Skeletal expansion using a miniscrew-assisted rapid palatal expansion in a 50-year-old patient

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This case report illustrates a nonsurgical treatment plan using a miniscrew-assisted rapid palatal expander (MARPE) in a 50-year-old patient with maxillary transverse deficiency. The MARPE appliance consisted of a conventional Hyrax expander anchored to 4 orthodontic miniscrews. The exact locations of the miniscrews were determined with virtual planning software. Cone-beam computed tomography (CBCT) scans were superimposed on the maxillary digital model, and 3-dimensional-printed surgical guides were used to accurately position the mini-implants. A slow expansion protocol was used, and the appliance was held in place during the entire treatment (almost 20 months). Pretreatment, postexpansion, and posttreatment CBCT scans show the parallel expansion obtained without dental torque compensation or bite opening. The posttreatment scan showed that a long period is required to complete the midpalatal suture mineralization. MARPE has proven effective in correcting transverse discrepancies, even in adults. However, posttreatment CBCT imaging showed incomplete ossification of the midpalatal suture, demonstrating that the retention period should be extended in some adult patients.

Rapid maxillary expansion (RME) was first introduced in 1860 by Emerson C. Angell. Today, RME appliances are considered the most reliable fixed orthopedic devices for treating transverse skeletal problems (cross-bite and maxillary constriction) in prepubertal patients.[1]

When used on children and adolescents, conventional RME appliances bonded to the teeth, opening the midpalatal suture and increasing maxillary width with orthopedic effects and limited associated dental consequences.[2-4] However, in postpubertal and adult patients (CS5-CS6), this approach is unsuccessful and often produces undesirable dentoalveolar effects, root resorption, buccal tipping, and gingival recession in the posterior teeth, with no skeletal movement.[5]

For many years, surgically assisted rapid palatal expansion was the only treatment for postpubertal patients with maxillary constriction. Nevertheless, the recent development of mini-implant anchorage has made other techniques available, such as miniscrew-assisted rapid palatal expansion.[6-11]

In 2010, Lee et al[7] were the first to propose bone-borne palatal expanders like MARPE to solve transverse discrepancy in a 20-year-old patient without surgery, thereby avoiding adverse dentoalveolar effects while optimizing skeletal expansion potential.

Bone-born expanders can potentially avoid surgery; thus, different MARPE appliances have been developed recently to solve transverse discrepancies in adults.[10,12-15]

This study presents a digitally planned cone-beam computed tomography (CBCT) patient of a 50-year-old patient treated with a rapid palatal expander anchored to 4 miniscrews.

DIAGNOSIS AND ETIOLOGY

This case report describes the treatment of an adult female patient with transverse deficiency and bilateral cross-bite. This study aimed to evaluate the

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Fig 1. Pretreatment extraoral and intraoral photographs.

dentoskeletal results obtained with a MARPE on 4 miniscrews, followed by fixed orthodontic treatment without orthognathic surgery.

The patient was a 50-year-old woman with Class III malocclusion; she reported no medical complications and no history of trauma. Facial analysis showed symmetry, balanced facial thirds, and a straight soft tissue profile. The maxillary dental midline coincided with the face midline, and the mandibular dental midline deviated 2 mm to the left (Fig 1).

Intraoral clinical examination and dental casts analysis revealed a transverse maxillary deficiency and bilateral cross-bite from the second molar to the canine on both sides (transverse discrepancy was −6 mm), a Class III right and left molar and canine relationship, an edge-to-edge overjet, and a 0-mm overbite. Maxillary and mandibular arch length discrepancies were 9 mm and 7 mm, respectively; maxillary intermolar and intercanine widths were 36 mm and 28 mm, and mandibular intermolar width was 42 mm (Figs 1-2).

The panoramic and cephalometric radiographs showed fillings on the maxillary and mandibular molars and the first premolars, endodontic treatment of the mandibular second molars, and left first premolar without periapical complications, impaction of the mandibular right third molar (Figs 3, *A* and *C*), and diffuse horizontal bone loss. The CBCT slice gave a clear view of the thin vestibular cortical bone (Fig 3, *D*).

The cephalometric analysis showed a Class I relationship with skeletal retrusion (SNB, 78°; SNB, 76°; ANB, 2°; Wits appraisal, −1.8 mm) and a normal vertical pattern (SN-GoGn, 34°). Maxillary incisors had a 110° inclination, and mandibular incisors had a lingual inclination (85°), as shown in Table I and Figure 3, *B*. Overjet and overbite were reduced. There was no clinical evidence of acute inflammation. Soft tissue examination revealed a flat gingival biotype with recession visible at the maxillary and mandibular cuspids and bicuspids and minor recession at the mandibular incisors (Fig 1).

A CBCT scan was used to assess midpalatal suture (MPS) maturation according to the classification by Angelieri et al.[16] Based on this method, the patient had a stage B maturation (Fig 4). The same CBCT scan was used to plan the placement of the miniscrews.

TREATMENT OBJECTIVES

The following treatment objectives were established: (1) Correct the posterior cross-bite and transverse

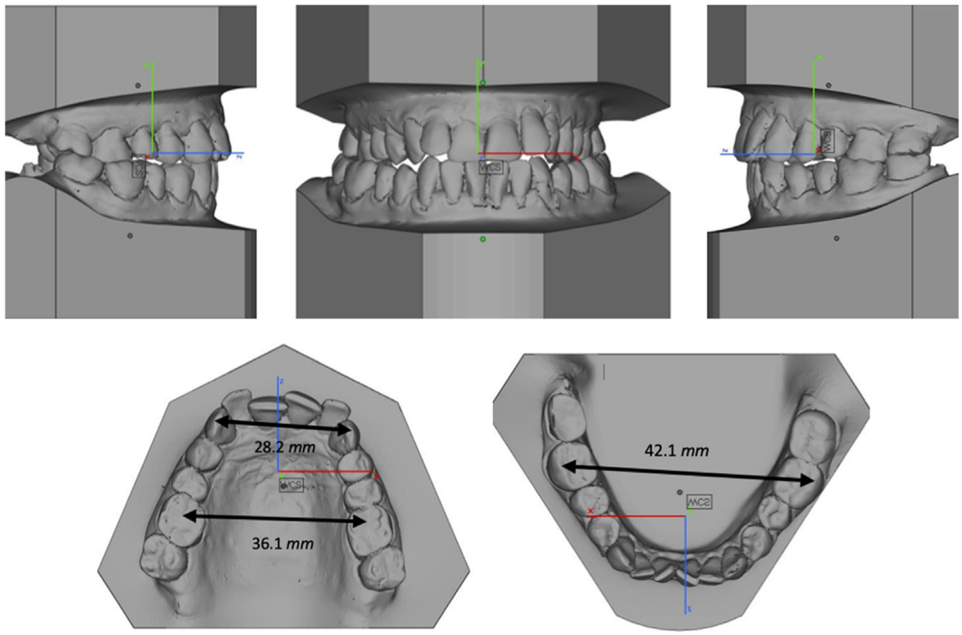

Fig 2. Pretreatment digital dental casts.

discrepancy through maxillary skeletal expansion without surgery. The goal was to achieve stable orthopedic correction, avoiding dental compensation and adverse effects on the maxillary teeth or dental bone. (2) Maintain the facial profile while improving smile esthetics and reducing black buccal corridors when smiling. (3) Achieve Class I molar and canine relationships. (4) Resolve the crowding and obtain the ideal overjet and overbite without incisor proclination. (5) Correct the dental midline deviation and obtain a stable occlusal relationship in the long term.

TREATMENT ALTERNATIVES

Surgically assisted rapid maxillary expansion is an effective method for treating severe maxillary transverse discrepancy and minimizing transverse maxillary relapse in skeletally mature patients. However, this approach involves invasive procedures, increased treatment costs and time, and the potential complications of a surgical procedure. We discussed this option with the patient, who refused it.

In patients with the mild skeletal discrepancy, nonsurgical compensation can be achieved with orthodontic tooth movement alone, using fixed appliances. However, the patient's periodontal status and the degree of transverse discrepancy would have increased the risk of undesirable dentoalveolar effects, root resorption, buccal cortex fenestration, gingival recession, and relapse.

We discussed these options with the patient and opted for the MARPE approach. Based on the literature, we believed that MARPE could optimize the results of fixed appliance therapy and provide an expansion force that separates the rigid midpalatal suture without surgery, resulting in optimal orthopedic correction and minimal tooth movement.

TREATMENT PROGRESS

A CBCT image of the maxilla was taken with a NewTom VGI EVO scanner (Imola, Italy) with a field of view of 8 cm × 12 cm. A standard triangulation language (STL) digital model of the initial maxillary dental cast was acquired with a 3-dimensional (3D) scanner (3Shape E3 scanner; 3Shape A/S, Copenhagen, Denmark), superimposed onto the CBCT (digital imaging and communications in medicine) files, and matched by the Easy Driver 3DRM-Resource Matching Software (Uniontech, Parma, Italy) (Fig 5, *A*). We identified the ideal insertion points for the miniscrews on the STL 3D model matched with the digital imaging and communications in medicine files. Two virtual miniscrews (2 × 9 mm, Benefit System; PSM Medical Solutions, Tuttlingen, Germany) were positioned in the anterior region on the palatal rugae, between the distal area of the canines and the distal area of the second premolars, aiming for bicortical anchorage; the other 2 miniscrews (2 mm × 11 mm) were placed in the interradicular space between the second premolar and the first molar. The placement site and

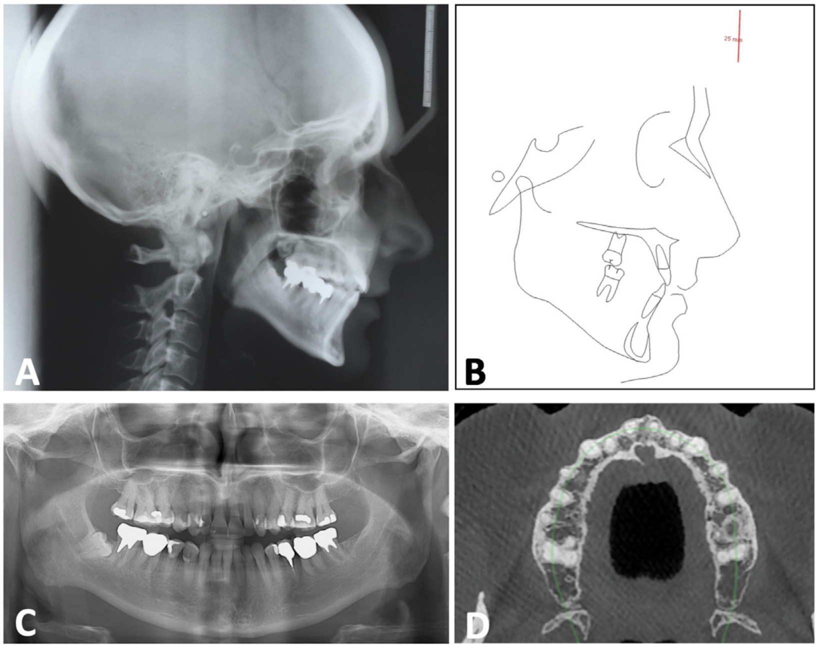

Fig 3. Pretreatment records: **A,** Lateral radiograph; **B,** Lateral cephalometric tracing; **C,** Panoramic radiograph; **D,** CBCT axial slice.

Table I. Pretreatment and posttreatment cephalometric measurements

Measurements	*Norm*	*Pretreatment*	*Posttreatment*
SNA (°)	82.0	78.2	80.4
SNB (°)	80.0	76.1	77.2
ANB (°)	2.0	2.1	3.2
Wits (mm)	0.0	−1.8	−1.2
Maxillary skeletal (A-Na perp.) (mm)	−1.0	−3.0	−1.5
Mandibular skeletal (Po-Na perp.) (mm)	−2.0	−6.5	−6.3
SN-GoGn (°)	34.0	34.3	34.3
SN-Palatal plane (°)	7.0	12.3	12.2
Palatal plane-GoGn (°)	20.0	22.2	22.4
L1-MP (°)	90.0	85.6	92.7
U1-PP (°)	110.0	110.0	112.2
U1 protrusion (U1-Apo) (mm)	6.0	2.9	4.5
L1 protrusion (L1-Apo) (mm)	1.0	0.2	1.3

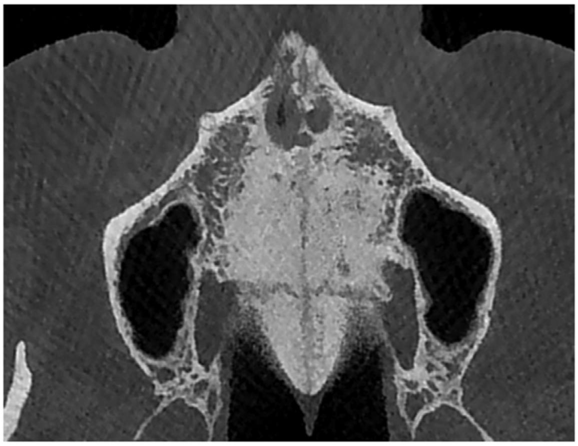

Fig 4. CBCT cross-section used for the midpalatal suture stage evaluation.

insertion angle were determined considering the bone width and thickness in the palatal vault and the distance between the tooth roots (Fig 5, *B*).

The same software was used to design 2 surgical guides, and the 3D STL model was printed using a 3D printer (Fig 6).

Uniontech Laboratory created a maxillary arch model with the miniscrew analogs in place. This model was used to make the expansion device (Fig 7, *A*). Both the model creation and analog application processes are patented by Uniontech.

Ortotec SRL dental technician laboratory (Udine, Italy) made a Hyrax expander using a 12 mm expansion screw (Leone SpA, Sesto Fiorentino, Italy). The anterior and posterior metal arms of the prefabricated expansion screw were bent to reach the heads of the miniscrews following the palatal curvature. They were then laser-

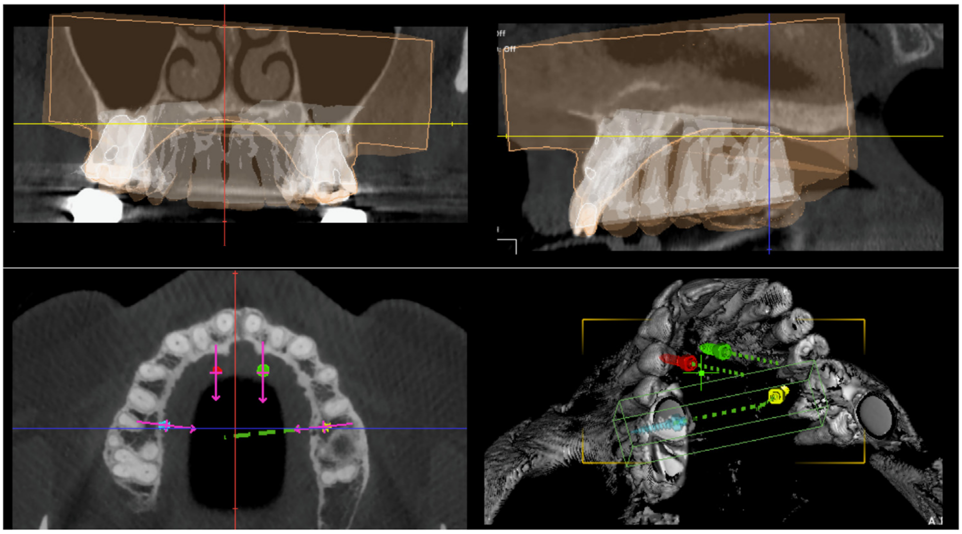

Fig 5. STL initial maxillary model superimposed onto the digital imaging and communications in medicine CBCT files. CBCT cross-sections show the palatal bone thickness and virtual position of the 4 miniscrews in the anterioposterior palatal plane.

Fig 6. Three-dimensional surgical guide printed used for correct miniscrew placement.

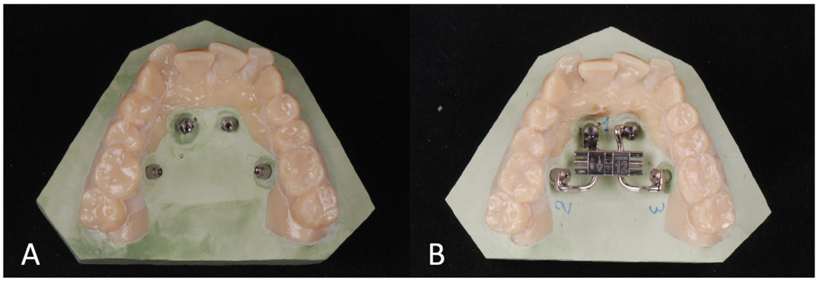

Fig 7. **A,** Maxillary arch model with the analogs of the screw position; **B,** Hyrax expansion device with a 12 mm expansion screw.

welded to 4 metal abutments designed to fit over the heads of the miniscrews and fixed in place with microscrews (Fig 7, *B*).

Before inserting the screws, the patient was rinsed with a 0.2% chlorhexidine solution. Local anesthesia was performed with 2% carbocaine with 1:100,000

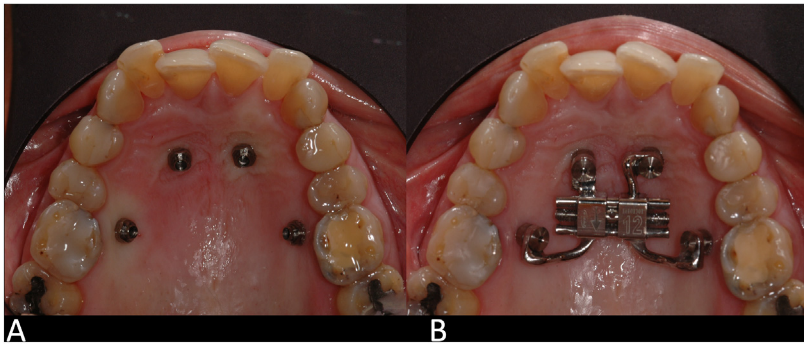

Fig 8. A, Miniscrews inserted into the palate after surgical guide removal; **B,** Miniscrew-assisted palatal appliance connected to the 4 miniscrews.

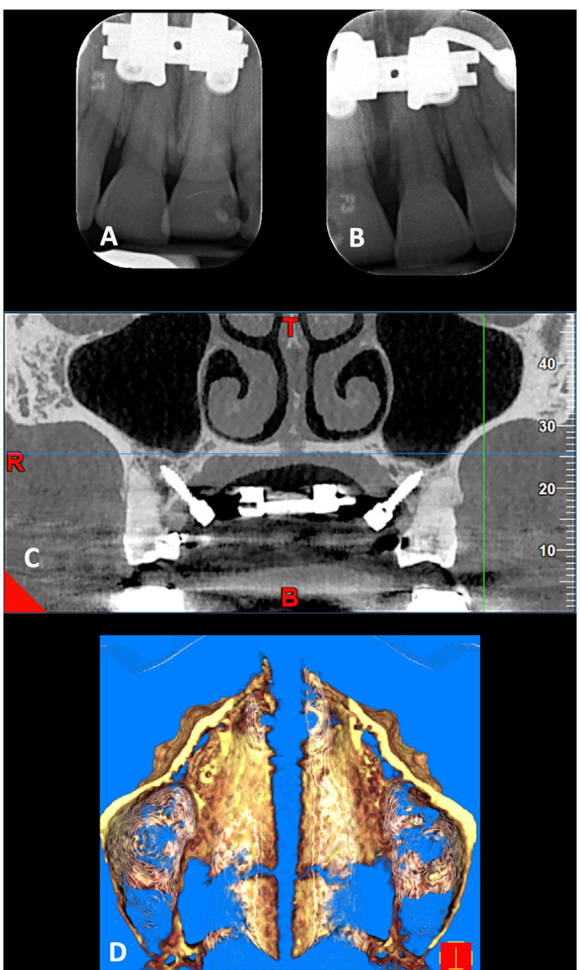

Fig 9. A, Periapical radiograph 2 weeks after activation; **B,** After midpalatal suture opening; **C** and **D,** CBCT imaging at the end of the expansion period.

adrenaline concentration. We used 2 surgical guides with preformed holes for cylindrical sleeves: 1 for the right anterior and left posterior screw and 1 for the left anterior and right posterior screw.

The surgical guide was first used to prepare the site and insert the miniscrews. Cylindrical sleeves were accurately positioned in the guide holes: 1 to accommodate the site-specific drill (1.4 mm in diameter) with vertical stops to control apicocoronal site preparation and 1 to accommodate specific pick-up drivers for the screws. The sleeves and surgical guides help control the angulation and depth of the miniscrew, as set by the computerized plan (Fig 8, *A*). During the same appointment, the maxillary expander was positioned and secured with fixation screws on top of microimplant heads (Fig 8, *B*)

A slow expansion protocol with a 40-day activation period was used to ensure optimal tissue adaptation and force distribution, as reported by Isaacson and Ingram[17] and Wehrbein and Yildizhan.[18] The activation protocol was one quarter of a turn (0.2 mm) once every 2 days for 2 weeks, after which the first periapical x-ray was taken (Fig 9, *A*), and the activation was modified to once a day; 33 total activations giving a total of 6.6 mm.

The midpalatal suture was split successfully, as shown by an intraoral periapical x-ray (Fig 9, *B*) and a CBCT performed right after the active phase of maxillary expansion and before the brackets were placed (Figs 9, *C* and *D*).

The appliance was held in place for the entire treatment period as a retention device (Fig 10, *A*). Before the fixed appliance treatment, a maxillary arch cast showed an intercanine, and a maxillary intermolar width of 33 mm and 40 mm, respectively (Fig 10, *B* and Table II), but the transverse discrepancy was still −2 mm.

At this point, a 0.022-in preadjusted edgewise appliance (Clarity; 3M Unitek, Monrovia, Calif) was bonded

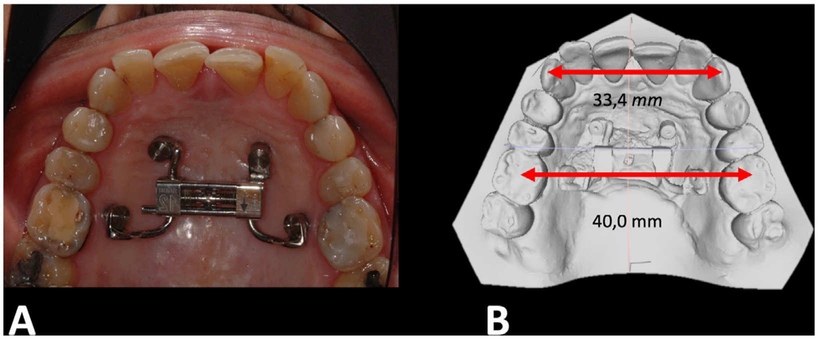

Fig 10. A, Hyrax in situ at the end of the activation period; **B,** Expansion obtained.

Table II. Pretreatment, postexpansion, posttreatment, and 1 y after removal of the palatal bar

Variables	*Pretreatment*	*Postexpansion*	*Posttreatment*	*1 y after bar removed*
Intercanine widths 3-3 (mm)	28.2	33.5	34.3	34.1
Intermolar widths 6-6 (mm)	36.1	40.0	42.3	42.1

Note. Intercanine and intermolar widths measured on maxillary digital dental casts.

directly to the teeth. A sequence of 0.014-in nickel-titanium (NiTi), 0.016-in NiTi, and 0.019 × 0.025-in NiTi continuous wires for the maxillary and mandibular arches were used during the alignment and leveling phase. The finishing stage was then completed with 0.019 × 0.025-in stainless steel archwires.

During this treatment period, 0.019 × 0.025-in NiTi and 0.019 × 0.025-in stainless steel archwires were used to achieve the optimum axial inclinations of the roots of all teeth and obtain the final dentoalveolar expansion.

TREATMENT RESULTS

The treatment was completed in 20 months. After removing the appliance, the posttreatment CBCT, panoramic radiograph, and cephalogram were taken with the MARPE appliance still in place (Fig 11).

The MARPE appliance was removed during the following appointment, and the anterior screw was used to create a transpalatal bar for retention (Fig 12). Maxillary and mandibular fixed lingual retainers were bonded to the anterior teeth, and a night-time removable retainer was placed on the maxillary arch. Finally, 2 final impressions were taken.

The cephalometric data revealed increased SNA (80°) and ANB (3°) and a decreased Wits index (−1 mm). Such results are in line with Song et al,[19] who demonstrated a downward and forward ANS displacement after MARPE. Table I shows that mandibular plane inclination remained relatively unchanged in relation to the anterior cranial base (SN-GoGn, 34°). This lack of mandibular rotation shows us how this type of expander can better control maxillary molar extrusion. Maxillary and mandibular incisors proclined slightly (112° and 92°, respectively; Table I and Fig 13).

A satisfactory occlusal outcome was achieved despite the patient's poor dental hygiene. The soft tissue facial profile was maintained, and the smile esthetics improved, allowing the patient to display a broad smile with good incisor exposure and narrow buccal corridors (Fig 12).

Posttreatment casts showed the correction of the maxillary transverse constriction and bilateral crossbite and achieved a Class I relationship (Fig 14). At the end of the fixed appliance treatment, maxillary intercanine and intermolar widths were 34 mm and 42 mm, respectively, with a 6 mm overall increase in both measurements (Table II).

The transpalatal bar was removed after 1 year, and an impression was taken after another 12 months. Figure 15 shows how expansion was maintained 1 year after the transpalatal bar was removed and 2 years after the end of treatment.

DISCUSSION

Complete ossification of the midpalatal suture was considered a limiting factor to the success of rapid palatal expansion, and surgery had long been the only option for orthopedic transverse correction in postpubertal and adult patients.[5]

Persson and Thilander demonstrated how the fusion of the midpalatal suture starts gradually in the posterior area, progresses anteriorly from the palatine bone, and varies considerably on the basis of the age and gender of the patient.[20] Other authors found that the fusion

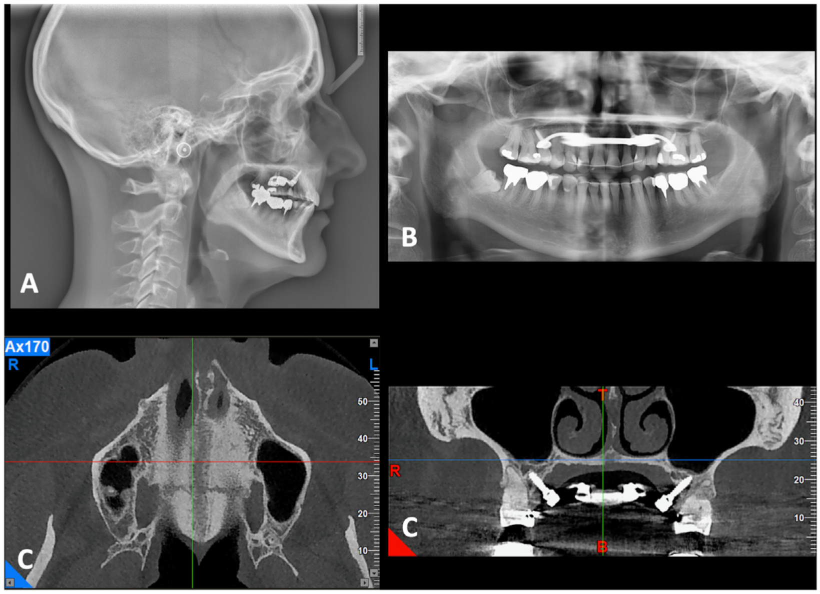

Fig 11. Posttreatment records. **A,** Lateral radiograph; **B,** Panoramic radiograph; **C,** CBCT axial slices.

Fig 12. Posttreatment extraoral and intraoral photographs.

of the midpalatal suture is not directly related to chronological age, particularly in late adolescents and young adults.[21]

Different maxillary skeletal expanders with palatal mini-implants have been developed in recent years, and the digital workflow has made the positioning of

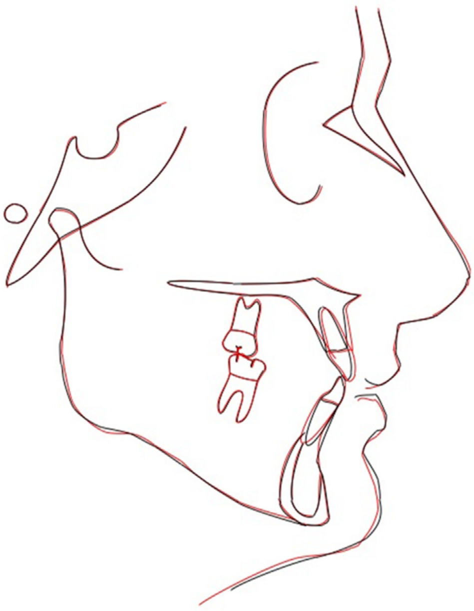

Fig 13. Posttreatment cephalometric tracing.

microimplants easier and safer. These bone-borne expanders (prefabricated and adapted to the implants or fully customized and 3D metal printed[15,22]) are positioned and secured with fixation screws on top of microimplant heads.

In 2013, Angelieri et al[16] introduced a method for assessing MPS maturation using CBCT images. We currently use this method to classify our patients. However, recent studies[23,24] have shown that it is heavily influenced by the sharpness and clarity of the postacquisition images and, therefore, has some limitations in routine clinical application.

We used 3D planning software to digitally plan the miniscrew ideal position; the software allowed for parallel placement and bicortical skeletal anchorage stability for the anterior miniscrews. Posteriorly, we decided to place the miniscrews between the second premolars and first molars in a coronal-apical direction to maximize bone support, ensure adequate force distribution in that area, and achieve the complete disjunction of the midpalatal suture.

Screw insertion was easy and painless. The patient reported discomfort and pressure in the palatal and nasal cavity areas during the activation protocol, probably because of soft tissue disruption.

Classic RME studies showed how midpalatal suture displacement is more significant in the anterior than the posterior area. This pyramidal shape results from different degrees of resistance along the suture.[3,4]

Postexpansion CBCT images revealed close to parallel maxillary suture splitting and bone expansion in type I palatal split pattern (ie, total MPS opening from the anterior to the posterior nasal spine[25] (Figs 9, *C* and *D*).

These results seem to be in agreement with previous studies. Garrett et al[26] and Lin et al,[27] in 2 different studies comparing tooth-borne vs bone-borne rapid maxillary expanders, found a triangular skeletal expansion pattern in tooth-borne expanders, with a wider base at the anterior portion of the maxilla, whereas the pattern was rather parallel in the bone-borne subjects, moreover transverse dimension, in bone-borne expander subjects increased almost twice as much at the skeletal level than did the tooth-borne.

MARPE has shown that total MPS opening is possible in postpubertal patients even without surgery. Positioning the 2 posterior miniscrews in the alveolar process may have provided adequate posterior force distribution and promoted complete midpalatal suture separation.[25] Similar findings have been reported by Cantarella et al[12,28]; however, the lack of proportionality in skeletal expansion in our case is attributable to the resistance of the pterygomaxillary junction and the zygomatic buttress.

The CBCT slices showed how the position and root torque of the maxillary teeth remained unaltered during the expansion period (Fig 16), maintaining the thin buccal bone covering the roots without resorption or gingival recession. During classic RME the force delivered produces compression of the periodontal ligament on the buccal surfaces of the supporting teeth. This can reduce the buccal bone plate thickness of supporting teeth from 0.6 mm to 0.9 mm.[29] Bone dehiscences can be induced on the buccal aspect of the anchor teeth, especially in questionable periodontium patients.

The postexpansion and posttreatment CBCT superimpositions showed no differences in transverse stability (Fig 17).

A comparison of the postexpansion and posttreatment CBCT images in relation to MPS mineralization showed that midpalatal suture ossification was still incomplete (Fig 18). This finding is inconsistent with the study on young patients by Arat et al,[30] which showed complete MPS remineralization and remodeling after 3 months. This discrepancy may be due to the patients' different ages. Sannomiya et al[31] reported that midpalatal suture remineralization might be delayed in older patients.

This means that the recommended protocol—keeping the expander in place for 6 months and a removable appliance for another 6 months—may be insufficient in adult patients. Therefore, we opted for a transpalatal bar fixed on the anterior screw for 1 year and an additional removable appliance.

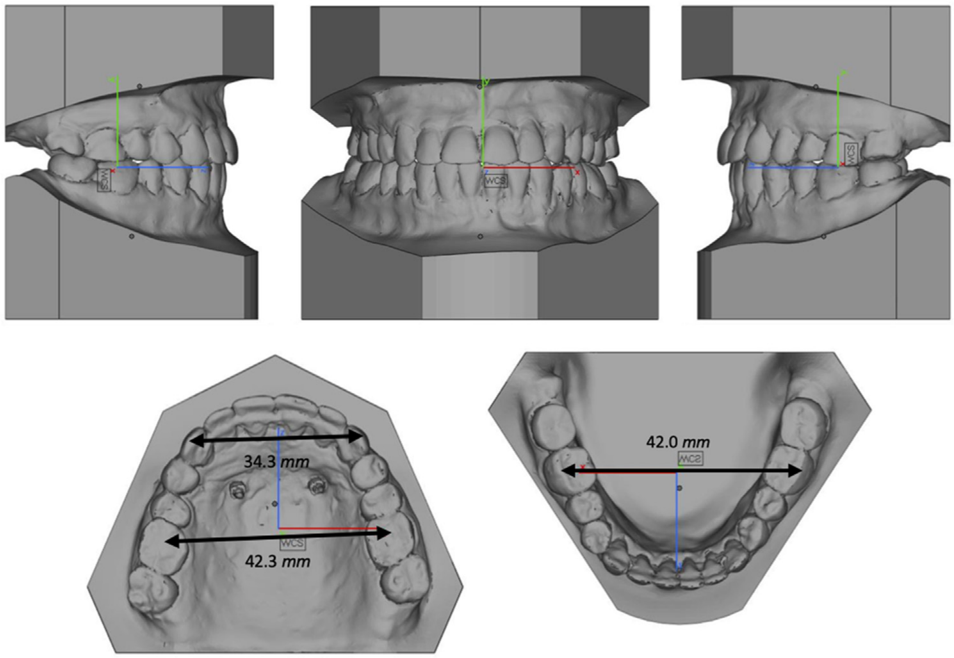

Fig 14. Posttreatment digital dental casts.

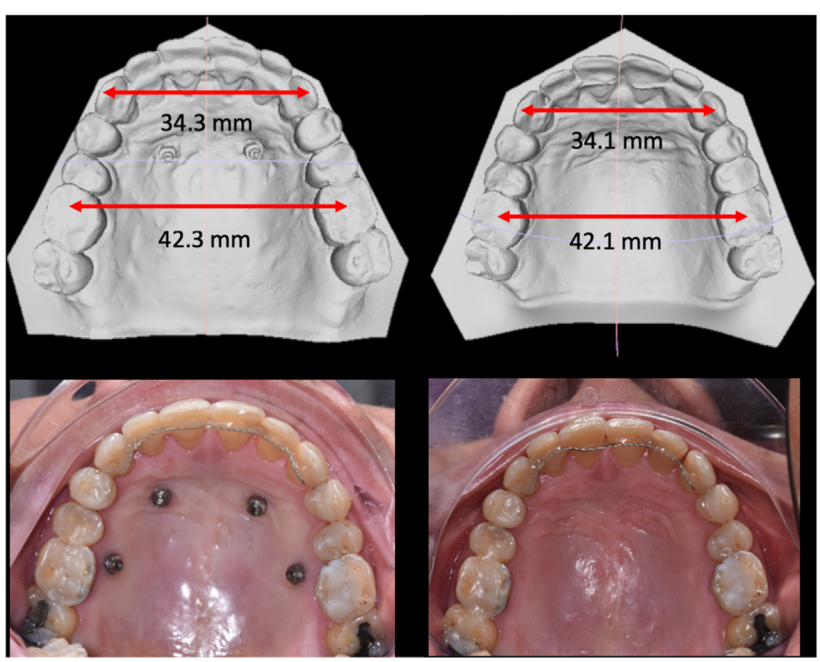

Fig 15. The expansion was maintained 1 year after the transpalatal bar was removed **(A)**, and 2 years after the end of treatment **(B)**.

SUMMARY AND CONCLUSIONS

Bone-borne appliances seem able to transmit forces directly to the maxillary basal bone through the miniscrew anchorage system, making them an alternative to tooth-borne appliances in adult patients. They can potentially avoid surgery, dental compensation, and adverse effects on the maxillary teeth or buccal cortical plate. Conventional retention protocols may be

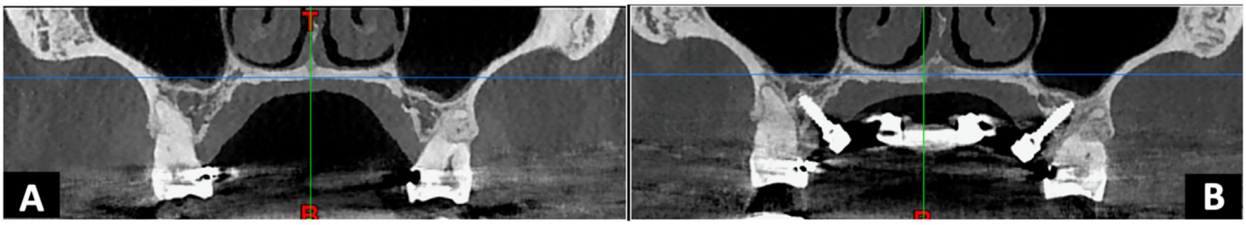

Fig 16. A and **B**, CBCT slices show the position and root torque of the maxillary teeth remained unaltered during the expansion period, maintaining the thin buccal bone covering the roots without resorption or gingival recession.

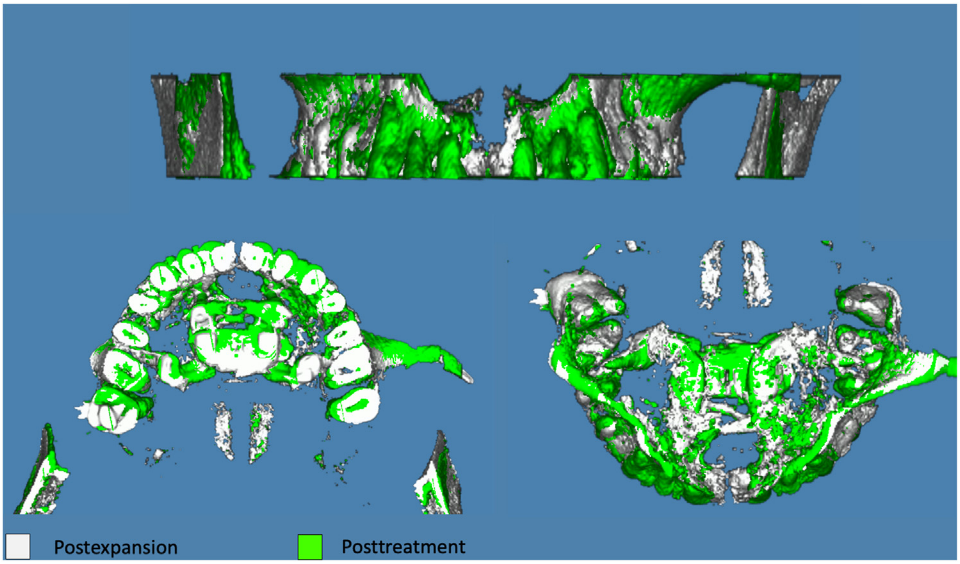

Fig 17. A and **B,** Postexpansion and posttreatment CBCT image comparison shows no differences in transverse stability

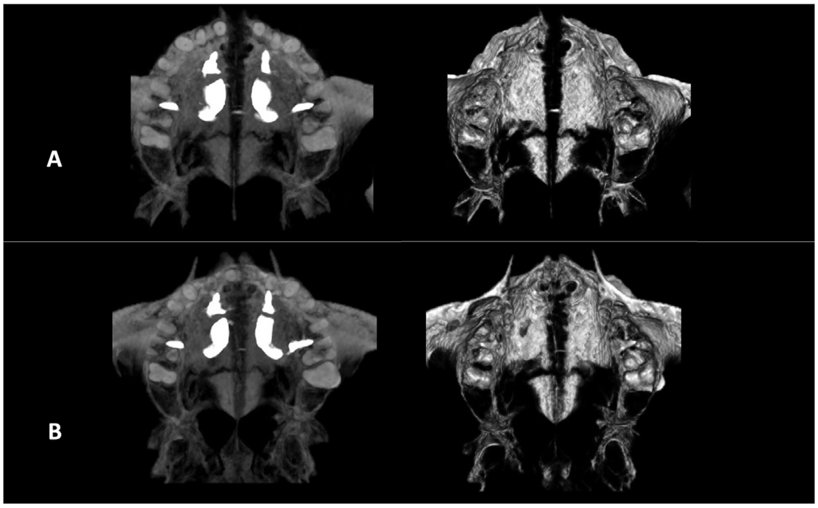

Fig 18. A and **B,** Postexpansion and posttreatment CBCT images show that midpalatal suture ossification was still incomplete.

insufficient for complete remineralization in adult patients; however, a fixed transpalatal bar has adequate stiffness to maintain the amount of skeletal expansion during the consolidation phase.

AUTHOR CREDIT STATEMENT

Michele Ceschi contributed to investigation, Riccardo Riatti contributed to software, Bruno Di Leonardo contributed to investigation, and Luca Contardo contributed to manuscript review and editing and supervision.

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