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Bidimensional dentoalveolar distraction osteogenesis for treatment efficiency

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This case report describes the treatment of a 16-year-old girl with a unilateral posterior buccal crossbite, a unilateral Class II molar relationship, and a maxillary right canine high in the labial sulcus. The treatment plan included surgically assisted unilateral maxillary expansion for the correction of the buccal crossbite, with simultaneous dentoalveolar distraction of the maxillary right canine into the extraction space of the first premolar aided by skeletal anchorage. Reduced orthodontic treatment time was facilitated by these 2 surgical procedures. A pleasing esthetic result and a good functional occlusion were achieved in 13 months. (Am J Orthod Dentofacial Orthop 2013;144:290-8)

Distraction osteogenesis is a bone-lengthening procedure that became popular after the extensive work by Ilizarov.[1] It was first performed in the human mandible by Guerrero[2] and McCarthy et al.[3] Since then, it has been applied to various bones of the craniofacial region for correction of skeletal malformations.[4]

First premolars are the most commonly extracted teeth for orthodontic purposes. Retraction of the canine into the extraction space is typically the second phase of orthodontic treatment, after the leveling and aligning phase. It has been reported that patients who undergo premolar extractions have prolonged treatment times.[5,6]

With more adults opting for orthodontic treatment in the last decade, various attempts have been made to reduce the total treatment time and increase the efficiency of orthodontic treatment.[7-13] To accomplish this, Liou and Huang[12] proposed distraction of the periodontal ligament fibers during orthodontic tooth movement; this elicited rapid canine retraction in 3 weeks. According to the authors, the process of periodontal ligament distraction is similar to distraction osteogenesis in the midpalatal suture. The main drawback of the technique was that once canine retraction was completed, the new bone tissue distal to the lateral incisors was still too fibrous to retract the anterior teeth; thus, treatment progress was delayed by the consolidation and secondary mineralization process. To overcome this problem, Kisnisci et al[9] and Iseri et al[8] described the technique of dentoalveolar distraction in which osteotomies surrounding the canines are made to achieve rapid movement of the canines through the dentoalveolar segment, according to the principles of distraction osteogenesis.

Because of increased resistance of the midpalatal suture toward separation in a skeletally mature patient under an orthopedic load,[14] surgically assisted rapid maxillary expansion has been recommended for correction of the maxillary transverse dimension[15]; it is now considered a form of distraction osteogenesis.[16] Although posterior maxillary subapical osteotomy with immediate repositioning of the segment in the desired position has been proposed for transverse correction of isolated unilateral posterior crossbite,[17,18] the stability of this procedure might be compromised.[16] Using the principles of distraction osteogenesis, Swennen et al[16] recently described how a posterior maxillary subapical osteotomy can be used to correct a unilateral posterior crossbite.

In this case report, we want to demonstrate how dentoalveolar distraction performed in 2 directions can simultaneously correct malocclusion in both planes of space and reduce the total treatment time for a patient in the late adolescence.

DIAGNOSIS AND ETIOLOGY

A 16-year-old African American girl came to the orthodontic clinic at the University of Connecticut with a

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Fig 1. Pretreatment facial and intraoral photographs.

chief complaint of irregular teeth in the maxillary front region of the jaw. Her medical history was noncontributory, and the temporomandibular joint examination was normal with no mandibular shift.

The pretreatment facial examination showed an orthognathic soft-tissue profile (Fig 1). The ratio of lower anterior facial height to upper anterior facial height and the ratio of lower facial height to throat depth were within normal limits. The nasolabial angle and the lip protrusion were within normal limits. The interlabial gap was 2 mm, and 100% of the occlusogingival length of the maxillary incisors was visible upon smiling. The maxillary and mandibular dental midlines were deviated to the right by 1 and 2 mm, respectively, from the facial midline.

The intraoral examination showed that the patient had a full complement of teeth except for the third molars (Figs 1 and 2). The molar relationships were Class I on the left side and full-cusp Class II on the right side. The maxillary right buccal segment and the lateral incisor was in complete lingual crossbite, and the maxillary canine on right side was highly placed in the labial sulcus. The mandibular dental arch was well aligned without crowding or spacing. The mandibular first molars had excessive labial crown inclinations. The patient had an overbite of 2 mm and an overjet of 3 mm (Fig 3).

The cephalometric analysis showed a mild skeletal Class II relationship (ANB angle, 5°) with a slightly increased mandibular plane angle (SN-Go-Gn angle, 34°), and proclined maxillary incisors (U1-NA, 12 mm/28°) and mandibular incisors (L1-NB, 16 mm/40°) (Table).

The patient was diagnosed with a skeletal and dental Class II subdivision right malocclusion with a slightly prognathic maxilla, moderate maxillary crowding, and a unilateral posterior crossbite on the right side.

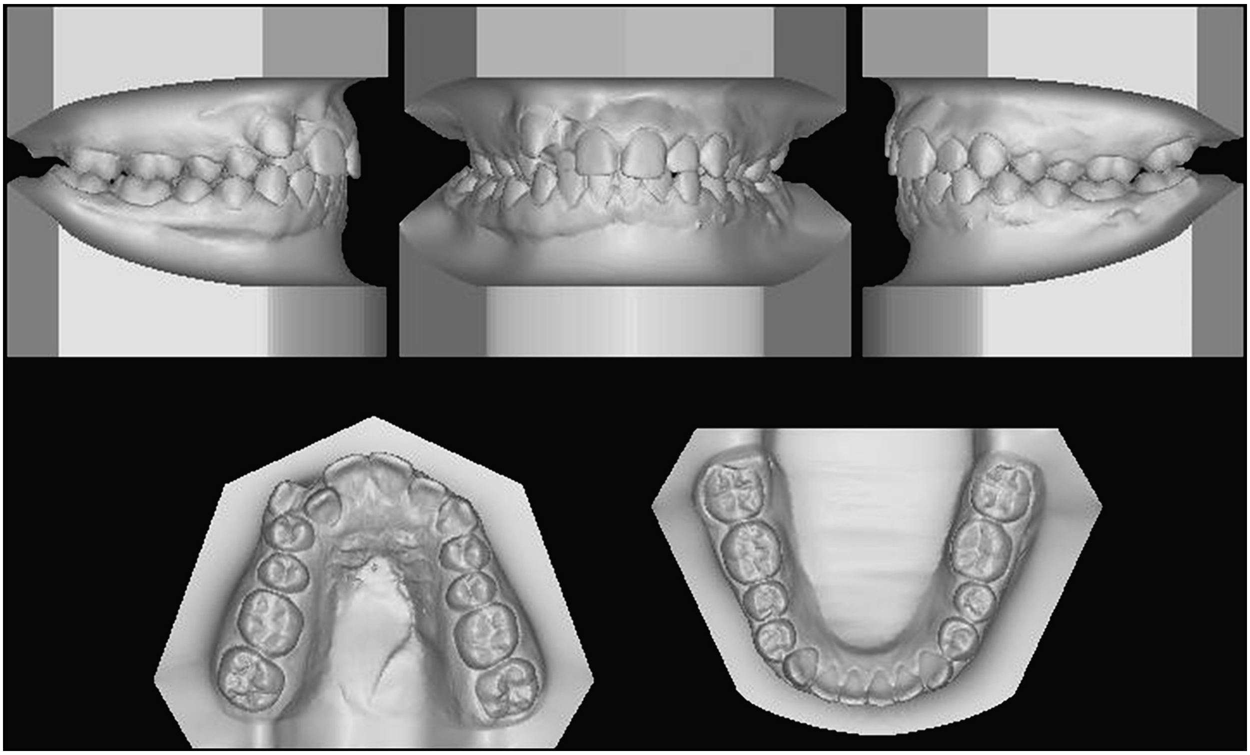

Fig 2. Pretreatment dental casts.

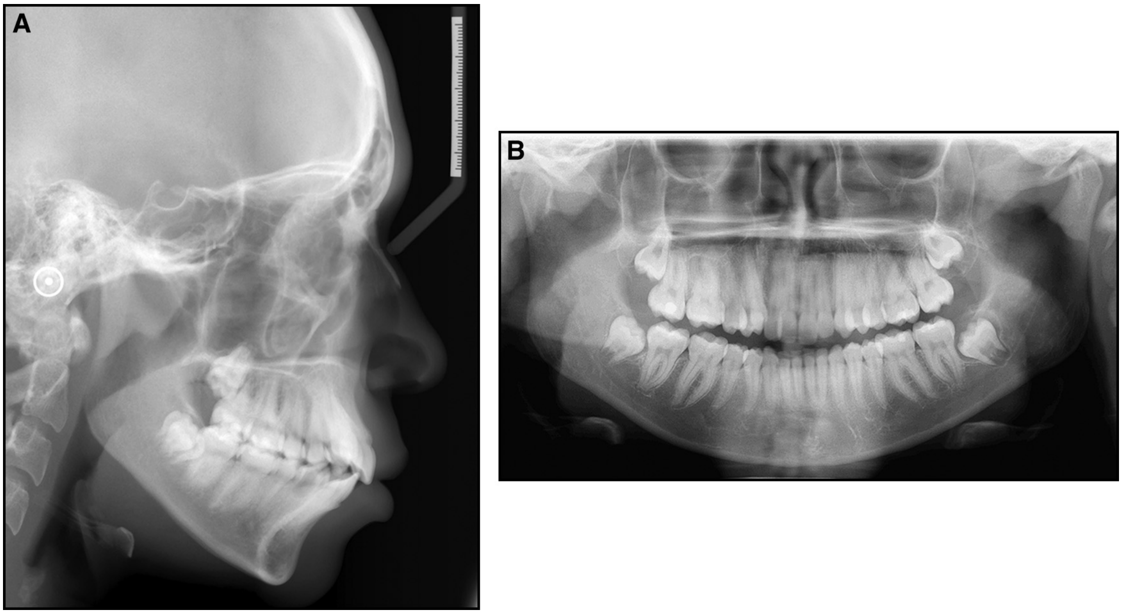

Fig 3. Pretreatment radiographs: **A,** lateral cephalogram; **B,** panoramic radiograph.

TREATMENT OBJECTIVES

The main goals of the treatment were to align the maxillary dental arch, correct the buccal crossbite, maintain ideal overjet and overbite, and achieve a good functional occlusion while maintaining the soft-tissue profile.

Table. Cephalometric measurements

	African American norm	Pretreatment	Posttreatment
SNA (°)	85	87	87
SNB (°)	81	82	82
ANB (°)	4	5	5
Occlusal plane to SN (°)	16	12	8
Pg-NB (°)	0	0	0
MP-SN (°)	33	34	35
Maxillary incisor-NA (mm)	8	12	12
Maxillary incisor- NA (°)	23	28	25
Mandibular incisor-NB (mm)	10	16	17
Mandibular incisor-NB (°)	33	40	42
IMPA (°)	101	104	106
Interincisal angle (°)	119	105	111
Facial convexity G-Sn-Pg (°)	13	10	10
Upper lip protrusion Ls–Sn-Pg (mm)	9	13	12
Lower lip protrusion Li–Sn-Pg (mm)	7	14	13

S, Sella; *N*, nasion; *A*, A point; *B*, B point; *IMPA*, lower incisor to mandibular plane angle; *G*, glabella; *Sn*, subnasale; *Pg*, pogonion; *Ls*, labrale superioris; *Li*, labrale inferioris.

TREATMENT ALTERNATIVES

This patient's malocclusion was in 2 planes of space, sagittal and transverse. The traditional approach would be to address the transverse dimension early in treatment with surgically assisted rapid palatal expansion, followed by extraction of the maxillary right first premolar to align the labially placed maxillary right canine. The total treatment time was expected to be about 20 to 24 months.

The second alternative was to simultaneously perform surgically assisted rapid palatal expansion and distraction of the labially placed maxillary right canine into the extraction space of the right first premolar, taking anchorage from a skeletal anchorage device.

The third alternative would entail 4 premolar extractions to reduce the incisor inclinations in conjunction with the first or the second option. This option would also require distalization of the maxillary right buccal segment (aided by skeletal anchorage) to move the incisors lingually without affecting the maxillary midline.

The patient chose the second option over the conventional approach, since the total treatment time was estimated to be 12 to 15 months.

TREATMENT PROGRESS AND SURGICAL PLAN

After the initial appointment for the records, the patient was referred to the Division of Oral Surgery at the University of Connecticut for placement of a skeletal anchorage plate. A miniplate (Stryker, Kalamazoo, Mich) was placed below the key ridge area on the right maxilla under local anesthesia. It was positioned so that the attachment head would be at the same level as the crown of the highly placed maxillary right canine. Impressions were taken to fabricate a custom distraction appliance for the canine retraction.

Two weeks later, the patient was scheduled for the osteotomy for canine distraction and unilateral surgically assisted rapid palatal expansion. The operation was performed under general anesthesia with nasal endotracheal intubation after local infiltration with a vasoconstrictor (lidocaine 2% with 1:100,000 epinephrine) at the height of the maxillary vestibule. A horizontal soft tissue incision was made 3 to 4 mm apical to the attached gingivae from the midline to the first molar on the right side. The mucoperiosteum was carefully reflected with a periosteal elevator, exposing unilaterally the nasal floor and the lateral aspect of the maxilla between the canine root and the infraorbital nerve. Posteriorly, the periosteum was undermined up to the pterygomaxillary junction.

For the canine distraction, the surgical bone cuts were done with a piezotome, under copious external saline-solution irrigation. Cortical cuts were made on the mesial and distal aspects of the canine root starting at the midroot region and continuing apically 3 mm from the apex. Cortical bone cuts were advanced in the coronal direction with narrow osteotomes. The first premolar was extracted at this stage. Osteotomes of appropriate sizes were then used from the mesial aspect of the dentoalveolar segment that included the canine to split the surrounding trabecular bone around its root from the palatal cortex and neighboring teeth. The transport dentoalveolar segment included the buccal cortex and the underlying trabecular bone-enveloped canine root while leaving an intact palatal cortical plate (Fig 4, *A*).

For the surgically assisted rapid maxillary expansion, a unilateral subapical horizontal osteotomy was made through the thin lateral maxillary wall with a saw starting from the mesial aspect of the second premolar. Great care was taken to remove an adequate amount of bone at the zygomatic buttress (lateral support) to allow lateral expansion of the osteotomized dentoalveolar segment during the surgically assisted rapid maxillary expansion. A vertical osteotomy was made with a saw at the alveolar region just mesial to the roots of the second premolar. The pterygomaxillary junction (posterior support) was released with a curved osteotome. The osteotomy was then extended through the palate (medially and anteriorly) with a fine curved osteotome placed in the vertical bony cut made just mesially to the second premolar. A septal osteotome was used to release the

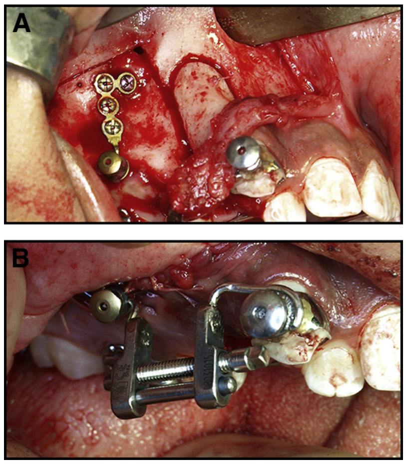

Fig 4. A, Osteotomy and cortical cuts for unilateral dentoalveolar expansion and canine retraction, respectively; **B,** trial mounting of the distraction appliance during surgery to confirm mobility of the osteotomized dentoalveolar segment and the canine.

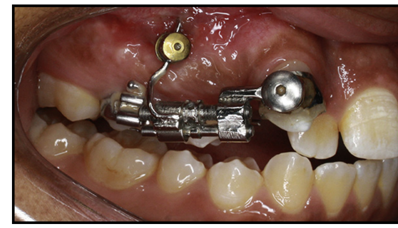

Fig 5. Right buccal view showing the new distractor in place; bending of the skeletal miniplate in the mesiolingual direction is evident.

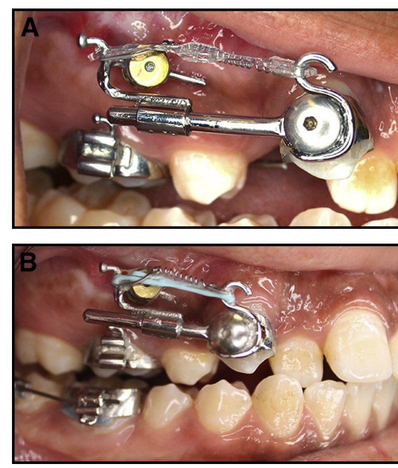

Fig 6. A, Right buccal view showing the sliding yoke appliance attached from the skeletal miniplate to the canine, allowing orthodontic retraction of the canine; **B,** right buccal view showing the progress of canine retraction after 2 months.

nasal septum. Scoring of the hard palate in the midpalate region was performed from the nasal side from the second premolar to the pterygomaxillary junction (with a finger on the palatal mucosa to guide the osteotome) to release the medial side of the dentoalveolar segment. At this time, the mobility of the osteotomized dentoalveolar segment was verified by trial activation of the hyrax expander to ensure that all bony resistance was released. Down-fracturing the dentoalveolar segment was not performed. The wound was irrigated with saline solution and closed in a single mucosal layer with an absorbable suture. The custom-made distraction appliance fabricated for the canine was trial mounted between the canine (to be distracted) and the attachment head of the anchorage plate, and it was activated to confirm the mobility of canine (Fig 4, *B*).

Two days after the surgery, the patient was instructed to activate the canine distractor by 0.75 mm per day (1 turn in the morning and a half turn in the evening) and the palatal expander by 1 mm per day (2 turns in the morning and in the evening). The patient reported a broken canine distractor 5 days after the start of activation. Immediately, the broken distractor was removed, a new distractor was placed, and the patient was instructed to activate the distractor only 1 turn per day. After a week of further activation with the new distractor, bending of the anchorage plate in a mesial and lingual direction was noticed (Fig 5). At this point, the distractor was removed, and a sliding yoke appliance (that could allow distalization of the canine under a heavy orthodontic force) was placed, taking the anchorage from the miniplate (Fig 6, *A*). An orthodontic force of approximately 500 g was placed with a nickel-titanium coil spring and an elastomeric chain. Also, the initial hyrax expander was replaced with a new one since the transverse capacity of the screw was maximized on the initial expander, and further expansion was needed. After 2 months of orthodontic force, the canine was fully retracted (Fig 6, *B*).

Crossbite elastics were given for a short time to restrict the unwanted side effect of expansion of the maxilla on the left side. Simultaneously, the mandibular first molars were banded, and a 0.032 × 0.032-in beta-titanium lingual arch was placed. Sectional leveling of the buccally positioned mandibular second molars was done with a 0.017 × 0.025-in beta-titanium wire placed from the mandibular first molar to the second molar.

At the start of the fourth month of treatment, the maxillary arch was bonded with a 0.022-in preadjusted edgewise orthodontic appliance, and leveling was started with a 0.016-in nickel-titanium wire that was

Fig 7. Posttreatment extraoral and intraoral photographs after debonding.

upgraded to a 0.021 × 0.025-in nickel-titanium wire during the next 4 months. The mandibular arch was bonded at the start of the eighth month of treatment, and leveling was started with a 0.016-in nickel-titanium wire and continued with a sequence of archwires up to a 0.016 × 0.022-in beta-titanium wire. It took 13 months to finish the treatment (Fig 7).

TREATMENT RESULTS

At the end of treatment, the maxillary and mandibular dental arches were well aligned, the buccal crossbite was corrected, a well-interdigitated occlusion with a Class I molar relationship on the left and a Class II relationship on the right was obtained, and Class I canines were achieved (Fig 7). Coincidental maxillary and mandibular midlines with respect to the facial midline and a consonant smile arc were also achieved (Fig 8). Clinically, at the end of treatment, there was no mobility or discomfort at the maxillary right canine, and the gingival tissue appeared healthy with no periodontal pockets. Vitality of the maxillary canine was absent at this time, but no symptoms or radiographic pathologic findings were observed.

The posttreatment cephalometric analysis showed minimal changes compared with pretreatment (Fig 9, *A*; Table). The panoramic radiograph showed no significant bone loss or root resorption (Fig 9, *B*). The superimposition of the pretreatment and posttreatment cephalometric radiographs showed a minimal change in the profile (Fig 10). At the end of treatment, the patient was extremely pleased with the results and expedited treatment time.

DISCUSSION

To correct the malocclusion of our patient, most of the tooth movements were achieved in 2 directions:

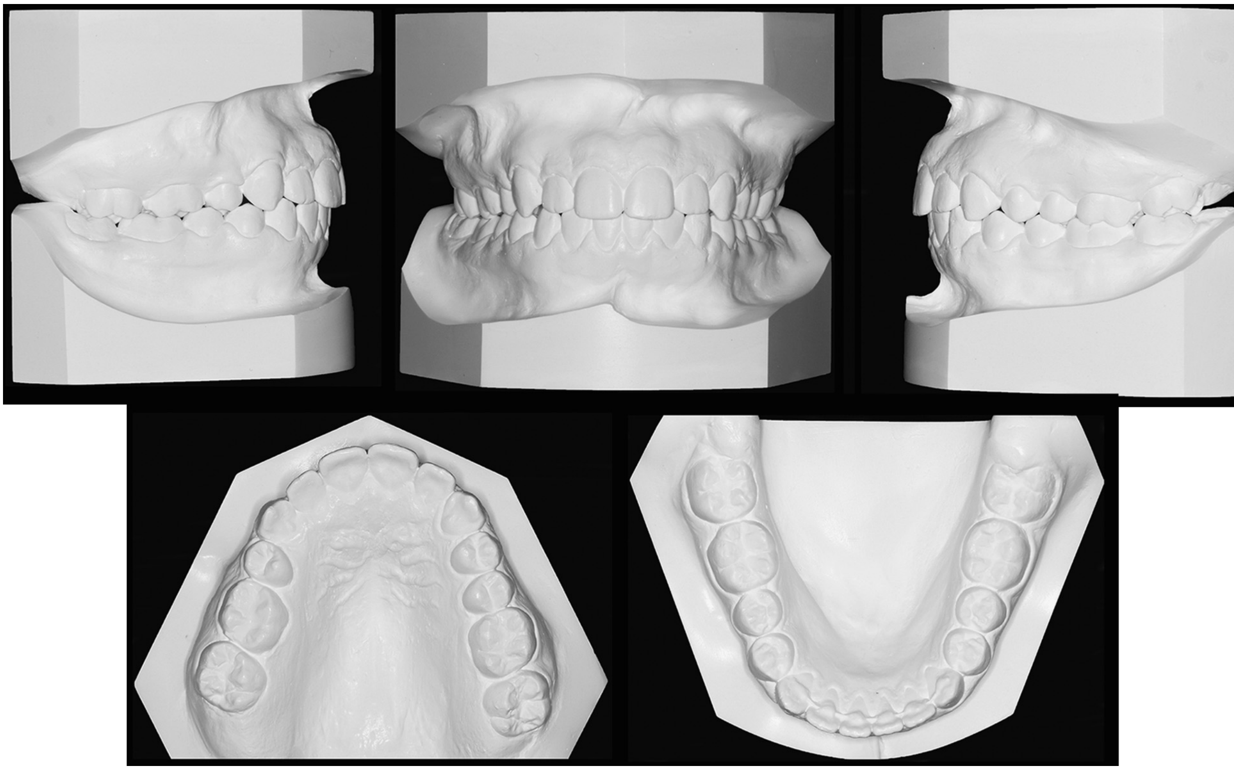

Fig 8. Posttreatment dental casts.

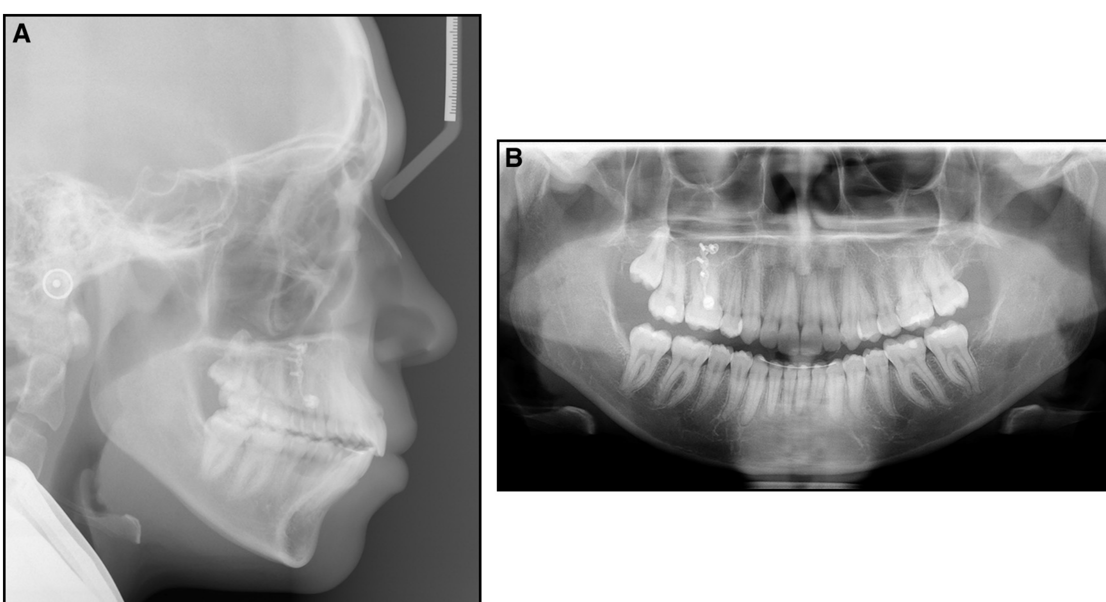

Fig 9. Posttreatment radiographs: **A,** lateral cephalogram; **B,** panoramic radiograph.

sagittal and transverse. Traditionally, this type of malocclusion is approached by correcting the transverse dimension first and then addressing the sagittal tooth movement. With this approach, we wanted to demonstrate how correction in both dimensions can be telescoped into 1 procedure with dentoalveolar surgery to

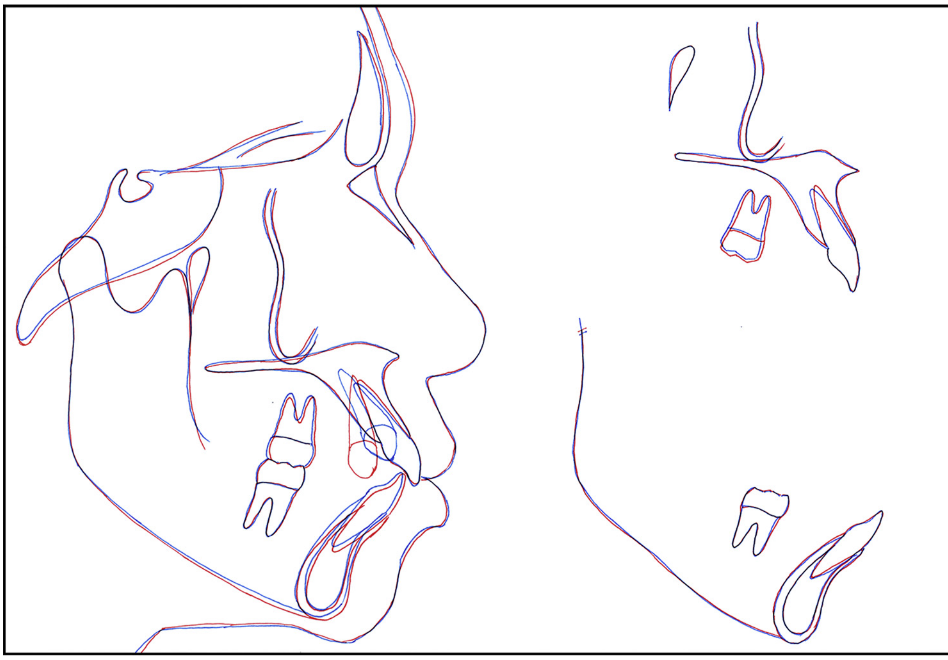

Fig 10. Cephalometric superimpositions: *black line*, pretreatment; *red line*, posttreatment.

increase the rate of tooth movement and reduce the patient's total treatment time.

Although both periodontal distraction and dentoalveolar distraction can retract the canine in 2 to 3 weeks,[9,12] difficulty of access and lack of visibility of the septal bone between the canine and the premolar make the periodontal distraction technique sensitive.[18] Moreover, if the osteotomy is inadequate in the premolar socket, it can result in a longer retraction time and more tipping of the canine. Kharker et al[19] compared periodontal distraction with dentoalveolar distraction and found that although dentoalveolar distraction is more extensive, it provides faster retraction of the canines, fewer office visits, and less canine tipping compared with periodontal distraction.

To correct the unilateral crossbite in this patient, unilateral subapical osteotomy in the maxilla was performed on the right side, and the hyrax expander was placed with the intention of expanding only the side that was constricted. As the expansion progressed, some unwanted expansion was observed on the left side. This side effect was counteracted by cross elastics in the left buccal segment. Mossaz et al[20] reported that expansion is minimal on the nonoperative side compared with the operative side and undergoes total relapse in the retention phase, suggesting that it is entirely dentoalveolar.

The anchorage plate was positioned high in the key ridge area to allow for the subapical horizontal osteotomy cut for the surgically assisted rapid maxillary expansion to be made coronal to the base of the anchorage plate. The intent was that the plate would be attached to the higher stable bone, providing excellent anchorage for canine distraction while allowing simultaneous transverse expansion. Even though the subapical osteotomy cut was made apical to the base of the anchorage plate, it provided good anchorage for distalization of the canine into the premolar extraction space.

Kisnisci and Iseri[21] emphasized that after the first premolar is extracted, the buccal bone should be carefully removed through the extraction socket with large round burs between the outlined bone cut at the distal canine region anteriorly and the second premolar posteriorly. They also stated that the bone below the extraction socket and any other possible bony interference at the buccal aspect encountered during the distraction process should be removed. In our patient, probably not enough bone was removed in this region, leading to the excessive stress on the plate during distraction, which caused breakage of the first distractor and bending of the anchorage plate. Trandem et al[22] compared deformation of the lever arms of 3 commercially available miniplates (Stryker; KLS Martin, Tuttlingen, Germany; and Synthes, West Chester, Pa) and found that all 3 could withstand the orthopedic forces, but the mean yield strength was lowest for the Stryker miniplate; this means that it undergoes permanent deformation at a lower stress compared with the other two.

Lee et al[23] studied the effect of corticotomies and osteotomies in alveolar bone when combined with orthodontic tooth movement and found that osteotomies produced changes resembling a distal distraction site, whereas corticotomies produced a regional loss of bone supporting the dental roots, typical of a regional accelerated phenomenon. According to that study, the reason for the differences in bone response to a corticotomy as compared with an osteotomy is that the osteotomized segments undergo fracture-like healing, whereas healing after a corticotomy is produced by exposing the surgical site to the underlying marrow vascular spaces, thus enhancing the healing potential of the bone. In our patient, the reason for the short distalization period of the canine was most likely related to the extensive decortication performed in the region just distal to the canine; this probably led to a regional acceleration phenomenon. Moreover, 500 g of tipping force might have resulted in some distraction of the osteotomized canine segment, thus leading to expedited tooth movement.

CONCLUSIONS

This report demonstrates how dentoalveolar distraction in 2 planes can be performed simultaneously. Meticulous surgical planning and proper execution could have further reduced the total treatment time.

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