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Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult

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This case report describes the use of a microimplant-assisted rapid palatal expansion (MARPE) appliance to orthopedically correct a transverse maxillary deficiency in an adult patient. Expansion forces transmitted through the teeth in traditional rapid palatal expansion appliances create unwanted dental effects rather than true skeletal expansion, particularly in older patients with more rigid interdigitation of the midpalatal suture. This 19-year-old patient had maxillary constriction with a unilateral posterior crossbite. A MARPE appliance secured to the palatal bones with 4 microimplants was expanded by 10 mm. Pre-MARPE and post-MARPE cone-beam computed tomography cross sections demonstrated 4 to 6 mm of expansion of the maxillofacial structures, including the zygoma and nasal bone area, and widening of the circummaxillary sutures. Minor buccal tipping of the dentition was observed, but the integrity of the alveolar bone was preserved. This report demonstrates that careful design and application of the MARPE appliance can achieve successful transverse expansion of the maxilla and the surrounding structures in a patient beyond the age typically considered acceptable for traditional rapid palatal expansion. (Am J Orthod Dentofacial Orthop 2016;149:716-28)

Previous research has indicated that approximately 18% of mixed-dentition patients have a transverse maxillary constriction.[1] Traditionally, they are treated with rapid palatal expansion (RPE) techniques that rely on a combination of orthopedic and dental expansion to correct the skeletal disharmony.[2,3] Many types of RPE appliances have been developed[4-6] with different rates of expansion, but the principles are essentially the same.[7] By exerting a rapid transverse force on the maxillary dentition, the midpalatal suture is disrupted and separated, leading to increased cellular activity in that area that induces bone remodeling.[8] Because conventional RPE appliances by design transmit the expansion forces through the teeth, alveolar bone bending and dental tipping are inevitable, particularly in older patients. Such movements not only take up a significant portion of the total activation of the device, reducing the true skeletal expansion,[9] but also lead to clockwise rotation of the mandible and opening of the bite.[10]

Recently, microimplant-assisted RPE (MARPE) appliances that can localize the lateral forces to the midpalatal suture while minimally using the dentition have become available for treatment of transverse maxillary constriction in older patients.[7,11] However, the method to maximize the effects of the MARPE technique in clinical situations has not been thoroughly studied, and a standardized design or an expansion protocol has not been published. This case report illustrates the successful orthopedic correction of an adult before fixed orthodontic treatment. Elimination of the transverse skeletal discrepancy was achieved using a novel MARPE design and expansion protocol. Clinicians and researchers must continue to investigate the mechanism of successful MARPE treatment and establish an effective treatment protocol.

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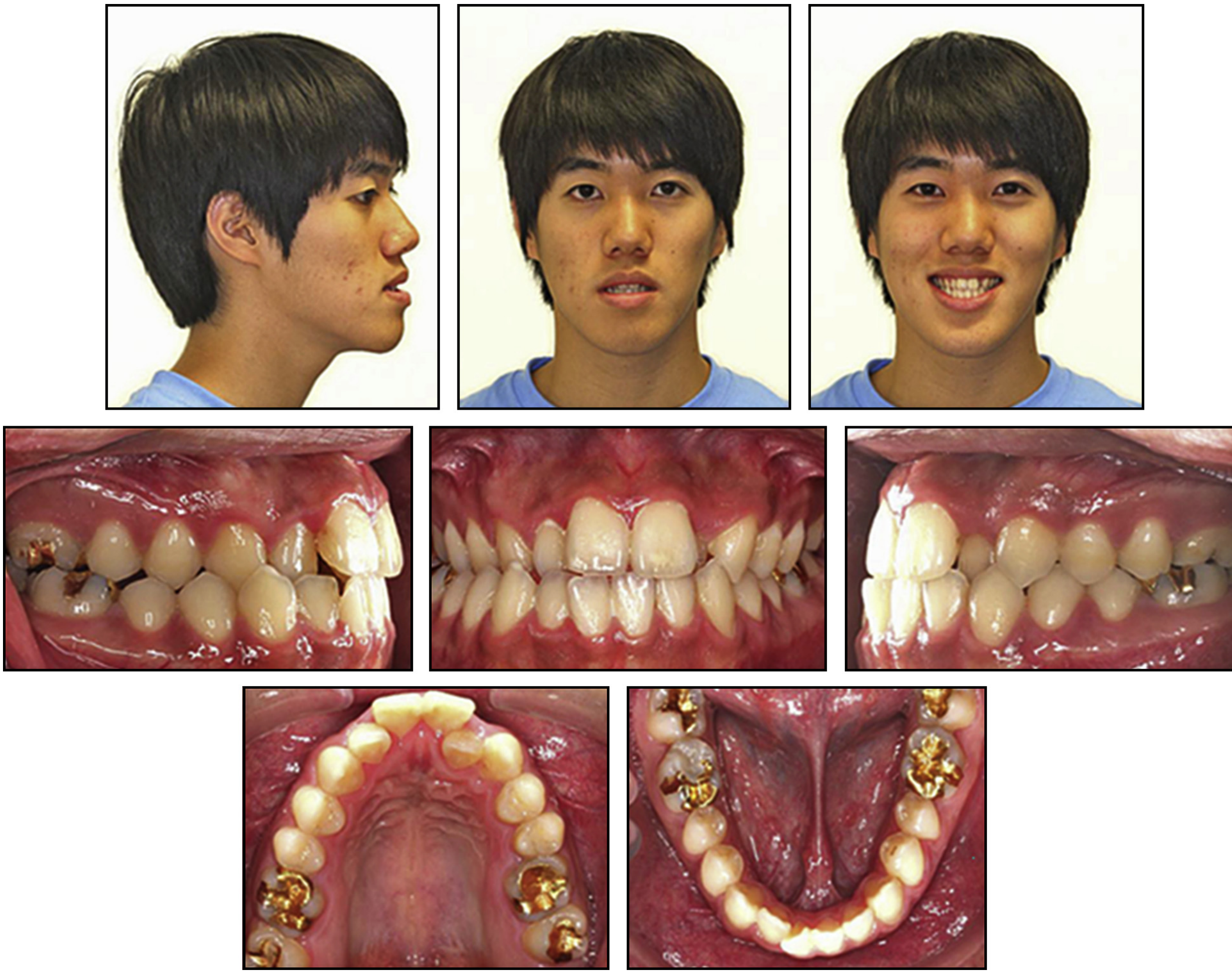


Fig 1. Initial facial and intraoral photographs.

DIAGNOSIS AND ETIOLOGY

A Korean man, 19 years 4 months of age, came to the orthodontic clinic at the University of California, Los Angeles, for consultation and screening (Figs 1-3). His chief complaint was "I have crowding in the front, and I am not happy with the arrangement of my teeth." He had 6 mm of arch width discrepancy measured by the distance between the first molars accompanied by a unilateral crossbite of the right posterior dentition as well as 3 mm of mandibular dental midline and chin deviation to the same side. There were crowding amounts of 7 mm in the maxilla and 3 mm in the mandible. He had already had numerous orthodontic consultations and wanted to avoid any form of orthognathic surgery. There was no history of a family predilection for a Class III skeletal growth pattern.

TREATMENT OBJECTIVES

The patient had a unilateral posterior crossbite with dental compensation caused by a skeletal imbalance (Fig 4). Since a harmonious occlusion could not be achieved with such a skeletal problem, the first objective of orthodontic treatment was orthopedic correction of the posterior crossbite, followed by fixed orthodontic treatment. Consistent with the amount of arch width discrepancy measured at the first molars, it was concluded that an increase of approximately 8 mm in the width of the basal structures was the goal for the expansion phase of this treatment. In this case report, we address mainly the effect of the expansion phase of treatment to highlight the importance of the MARPE protocol. These additional objectives of care were also included: (1) improve the facial profile and symmetry, (2) create ideal overbite

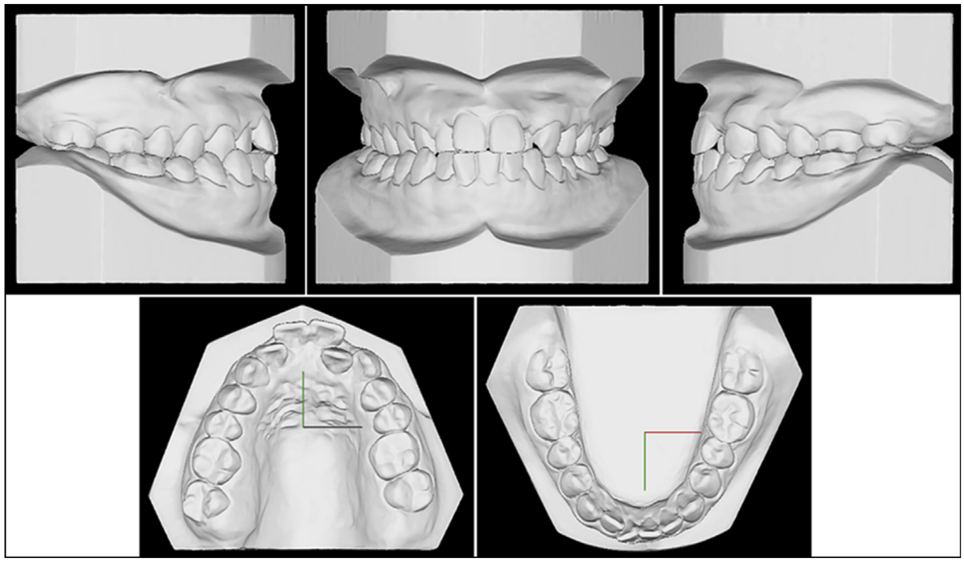


Fig 2. Initial study models.

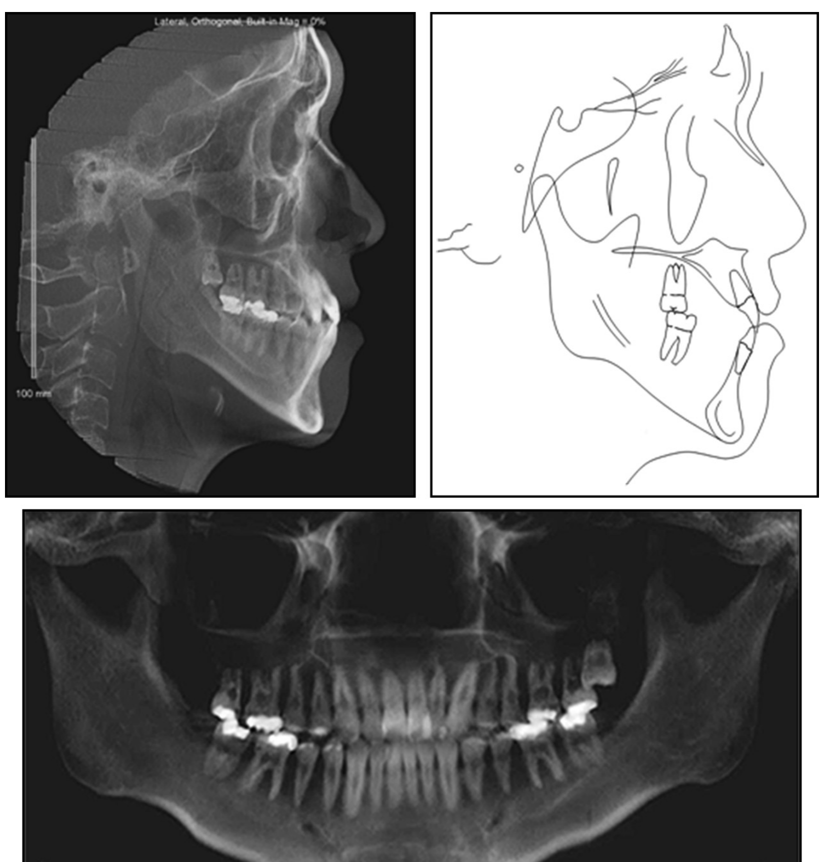


Fig 3. Initial orthogonal lateral cephalometric radiograph, cephalometric tracing, and panoramic radiograph.

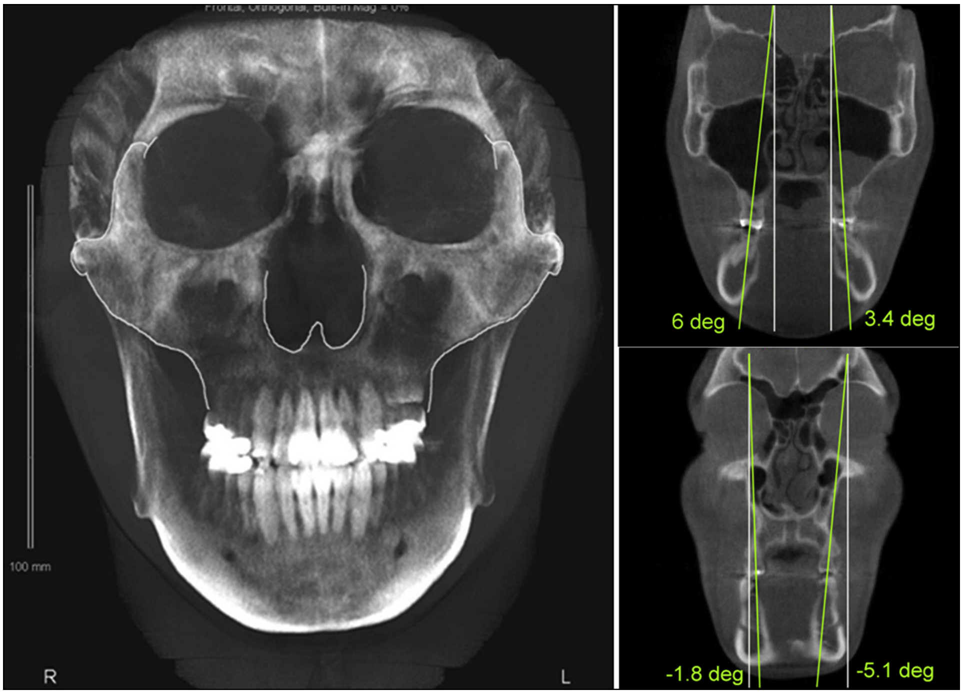


Fig 4. Initial posteroanterior orthogonal cephalometric radiograph and CBCT axial cuts showing the initial dentition angulation.

and overjet, and (3) improve the dental and skeletal relationships in 3 planes of space.

TREATMENT ALTERNATIVES

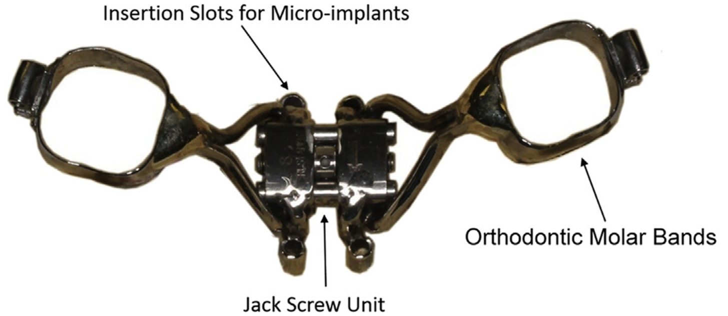
A common treatment modality for correcting an arch width discrepancy caused by a constricted maxilla is conventional RPE.[4-6] Because of the rigid, interdigitated form of the palate in adults, limited lateral and midline maxillary osteotomies can be combined with fixed palatal expanders for surgically assisted RPE.[12,13] Other surgical methods such as a 3-piece LeFort I osteotomy can also be considered, especially if there is a skeletal disharmony in the anteroposterior or vertical dimension.[14,15] However, these approaches involve more invasive procedures, with increased risks and costs for the patient.[16]

Another option was to treat the patient entirely with dental movement. It has been suggested that the arch dimensions can be significantly increased by using fixed orthodontic appliances with light forces and reduced friction.[17,18] However, such translational tooth movement and buccal bone remodeling have not been adequately described in previous studies.[19]

All options were discussed with the patient, and he chose the MARPE approach to reduce the costs and potential surgical risks. Based on previous patients treated in our clinic, we believed that MARPE could provide an expansion force that separates the rigid midpalatal suture without the need for surgery. Additionally, the risks and costs are minimal compared with the surgically assisted RPE approach.[20] In contrast to RPE, MARPE is advantageous because it directs expansion forces toward the midpalatal suture and away from the molars, resulting in more notable orthopedic correction and minimal tooth movement. An example of the MARPE appliance used for this patient is shown in Figure 5.

TREATMENT PROGRESS

The MARPE expander was delivered with 4 microimplants (1.5 × 11 mm) inserted in the 1.5 × 2-mm slots of the appliance. The insertion slots ensure a precision fit with the microimplants and guarantee that the microimplants are in a secured perpendicular position. The 11-mm length was chosen by considering the 2-mm height of the insertion slots, the 1 to 2 mm of space between the appliance and the palatal surface, the 1 to 2 mm of gingival thickness, and a desired 5 to 6 mm of bone engagement at a minimum. This was intended to promote the bicortical engagement of the microimplants into the palate. The size of the jackscrew was chosen based on the maximum screw size that would fit in the palatal vault, while still allowing close adaptation of



1. 2mm insertion slots for the MIs
2. Four MIs for force distribution and stability
3. 11mm MIs for bi-cortical engagement
4. Close adaptation of the Jack screw unit to the palate
5. Lateral force application against the buttress bone by placing the expander between maxillary first molars

Fig 5. Example of MARPE appliance design.

the appliance to the tissue surface between the maxillary first molars. This position was selected to apply lateral forces against the pterygomaxillary buttress bone, which is a major resistance factor in maxillary expansion.[21] The expansion rate was selected based on protocol developed by Dr Won Moon through clinical experience with the MARPE appliance and was adopted by the orthodontic clinic at the University of California at Los Angeles (Table I).

The activation started with 2 turns per day for the first 2 weeks until a diastema appeared; activation was stopped when the patient reported some discomfort in the palate and nasal cavity areas, and headache. The pain was resolved after a short discontinuation of the activation, and the activation resumed at a rate of 1 turn per day. After 10 mm of MARPE expansion and uprighting of the molars, 6 mm of expansion was gained at the maxillary first molars, and concomitantly 7 mm was achieved at the maxillary canines. The progress cone-beam computed tomography (CBCT) image was taken on the day that the expansion was completed. After 3 months to stabilize the expansion, the following were observed: (1) maxillary crowding was resolved, (2) the anterior crossbite was eliminated, and (3) the midlines were coincident (confirming the previously suspected functional shift).

Maxillary and mandibular fixed appliances were direct bonded to "idealize" the occlusion. A temporary anchorage device was placed between the maxillary right first and second premolars to slightly protract the maxillary right buccal segment. Finishing was completed with 0.017 × 0.025-in stainless steel archwires. The maxillary left third molar was then extracted (Fig 6).

Table I. Suggested expansion rates for different age groups

Age of the patient	*Initial expansion rate*	*Expansion rate after opening of the diastema*
Early teens	3 turns/week	3 turns/week
Late teens	1 turn/day	1 turn/day
Adults	2 turns/day	1 turn/day
Older patients (>30 years)	>2 turns/day	1 turn/day

TREATMENT RESULTS

When the expansion was done, the upper craniofacial structures, including the maxillary basal bone, were noticeably widened (Fig 7), leading to complete elimination of the crossbite. The preoperative and postoperative 2-dimensional radiographs and 3-dimensional CBCT images showed the observed expansion changes. The measurements show a relatively uniform increase in the width not only of the alveolar area, but also in the upper maxillofacial structures such as the zygoma and nasal bone (Table II; Fig 8). The first molars and premolars showed slight increases in buccolingual angulation (Table III). The effect of the expansion also measured on the dental casts showed an overall width increase of 6 mm in the maxillary arch that was maintained throughout the retention period (Fig 9). The patient finished treatment with Class I molar and canine relationships (Fig 10).

The anteroposterior and vertical position of the maxilla was relatively unchanged, as demonstrated by the overall superimposition. The mandibular plane

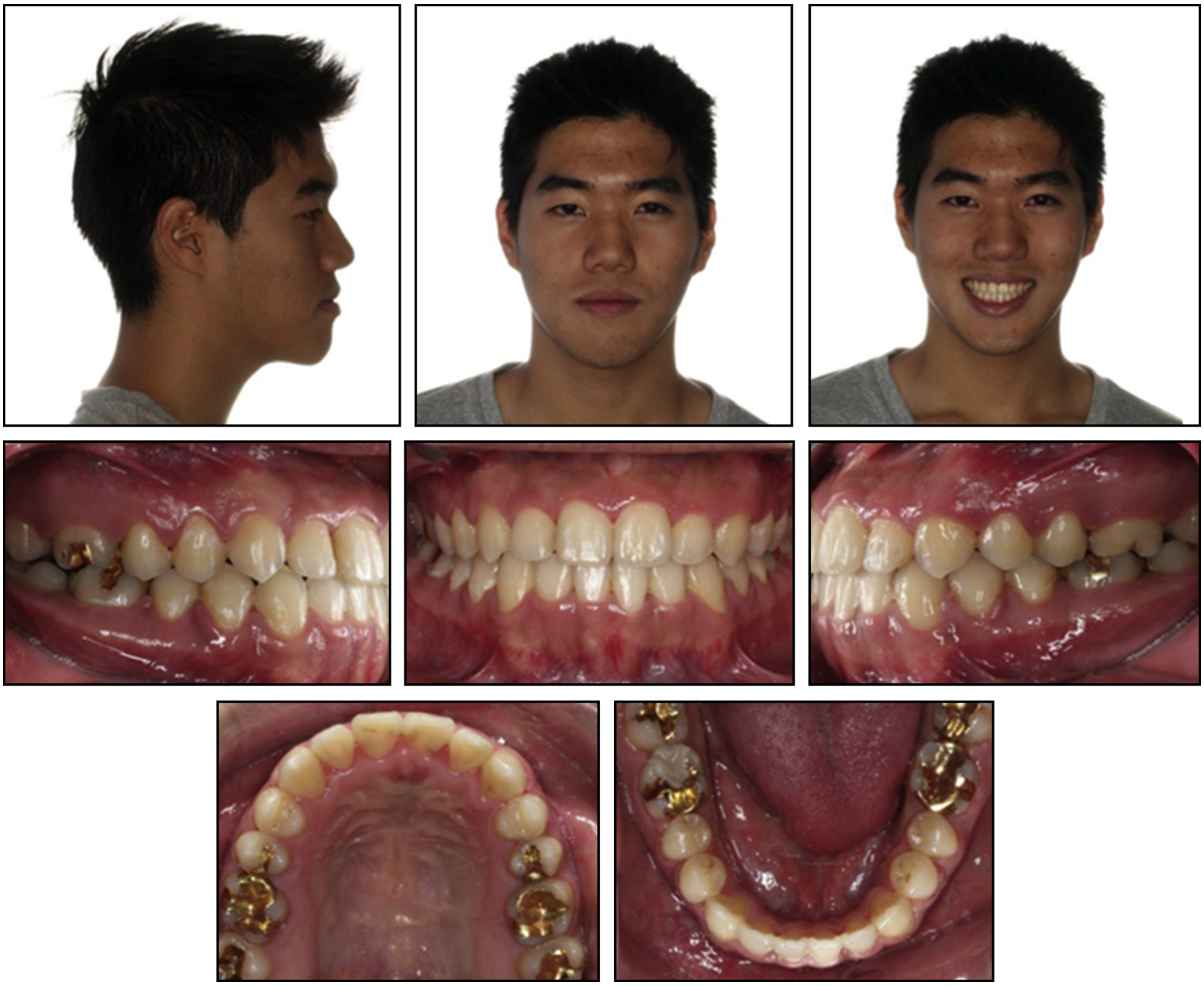


Fig 6. Final facial and intraoral photographs.

closed slightly from correction of the functional shift and removal of the interferences. As a result, it also came forward slightly with autorotation. The maxillary right first molar was protracted by approximately 1 mm by the temporary anchorage devices, but the vertical position was maintained (Fig 11; Table IV). The maxillary incisors remained slightly proclined, and the mandibular incisors were retroclined because of the slight Class III dental compensation, but the vertical positions of maxillary and mandibular posterior teeth were controlled adequately.

Although there was thinning of the buccal plates, there was still coverage of the maxillary first molar roots even after expansion. This can be seen in the both the posteroanterior cephalogram and the coronal slices (Fig 8). The patient has been in retention for approximately 5 months, and the transverse dimension is still stable. At age 21 years the patient showed no sign of mandibular growth on the superimposition, so fears that he may outgrow the treatment should be allayed. Most notable were the amounts of expansion seen in the zygomatic arch, nasal cavity, and nasal floor areas as shown in the 3-dimensional superimposition slices.

The maxillary intermolar width was increased by 6.0 mm, and the maxillary intercanine width was increased by about 7.0 mm. The mandibular intermolar width was increased by 0.5 mm, and the mandibular intercanine width was increased by about 1.0 mm. All dental and skeletal objectives were achieved, and a satisfactory occlusal outcome was obtained. Minimal flattening of the contact areas interproximally between the mandibular anterior teeth was accomplished to improve the long-term stability of the dentition. A

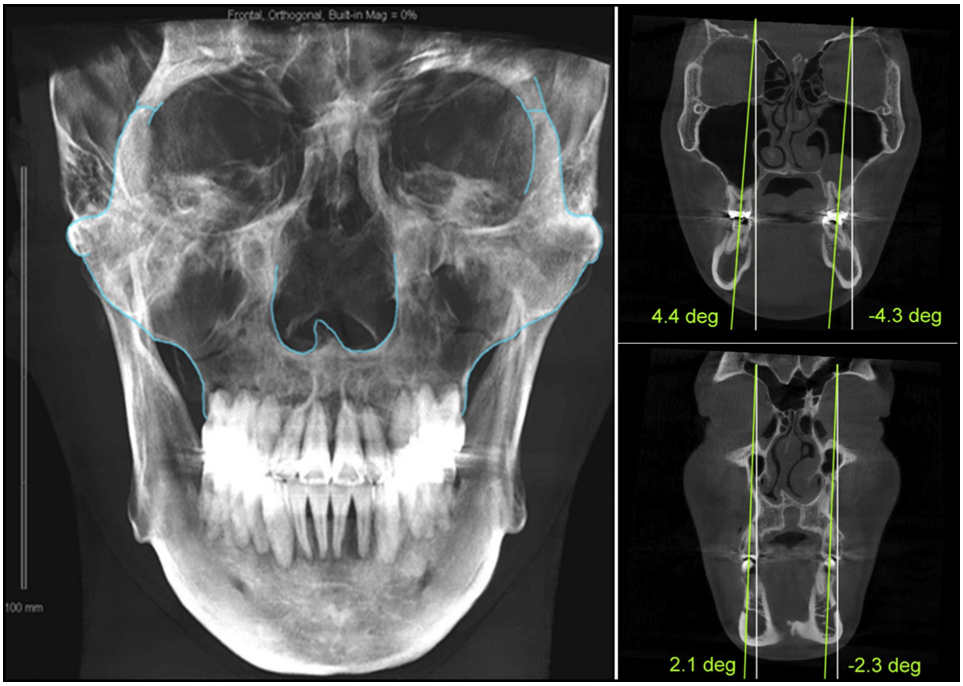


Fig 7. Final posteroanterior orthogonal cephalometric radiograph and CBCT axial cuts showing initial dentition angulation.

Table II. Widths at various anatomic sites

Width	*Initial (mm)*	*Removal of the expander (mm)*	*Gain of width (mm)*	*Final (mm)*	*Gain of width (mm)*
Basal bone	59.7	65.8	6.1	65.8	6.1
Zygomatic bone	110.3	116.0	5.7	114.7	4.4
Nasal cavity	29.9	33.7	3.8	33.7	3.8

bonded mandibular canine-to-canine retainer and a maxillary removable acrylic wraparound retainer were used for retention. The patient's profile has been maintained and the overall esthetics improved. The patient has a nice broad smile, and the dark buccal corridors were eliminated (Fig 12).

DISCUSSION

Various types of RPE appliances, including hyrax and Haas expanders, are available.[4-6] Whereas the literature frequently supports the use of RPE in younger patients,[22] palatal expansion in nongrowing patients has been shown to be less successful because of maturation of the midpalatal suture and adjacent articulations,[23-26] resulting in greater resistance to mechanical forces.[27] This can be associated with the previously documented disadvantages of traditional tooth-anchored appliances, including tipping of the anchored teeth,[28] limited skeletal movement,[29] undesirable tooth movement,[30] root resorption,[31] and postexpansion relapse.[32]

Tipping of the teeth is a particular concern for this patient because of his already compensated maxillary dentition. Further tipping of the teeth would compromise function and impact the structural integrity of the periodontium. This potential risk of tooth-borne appliances has been recognized in the literature and linked to resorption of buccal cortical bone, fenestrations, and gingival retraction.[33]

Evaluation of the postexpansion records demonstrated an extremely successful MARPE protocol, especially when it is considered that the patient was 19.5 years old at the time of treatment. Authors of a recent systematic review conducted on patients 6 to 14.5 years old concluded that expansion of the midpalatal suture area and the nasal cavity area ranges from 20% to 50% and 17% to 33% of the total screw expansion, respectively.[21] In our patient, there was a relatively uniform expansion of the zygoma and the maxilla, measured as 3.8 to 6.1 mm of expansion at the midpalatal suture and the nasal bone area; this amounted to 38% to 61% of the screw expansion. This is considered an extremely effective expansion compared with previously reported results in younger patients.

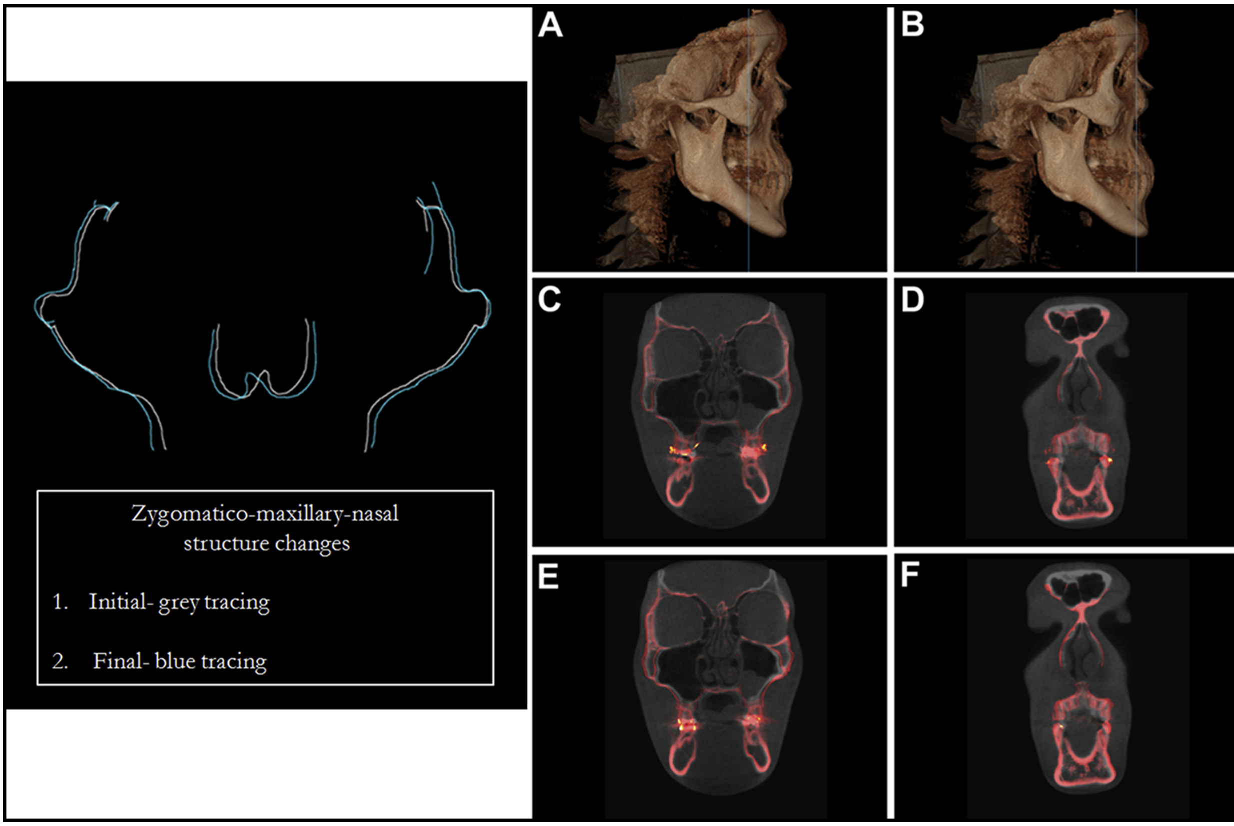


Fig 8. Three-dimensional superimposition: Cross-sectional planes through **A**, the first molar and **B**, nasion for the comparison of treatment outcome (*red*) with the initial record (*gray*). **C** and **D**, at the removal of the expander; **E** and **F**, at the completion of the treatment.

Table III. Angulation of the first molars and first premolars measured to the vertical line

	Initial (°)	*Removal of the expander (°)*	*Change of angulation compared with initial (°)*	*Final (°)*	*Change of angulation compared with initial (°)*
Right first molar	6	7.1	1.1	4.4	−1.6
Left first molar	3.4	2.6	0.8	−4.3	−7.7
Right first premolar	−1.8	3.4	5.2	2.1	3.9
Left first premolar	−5.1	−3.7	1.4	−2.3	2.8

It has been a consensus for many years that age is a primary factor in the success of palatal expansion, based on the idea that palatal expansion rapidly becomes inefficient after the early teens.[2,34,35] For this reason, it was previously believed that surgery was the only option for orthopedic transverse correction after adolescence.[7] A few studies[6,35] have shown successful expansion in adults, but there were doubts about whether they represented general clinical situations.[36] Contrary to the strong belief that nonsurgical palatal expansion is impossible in adult patients, the treatment result of our patient shows a clear skeletal expansion, and it was verified by precise measurements and comparisons based on CBCT images and models. Furthermore, a careful design and expansion protocol with MARPE also resulted in the notable expansion of the higher maxillofacial structures. This notable expansion is a sign of successful orthopedic correction because it is thought that the rigidity of the facial skeleton was the reason for the previous failures of nonsurgically assisted RPE.[37-39]

There have also been reports about increases in nasal cavity volume, nasopharynx volume,[40] and cross-sectional areas of the upper airway as a result of RPE.[41] The mean ages of the subjects in these studies were 12.3 and 12.9 years, respectively. These studies agree with earlier research that reported the widening of the nasal cavity after RPE in patients from 9 to

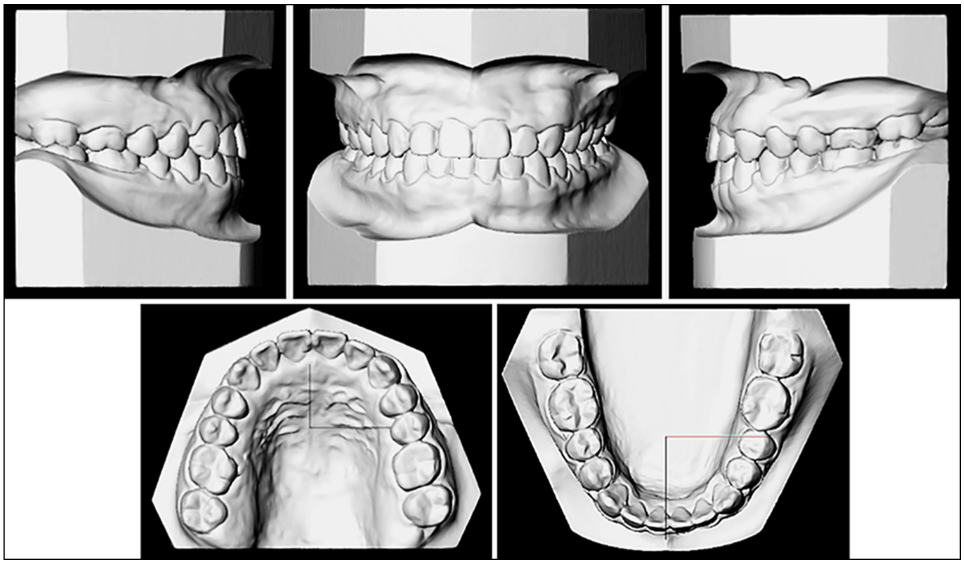


Fig 9. Final study models.

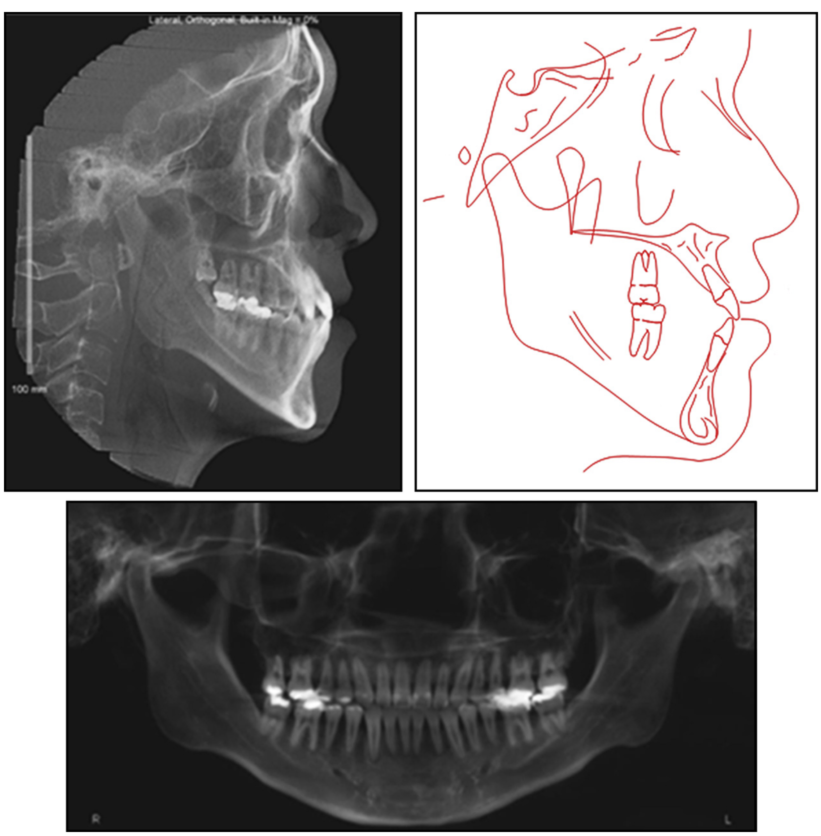


Fig 10. Final orthogonal lateral cephalometric radiograph, cephalometric tracing, and panoramic radiograph.

Fig 11. Overall superimposition, maxillary superimposition, and mandibular superimposition.

Table IV. Cephalometric assessment

Measurement	Pretreatment	Posttreatment	Change
SNA (°)	86	86	0.0
SNB (°)	85	86	1.0
ANB (°)	1	0	1.0
SN-MP (°)	37	36	1.0
FMA (°)	33	32	1.0
Upper 1 to SN (°)	109	110	1.0
Upper 1 to NA (mm)	7	7	0.0
Lower 1 to NB (mm)	7	5	2.0
Lower 1 to MP (°)	80	78	2.0
Upper lip to E-plane (mm)	−4	−4	0.0
Lower lip to E-plane (mm)	2	2	0.0

18 years old.[42] A more recent MARPE case report provided a clear picture using measurements from computed tomography.[37] It has been reported that the use of RPE and an increase in nasal cavity volume were observed with improvements in nasal respiration in patients 9 to 16 years old.[43,44]

The radiographic findings in this case report show the widening of the entire nasomaxillary complex and reaffirm the observations in previous expansion studies. It can therefore be reasoned that the effects on the airway can be replicated in older patients with the current MARPE treatment.

One notable problem caused by a nasomaxillary deficiency is mouth breathing,[45] and previous studies have demonstrated that orthopedic expansion can change the breathing pattern to nasal breathing.[46,47] Mouth breathing is often an etiologic factor leading to a constricted maxilla.[48-51] By effectively increasing the nasal cavity volume, MARPE treatment can improve the constricted airway and facilitate nasal breathing. These changes may in turn help with the long-term stability of the expansion.

Authors of a previous report found thinning of the buccal alveolar bone in the regions of the maxillary first premolar and first molar as a result of conventional RPE in patients with a mean age of 13.9 years, although the change was reversible over time.[52] The thickness of the buccal alveolar bone in our patient was maintained (Fig 8).

Dental tipping in the buccal direction has been reported in previous studies of conventional RPE[53] and MARPE.[11] The posttreatment results for this patient showed that the buccal tipping of the teeth was controlled and had a negligible effect because it could be decompensated by orthodontic treatment. This change may be the result of buccal tipping of the teeth or wedge-shaped expansion caused by the design and forces exerted by the expander. The change in inclination was minimized because the MARPE appliance is a rigid body, and the force is designed to be exerted on the bone through the microimplants before the teeth are affected. In this design, tipping of the microimplants can still occur to a certain extent because of the small gap between the microimplant and the interior surfaces of the insertion slots. A portion of the change in inclination is also likely due to the bodily rotation of the maxillary structure on each side.[8] Buccal rotation or bending

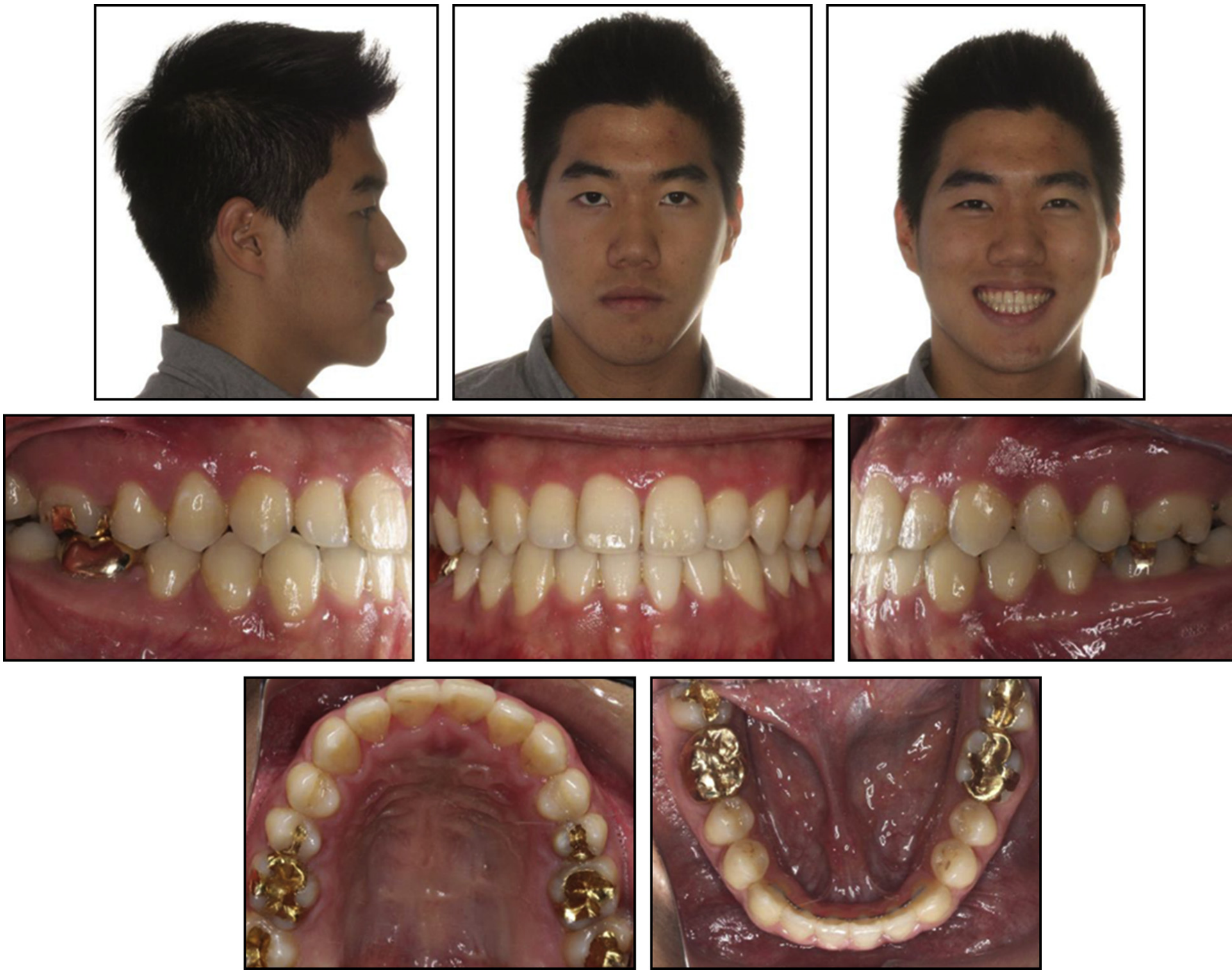


Fig 12. Facial and intraoral photographs after 7 months in retention (2 years 8 months postexpansion).

of the segments occurs throughout the arch, but the amount is greater from posterior to anterior.[9] This is most likely the reason for dental tipping in expansion patients even without tooth anchorage and may also explain the angulation changes of the molars and premolars.[11]

Although different types of MARPE appliances have been studied and analyzed, previous studies have not provided detailed descriptions of how the microimplants are fixated, and the expansion protocol was not well defined.[54]

This case report is unique for the following reasons: (1) the appliance design was thoroughly described and explained, (2) the expansion protocol was established, (3) MARPE was used in an older patient, (4) large orthopedic effects on the maxilla and the surrounding bones were illustrated, and (5) CBCT was used for better analysis and understanding.

This patient had a particularly successful expansion in terms of the gain in transverse width and the range of effects seen in the nasomaxillary structures with relatively minor dental effects. The unique design of the MARPE summarized in Figure 5 and the expansion protocol detailed previously may be the main contributing factors for the successful outcome.

CONCLUSIONS

This case report demonstrates the successful treatment of an adult patient with a constricted maxilla and a posterior crossbite using a novel MARPE design and expansion protocol. In addition to separating the midpalatal suture without surgery, the MARPE protocol resulted in expansion of the maxilla and the surrounding craniofacial structures. The circummaxillary sutures were opened, and the surrounding craniofacial structures including the zygoma and the nasal bone were widened. Although orthopedic correction in older patients is generally not accepted as an achievable goal in nonsurgical treatment, this case shows even more effective expansion than in previous reports on younger patients. Further studies should be conducted to demonstrate the effectiveness of this treatment approach across a variety of patient demographics. With reduced costs and far fewer risks than alternative treatment options, this novel MARPE design and protocol offer great promise for the future of nonsurgical orthopedic expansion in adult patients.

Supplementary materials for this case report include American Board of Orthodontics (ABO) Case Management Form, ABO Discrepancy Index, and ABO Cast-Radiograph Evaluation. For more information on these forms, visit www.americanboardortho.com.

All treated orthodontic cases have some deficiencies and may not conform to exact ABO specifications. This case is an example of a successfully completed case at the ABO clinical examination. The ABO does not support or endorse any treatment techniques or modalities, and there may be alternative methods, treatment plans, and mechanics that could have been used to achieve similar results. The Discrepancy Index, Cast-Radiograph Evaluation, and Case Management forms were scored by the examinee and not verified by the ABO.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ajodo.2015.04.043.

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