Alt-RAMEC protocol. *J Clin Orthod*. 2014;48:84–93.
16. Ngan P, Wilmes B, Drescher D, Martin C, Weaver B, Gunel E. Comparison of two maxillary protraction protocols: tooth-borne versus bone-anchored protraction facemask treatment. *Prog Orthod*. 2015;16:26.
17. Bazargani F, Magnuson A, Ludwig B. Effects on nasal airflow and resistance using two different RME appliances: a randomized controlled trial. *Eur J Orthod*. 2018;40:281–284.
18. Wilmes B, De Gabriele R, Dallatana G, Tarraf N, Ludwig B. Bone first" principle with CAD/CAM insertion guides for mini-implant-assisted rapid palatal expansion. *J Clin Orthod*. 2022;56:158–166.
19. Wilmes B, Tarraf NE, de Gabriele R, Dallatana G, Drescher D. Procedure using CAD/CAM-manufactured insertion guides for purely mini-implant-borne rapid maxillary expanders. *J Orofac Orthop*. 2022;83:277–284.
20. Winsauer H, Walter A, Katsaros C, Ploder O. Success and complication rate of miniscrew assisted non-surgical palatal expansion in adults - a consecutive study using a novel force-controlled polycyclic activation protocol. *Head Face Med*. 2021;17:50.
21. Bai J, Choi JY, Kim SH. The design of bone-borne maxillary expander affects the different dentoalveolar inclination and expansion pattern: A CBCT study. *Semin Orthod*. 2024. https://doi.org/10.1053/j.sodo.2024.05.002.
22. Wilmes B. Appliance First" or "Bone First" for miniscrew assisted rapid palatal expansion? *APOS Trends in Orthodontics*. 2022;12:3–6.
23. Becker K, Unland J, Wilmes B, Tarraf NE, Drescher D. Is there an ideal insertion angle and position for orthodontic mini-implants in the anterior palate? A CBCT study in humans. *Am J Orthod Dentofacial Orthop*. 2019;156:345–354.
24. Kim HJ, Yun HS, Park HD, Kim DH, Park YC. Soft-tissue and cortical-bone thickness at orthodontic implant sites. *Am J Orthod Dentofacial Orthop*. 2006;130:177–182.
25. Wilmes B, Ludwig B, Vasudavan S, Nienkemper M, Drescher D. The T-Zone: Median vs. Paramedian Insertion of Palatal Mini-Implants. *J Clin Orthod*. 2016;50:543–551.
26. Ponna P, Tarraf NE, Dalci K, Wilmes B, Darendeliler MA, Dalci O. Dentoskeletal effects of mini-screw assisted, non-surgical palatal expansion in adults using a modified force-controlled polycyclic protocol: a single-centre retrospective study. *Eur J Orthod*. 2024;46.
27. Lee RJ, Moon W, Hong C. Effects of monocortical and bicortical mini-implant anchorage on bone-borne palatal expansion using finite element analysis. *Am J Orthod Dentofacial Orthop*. 2017;151:887–897.
28. Graf S, Vasudavan S, Wilmes B. CAD-CAM design and 3-dimensional printing of mini-implant retained orthodontic appliances. *Am J Orthod Dentofacial Orthop*. 2018;154:877–882.
29. Muchitsch AP, Wendl B, Winsauer H, Pichelmayer M, Payer M. Rapid maxillary expansion screws on the test bench—a pilot study. *Eur J Orthod*. 2011;33:256–262.
30. Holberg C, Rudzki-Janson I. Stresses at the cranial base induced by rapid maxillary expansion. *Angle Orthod*. 2006;76:543–550.
31. Naveda R, Dos Santos AM, Seminario MP, Miranda F, Janson G, Garib D. Midpalatal suture bone repair after miniscrew-assisted rapid palatal expansion in adults. *Prog Orthod*. 2022;23:35.
32. Haas AJ. Palatal expansion: Just the beginning of dentofacial orthopedics. *American Journal of Orthodontics*. 1970;57:219–255.
33. Gunyuz Toklu M, Germec-Cakan D, Tozlu M. Periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion appliances. *Am J Orthod Dentofacial Orthop*. 2015;148:97–109.
34. Kayalar E, Schauseil M, Kuvat SV, Emekli U, Firatli S. Comparison of tooth-borne and hybrid devices in surgically assisted rapid maxillary expansion: A randomized clinical cone-beam computed tomography study. *J Craniomaxillofac Surg*. 2016;44:285–293.
35. Koudstaal MJ, van der Wal KG, Wolvius EB, Schulten AJ. The Rotterdam Palatal Distractor: introduction of the new bone-borne device and report of the pilot study. *Int J Oral Maxillofac Surg*. 2006;35:31–35.
36. Carvalho PHA, Moura LB, Trento GS, Holzinger D, Gabrielli MAC, Gabrielli MFR, et al. Surgically assisted rapid maxillary expansion: a systematic review of complications. *Int J Oral Maxillofac Surg*. 2020;49:325–332.
37. Wilmes B, Tarraf N, Drescher D. Treatment of maxillary transversal deficiency by using a mini-implant-borne rapid maxillary expander and aligners in combination. *Am J Orthod Dentofacial Orthop*. 2021;160:147–154.
38. Persson M, Thilander B. Palatal suture closure in man from 15 to 35 years of age. *Am J Orthod*. 1977;72:42–52.
39. Choi SH, Shi KK, Cha JY, Park YC, Lee KJ. Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. *Angle Orthod*. 2016;86:713–720.