Case Report

Treatment of anterior open bite and an ankylosed incisor by applying multiloop edgewise archwire, mini-implants, and dentoalveolar distraction

Tae-Woo Kim[a]; Soon Jung Hwang[b]; Tingxi Wu[c]

ABSTRACT

An 18.7-year-old female patient with an anterior open bite and an ankylosed left maxillary central incisor was referred from a private orthodontic clinic. Canine relationships were Class II and molar relationships were Class I. The open bite was closed with the multiloop edgewise archwire and up-and-down elastics. The maxillary left central incisor was extruded by dentoalveolar distraction assisted with mini-implants. Active treatment took 2 years and 1 month, and the treatment result remained stable 14 months after debonding. (*Angle Orthod.* 2023;93:482–492.)

KEY WORDS: Ankylosis; Open bite; Dentoalveolar distraction; Orthodontic mini-implant; Ankylosis; MEAW; TAD

INTRODUCTION

An ankylosed central incisor in a growing child will fail to erupt with no vertical growth of the surrounding alveolar process and cause anterior open bite as presented in many case reports. The anterior open bite may be limited only to the ankylosed incisor[1–6] or involve the whole anterior segment due to a secondary tongue-thrusting habit, low tongue posture, or the inherent growth pattern.[7–9]

In the past, an ankylosed permanent incisor was often replaced with a fixed or removable prosthetic tooth.[6] Waiting for re-eruption,[10] decoronation,[11] and extraction/space closing[12] have been reported in growing children. When growth is complete, there are several surgical treatment protocols to extrude an ankylosed tooth, such as single-tooth osteotomy,[4,13,14] surgical luxation,[15–18] corticotomy,[8] and distraction osteogenesis (DO).[1,3,7,9,13,16,19–26] DO using distraction devices has become one of the most predictable treatment methods for ankylosed teeth. Kinzinger et al.[27] applied a bone-borne distraction device which used adjacent alveolar bone as a source of anchorage. It required a second surgery to remove the device. Tooth-borne distractors became more popular for easy use without a need for surgical removal.[1,3,9,13,20] However, because they obtain anchorage from the patient's dentition, intrusive forces and moments on adjacent teeth develop, or aggravate, anterior open bite.[1,7,9,13,20,26] To reduce this adverse effect, Im et al. used mini-implants as anchorage to make tooth movement more predictable without adverse movements (intrusion) of anchorage teeth.[3]

In the present patient, anterior open bite was resolved first with the multiloop edgewise archwire (MEAW) and up-and-down elastics, excluding the ankylosed maxillary left incisor. After osteotomy, surgical wires were used to distract the ankylosed incisor while two mini-implants were used to provide indirect anchorage.

Diagnosis and Etiology

The patient was a female aged 18.7 years who complained of an anterior open bite. She had an ankylosed maxillary left central incisor. Pretreatment facial photographs showed a straight profile with a slightly excessive lip protrusion (Figure 1). On smiling, her upper incisal display was deficient (Figure 1). Relative to the adjacent right central incisor, the gingival margin of the ankylosed tooth was displaced 5-mm apically. Her former dentist failed to extrude the anterior tooth even after luxation of the ankylosed

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Figure 1. Pretreatment photographs. Black arrow indicates the gingival margin.

incisor during the 5 years of treatment. For esthetic reasons, a pink-colored resin was bonded to its labial cervical area, and a tooth-colored resin was added to the incisal edge for camouflage (Figure 1). The pretreatment model demonstrated Class II canine and Class I molar relationships (Figure 2).

Cephalometric analysis (Figure 3A,B and Table 1) showed a mild Class II skeletal relationship (ANB angle, 5.0°). She showed a normal FMA angle (27.4°), which suggested that the open bite was of dentoalveolar origin. The maxillary and mandibular incisors were slightly labially inclined (U1 to FH, 127.3°; IMPA, 97.9°).

A panoramic radiograph (Figure 3C) showed the maxillary left central incisor in an abnormally high position. On a periapical radiograph of the maxillary left central incisor (Figure 3D), a radiopaque mass (resin) was found on the incisal half of the crown, and its periodontal membrane was indistinct. The distal cervical root surface showed external root resorption (Figure 3D, white arrow).

The anterior open bite involved the whole anterior segment due to a secondary tongue-thrusting habit, which disappeared after closing the open bite.[7,8,20] The initial tongue position was not low at rest (Figure 3A), showing no remarkable changes through the follow-up.

Table 1. Cephalometric Summary[a]

Measurement	Korean Norm[b] (SD)	T1	T2
SNA	81.6 (3.2)	84.0	83.5
SNB	79.2 (3.0)	79.0	79.0
ANB	2.5 (1.8)	5.0	4.6
FMA	24.3 (4.6)	27.4	26.9
ODI[c]	72.2 (5.5)	70.3	70.2
U1 to FH	116.0 (5.8)	127.3	106.3
IMPA	95.9 (6.4)	97.9	97.7
Interincisal angle	123.8 (8.3)	107.4	129.2
Upper lip E-plane	−0.9 (2.2)	0.7	−0.9
Lower lip E-plane	0.6 (2.3)	4.0	2.2

[a] SD indicates standard deviation; T1, pretreatment records at age 18 years and 8 months; and T2, posttreatment records at age 21 years.
[b] Data from the Korean Association of Orthodontists.
[c] Overbite depth indicator.

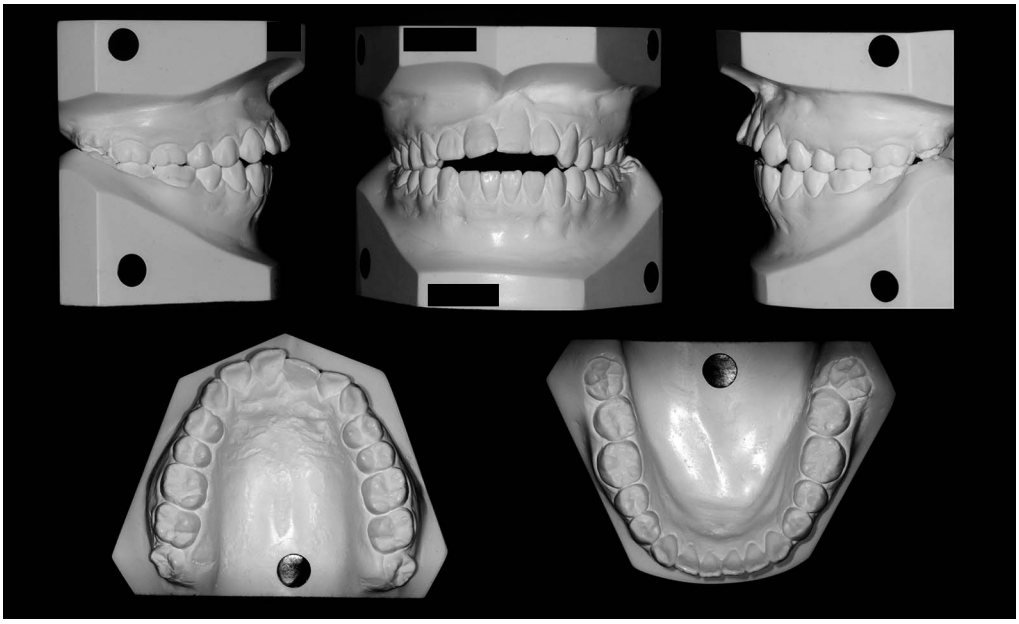

Figure 2. Pretreatment study models.

Treatment Objectives

The main treatment objectives were the following:

- Obtaining a functional occlusion,
- Aligning the ankylosed maxillary left incisor with the dentoalveolar distraction assisted by mini-implants, and
- Correcting the anterior open bite with MEAW.

Treatment Alternatives

Two treatment options were proposed to the patient and her parents involving the extraction of four third molars. For the first option, the ankylosed incisor was planned to be preserved and distracted. Despite the complicated distraction procedure for extruding the ankylosed incisor and its uncertain longevity due to external root resorption, the patient and her parents still wanted to preserve the incisor as long as possible. The distraction of bone was preferred to avoid additional bone graft surgery and to enhance the esthetic result.

The second alternative treatment included extraction of the maxillary first premolars, the mandibular second premolars, and the ankylosed maxillary left central incisor. The maxillary left central incisor space would be preserved for prosthetic treatment. This alternative treatment plan was refused by the patient because of the anticipated negative effect on lip protrusion.

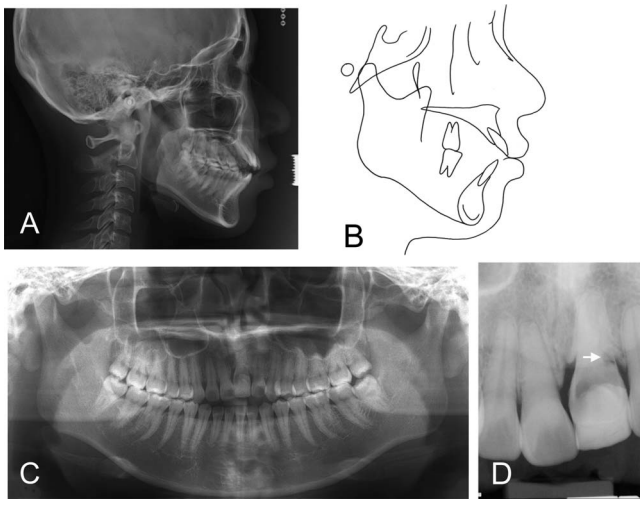

Figure 3. Pretreatment radiographs and tracing. (D) White arrow indicates external root resorption.

Treatment Progress

The treatment process proceeded in five stages.

1. *Open bite closed except for the maxillary left central incisor (Figure 4)*. All third molars were extracted before treatment. The maxillary and mandibular arches were bonded with .022-inch slot brackets (SmartClip, 3M Unitek, Monrovia, Calif) except for the maxillary left central incisor. After leveling, a MEAW 0.018 × 0.022 stainless steel archwire in the maxilla and an ideal arch (0.019 × 0.025 stainless steel) were ligated in the mandible. Class II (5/16-inch 6 oz) and up-and-down elastics (3/16-inch 6 oz) were applied to retract and extrude the maxillary anterior teeth. Dr. Kim's original method used a 0.016 × 0.022 wire in a 0.018 slot for MEAW,[28] but the authors used a 0.018 × 0.022 wire in a 0.022

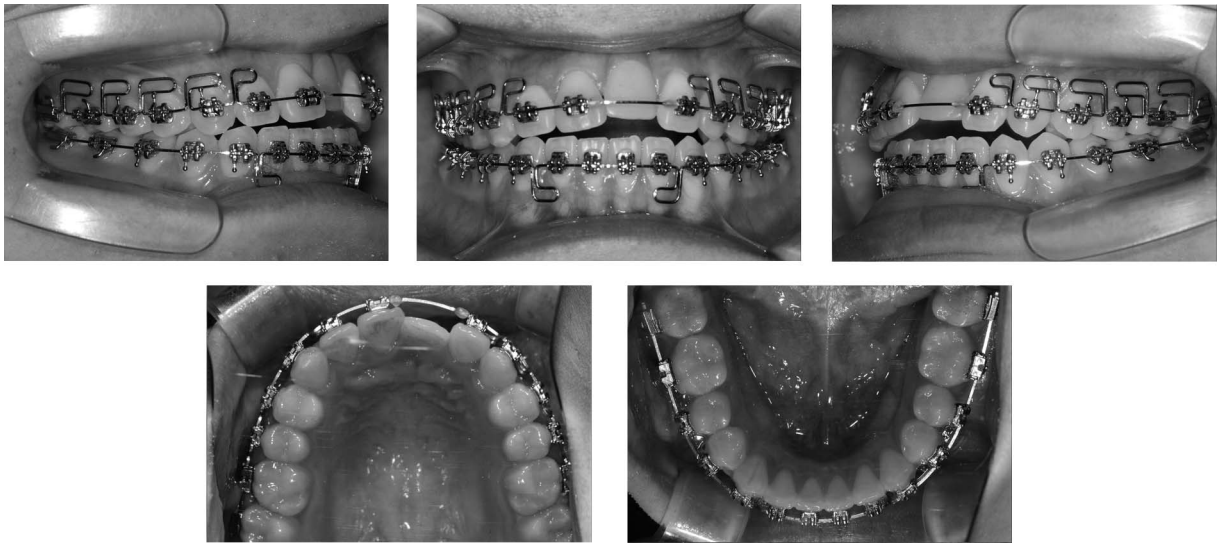

Figure 4. Progress intraoral photographs (5 months). Class II (5/16-inch 6 oz) and up-and-down elastics (3/16-inch 6 oz) were applied.

slot. This would make it more difficult to control torque because of the larger play compared with the original. However, in this case, torque control was not required during the first stage of closing the open bite with MEAW.

2. *Preparation for the dentoalveolar distraction (Figure 5)*. After 3 months, the open bite was resolved, and a temporary crown was cemented onto the tooth. In the maxillary arch, an ideal arch was made of 0.019 × 0.025-inch stainless steel for stabilization. Steps were provided for space maintenance of the maxillary left incisor, and a crimpable hook (no. 226-010, TP Orthodontics Inc., La Porte, Ind) was attached for wire ligation. Two 1.6 × 6.0-mm mini-implants were placed (16-JA-006H, Dual-Top JA, Jeil Medical Co., Seoul, Korea) between the maxillary right central incisor and lateral incisor and between the maxillary left lateral incisor and canine. Two 0.9-mm stainless steel wires were bonded for indirect anchorage.
3. *Osteotomy and distraction (Figures 6 and 7)*. Under local anesthesia, incisions were made on the labial mucosa, and a labial mucoperiosteal flap was elevated. The palatal mucosa was left intact for blood supply. Osteotomy was done 4–5 mm above the root apex and along the interseptal bone mesial and distal to the maxillary left central incisor (Figure 6A). The temporary crown on the ankylosed

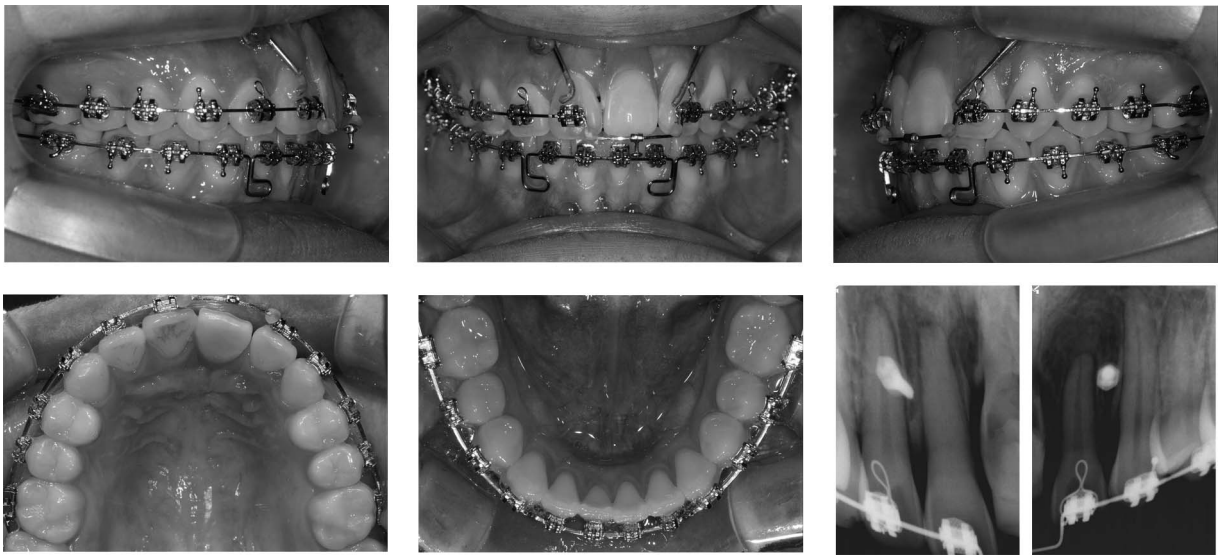

Figure 5. Progress intraoral photographs (12 months). After closure of the open bite (except for the ankylosed incisor), two mini-implants (1.6 × 6.0 mm) were placed. A temporary crown was cemented over the ankylosed incisor. Stainless steel wires (0.9 mm) were bonded for indirect anchorage.

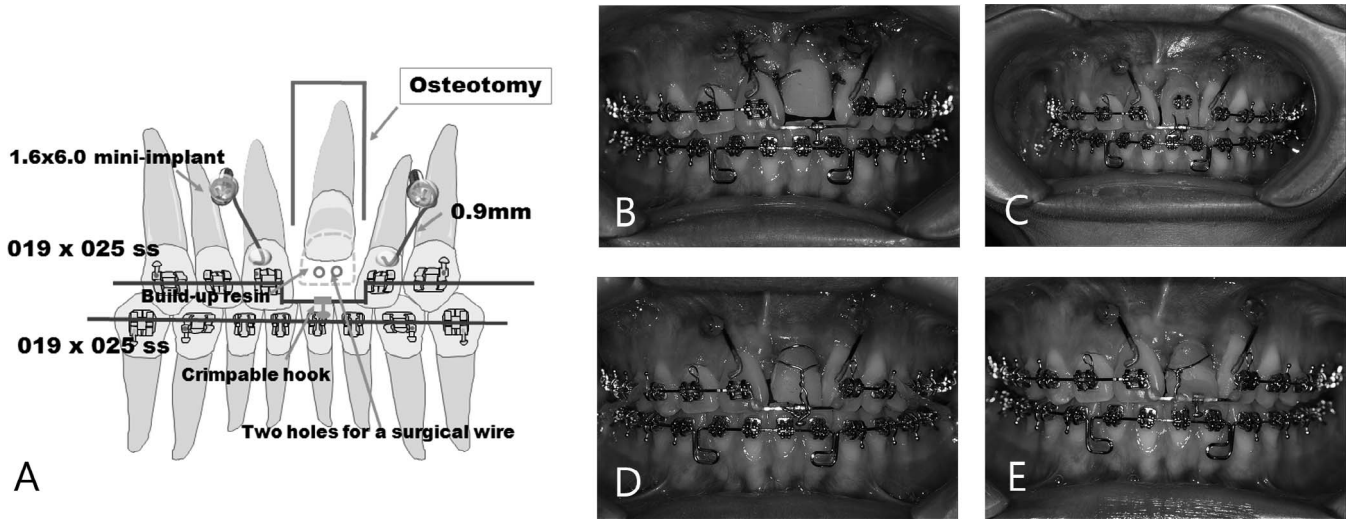

Figure 6. Dentoalveolar distraction. (A) Schematic drawing of the procedure. (B) Seven days after osteotomy. The temporary crown was removed before surgery. (C) Distraction 3 days. Two small holes were made on the incisal resin to insert the surgical wire. (D) Distraction 6 days. Resin was removed from the incisal edge as the incisor was extruded. (E) Distraction 13 days. Distraction was stopped. The incisor was fixed to the archwire by bonding resin.

maxillary left incisor was removed (Figure 6B). One day after suture removal, two holes were drilled on the incisal resin area for ligation of a distraction wire, and distraction was started using a soft 0.020 stainless steel surgical wire (Stainless Steel Soft Wire, HL-03309-3, Hanil Dental Ind. Co., Seoul, Korea) (Figure 6C). The distraction rate was planned to be 0.5 mm per day based on the distance between the incisal edge and the archwire (Figure 6). Distraction was continued for 13 days. As the incisal resin touched the maxillary archwire, it was ground with a bur (Figure 6D). After distraction was stopped, the incisal edge was bonded to the archwire for stabilization (Figures 6E). Indirect anchorage wires were removed (Figure 7).

4. *Alignment detailing (Figures 8 and 9)*. After 3 months of stabilization, this resin fixation was removed (Figure 8), and the maxillary left central incisor showed no mobility. A bracket was bonded on the maxillary left incisor, and a 0.018 $\times$ 0.022 stainless steel wire was engaged (Figure 9). Lingual root torque was applied on the mandibular right central incisor with a 0.019 $\times$ 0.025 TMA.
5. *Debonding and retention (Figure 10)*. The brackets and bands were removed after 2 years and 1 month of active treatment. Circumferential maxillary and

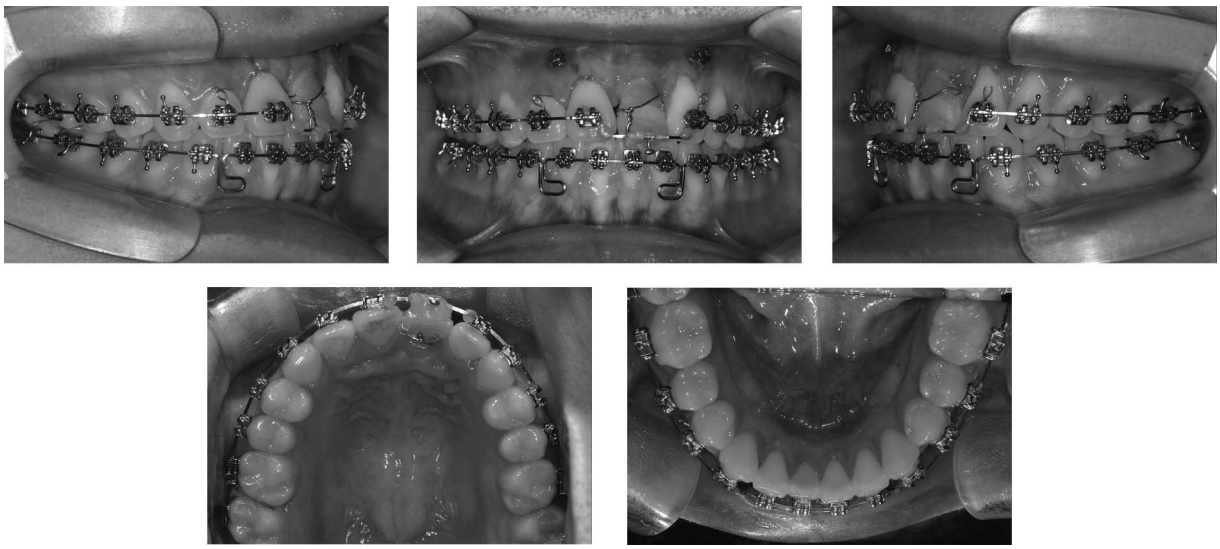

Figure 7. Progress intraoral photographs (1 year and 2 months). Wire segments bonded to mini-implants were removed, and the distracted incisor was bonded to the archwire for consolidation.

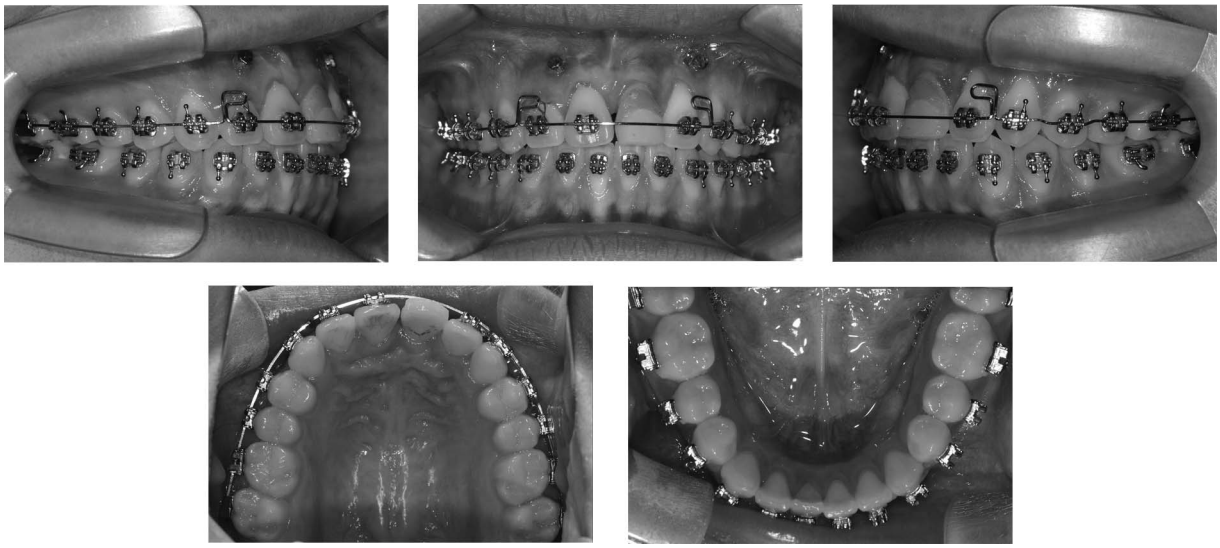

Figure 8. Progress intraoral photographs (1 year and 4 months; 3 months after distraction). The bonding resin on the incisor was removed.

mandibular retainers were placed the day after debonding. At 14 months after retention, the maxillary and mandibular lingual fixed retainers were bonded because the patient wanted the fixed type. She was recommended for permanent retention.

Treatment Results

The patient's facial profile slightly improved through retraction of the maxillary incisors with a satisfactory incisal display on smiling (Figure 10). The treatment concluded with Class I canine and molar relationships with adequate overbite and overjet (Figure 11). The posttreatment cephalogram showed the retraction of the maxillary incisors (Figure 12A,B). There was no significant root resorption (Figure 12C).

The patient wore circumferential retainers 24 hours a day for the first 3 months, followed by a year of nighttime wear. The 14-month postretention stability was good (Figure 13). Cephalometric superimposition showed no significant dental or skeletal changes after debonding (Figure 14).

DISCUSSION

Based on her dental history and the evidence of resorption on the root, the maxillary left central incisor was diagnosed as ankylosed. If there was no resorption or a history of initial orthodontic failure,

Figure 9. Progress intraoral photographs (1 year and 10 months). Mini-implants were removed, and a bracket was bonded on the maxillary left central incisor. In the mandibular arch, 0.019 × 0.025-inch TMA with lingual root torque for a mandibular right central incisor.

Figure 10. Posttreatment photographs (2 years and 1 month).

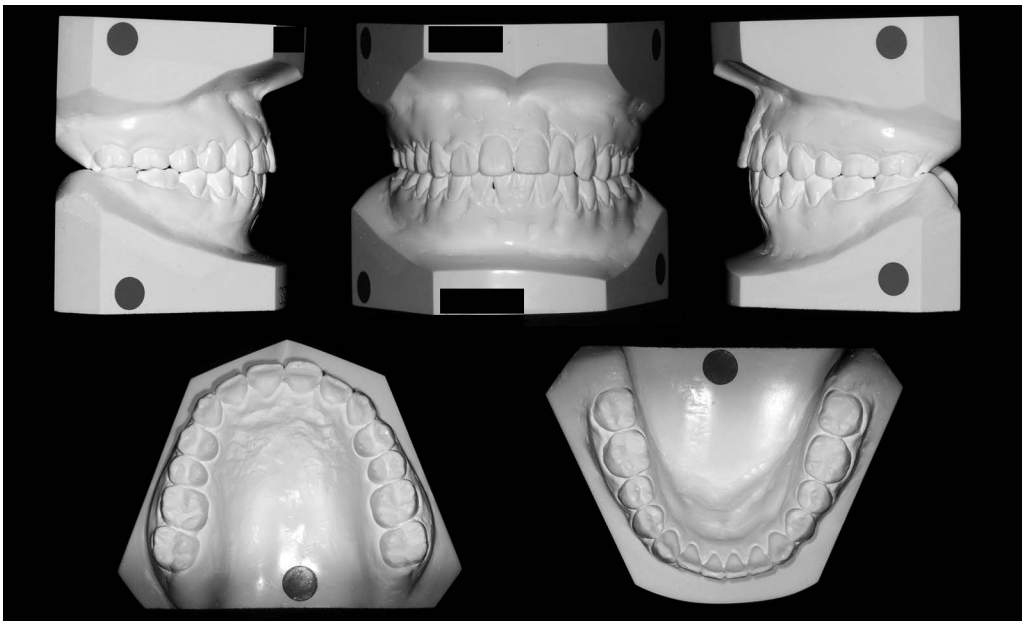

Figure 11. Posttreatment model.

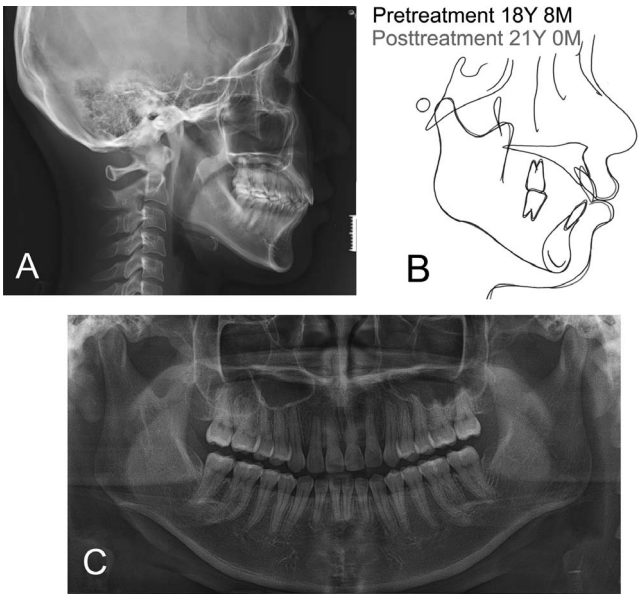

Figure 12. Posttreatment radiographs and superimposition.

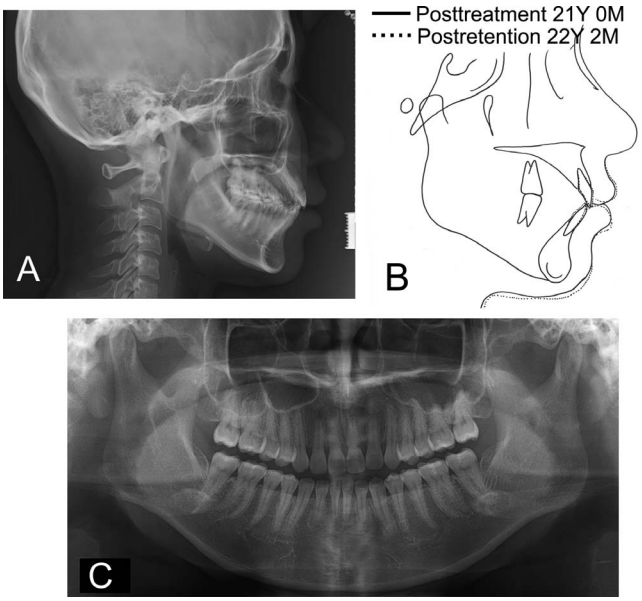

Figure 14. Follow-up radiographs and superimposition at 14 months.

Figure 13. Follow-up photographs at 14 months.

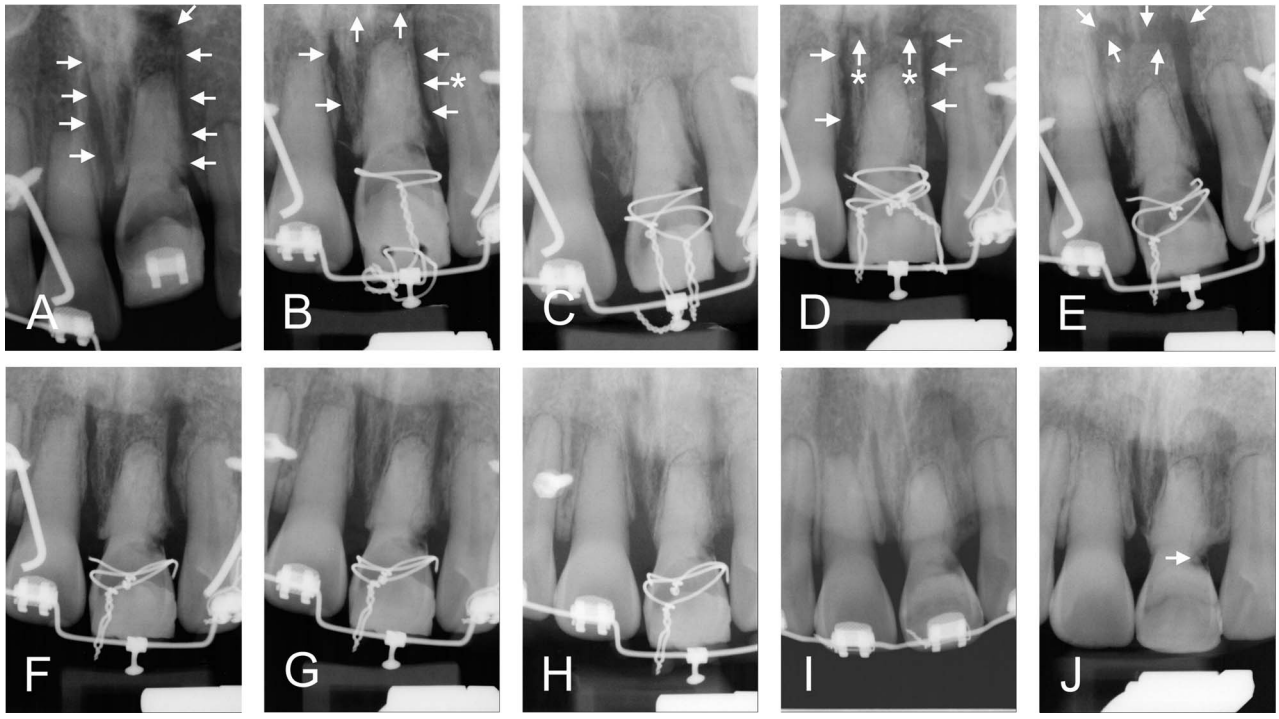

Figure 15. Radiographs after osteotomy. (A) Six days after osteotomy. White arrows indicate osteotomy lines. (B) Five days of distraction. After 3 mm of distraction, the osteotomy line has become more distinct (*). (C) Nine days of distraction. (D) Twelve days of distraction. The horizontal osteotomy line (*) has become wider and more evident. (E) Seven days after stopping distraction. Osteotomy line (white arrows) was distinct. (F) Thirteen days after end of distraction. (G) Thirty-five days. (H) Two months. (I) Ten months. (J) Twenty-five months. White arrow indicates external resorption.

subluxation and traction could have been tried first.[15,18]

A single-incisor dentoalveolar distraction was reported by Isaacson et al.[19] and others.[1,3,7,9,13,16,20–26,29] DO consists of 3 sequential periods: latency, distraction, and consolidation. The latency periods varied considerably for different case reports from 4 days to 2 weeks.[3,7,9,19,20] In most cases, after a latency period of 1 week, the distraction of the dentoalveolar segment began.[3,7] In the present case, distraction was started following a 7-day latency period after suture removal and the primary healing of soft tissue.

For dentoalveolar distraction of a single tooth, various rates of distraction have been used previously, from 0.5 mm to 1.0 mm per day.[1,3,5,7,9,19,20,29] In an animal study, bone regeneration produced by dentoalveolar distraction at the rate of 1 and 2 mm per day was similar in quality and quantity.[30] In the present case, the distraction rate was 0.5 mm per day by twisting the surgical wire for 13 days. The labial gingival line of the maxillary left central incisor was aligned well after distraction but showed progressive recession afterward.

The single-tooth osteotomy block can be distracted by various methods, such as vertical extrusion bends,[4,5,7,19] vertical elastics,[21,22] a coil spring or loop,[5] a nickel-titanium wire,[5,7,15,16,19,23–25] or a distraction device.[3,9,20,26] The advantages of using a distraction device are that the displacement of the dentoalveolar block gradually increases in precise amounts and that the patient can activate the distractor at home. The secondary surgery to remove the distractor is a disadvantage of the bone-borne distractor. Therefore, tooth-borne distractors have been introduced, eliminating the need for a second surgery.[3,9,13,20] Custom-made tooth-borne distraction devices were fabricated most commonly from expansion screws,[3,9,13,20] which requires complicated laboratory procedures. A ready-made tooth-borne distractor was also introduced,[31] but the ankylosed incisor cases are too diverse for a ready-made, unidirectional tooth-borne distractor to apply to all cases. It may be irritating to the vestibular gingiva or lips due to its bulkiness. In the present case, a soft surgical wire eliminated the laboratory work and lessened the esthetic and functional discomfort resulting from a bulky distraction device. Using a surgical wire, the direction of distraction could be adjusted slightly by the clinician.

One of the adverse effects of tooth-borne distractors or extrusive archwire bends is the intrusion of adjacent anchor teeth.[2,9,19,31] Box elastics[2,7,9] or up-and-down elastics[15] have been used to decrease these adverse

effects. However, these elastics might extrude the mandibular anterior teeth.[5] In the present case, mini-implants were used to acquire stable anchorage.

The stability of the dento-osseous block after distraction is considered a key determinant in bone formation within the gap.[32] For consolidation of the bone segment, in other case reports, a passive heavy archwire was left in place for 6 weeks,[7,19] 12 weeks,[9] or up to 5 months.[29] In the present case, the segment was consolidated for 3 months. After consolidation, the maxillary left incisor did not show mobility.

Bone formation during and after distraction was evaluated by serial periapical radiographs (Figure 15). The radiolucent osteotomy line mesial to the maxillary left central incisor was still seen 25 months after the end of distraction (Figure 15J), but other osteotomy lines healed well without mobility. According to Saulacic et al., the most common complication was insufficient bone formation (22 cases of 256 patients, 8%).[32] Incorrect design of the vertical osteotomy lines may also impede movement of the segment.[32] In the present case, there was no impediment to movement. Through this observation, the authors recommend making the osteotomy gap as narrow as possible during osteotomy and distraction procedures. External root resorption of the ankylosed incisor progressed slightly on the distal cervical area (Figure 15J). It may have been caused by the injury from the wire (Figure 15D) or increased cementoclastic activity after segmental surgery.

CONCLUSIONS

- Anterior open bite with ankylosis of the maxillary left central incisor was treated successfully using MEAW, mini-implant anchorage, and dentoalveolar distraction.
- The ankylosed incisor was distracted well by twisting a 0.020 surgical wire following an osteotomy.
- Mini-implants provided stable indirect anchorage during this procedure.

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