Orthodontic treatment of an ankylosed maxillary central incisor through single-tooth osteotomy by using interdental space regained from microimplant anchorage

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This case report describes the treatment of a boy, aged 13.6 years, whose ankylosed maxillary left central incisor had been avulsed and replanted 2.5 years earlier. Ankylosis of the tooth and adjacent alveolar process led to the development of infraocclusion, migration of adjacent teeth, midline deviation, and a vertical alveolar bone defect. Initially, distal tooth movement in the maxillary arch was performed with microimplant anchorage to gain space for repositioning the ankylosed tooth. Then a single-tooth osteotomy was performed in 1 surgical stage to allow for inferior repositioning of the tooth and bone. The ankylosed tooth was successfully leveled in the maxillary arch with a harmonic gingival margin. The total treatment period was 18 months, and the results were acceptable at 14 months after debonding. (Am J Orthod Dentofacial Orthop 2012;141:e39-e51)

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vulsion is a serious injury that causes damage to the periodontal ligament, alveolar bone, gingiva, pulp, and cementum.1 Replantation of avulsed teeth is frequently complicated by dentoalveolar ankylosis. This condition can result in replacement root resorption, in which the root is substituted by bone.2,3 Tooth ankylosis is a localized fusion of cementum and surrounding alveolar bone with obliteration of the periodontal ligament and is apparently caused by mechanical, thermal, or metabolic trauma to the periodontal membrane during or after tooth eruption. Permanent incisors frequently become ankylosed, when the periodontal ligament is traumatically damaged, such as in the case of replantation after avulsion with a prolonged replantation time.4,5

The diagnosis of ankylosis can be made by both clinical and radiologic evaluations. Clinical diagnosis can be made by infraocclusion, percussion, and mobility testing. However, the most important indicator of ankylosis is the lack of tooth movement with application of an orthodontic force.6,7 Total ankylosis is demonstrated radiographically by the absence of any periodontal membrane. However, it is difficult to identify when fusion occurs only in a small area or on the buccal or lingual surface.8 Radiographic examination has limited value in the early detection of ankylosis, because of the 2-dimensional image.9 Recent advancements have made it possible to measure the radiicular volume involved in ankylosis, and its exact location on the tooth can be demonstrated by using computed tomographic imaging. This imaging technique with tridimensional reconstruction provides a positive diagnosis of ankylosis.10

Treatment methods for ankylosed teeth include extraction, decoronation, restoration, surgical subluxation, ostectomy, osteocorticotomy, and distraction osteogenesis.4,6,11–20 Osteocorticotomy is a surgical procedure in which the intact ankylosed tooth and adjacent bone are either repositioned in 1 step or moved orthodontically.17 This technique does not correct the ankylosis, but it does permit optimal repositioning of the tooth.

In this case report, we present the treatment of a severely ankylosed maxillary central incisor that was brought into the arch by an individual ostectomy and...
by using an interdental space created by microimplant anchorage.

**DIAGNOSIS**

The patient was a boy, aged 13.6 years, seeking esthetic orthodontic treatment for a severely ankylosed maxillary left central incisor, displaced 7 mm apically relative to the adjacent central incisor. A traumatic injury at the age of 11.5 years had resulted in the avulsion of the maxillary left central incisor, which was later replanted and followed by endodontic treatment. As the patient grew, the infraoccluded state of the maxillary left central incisor worsened, with discoloration from accompanying root resorption (Fig 1).

The patient had a well-balanced and symmetrical face, but a slightly convex soft-tissue profile. He also had an asymmetric smile line because of the ankylosed maxillary left central incisor and a poor appearance of the gray malpositioned tooth upon smiling (Fig 1).

Intraorally, he had Class II canine relationships, particularly on the left side. The maxillary left central incisor was infraoccluded and in a labial position; the gingival level of this tooth was 7 mm higher than that of the adjacent teeth. The left anterior occlusion

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**Fig 1.** Pretreatment facial and intraoral photographs.
Fig 2. Pretreatment dental casts.

Fig 3. Pretreatment radiographs.
showed an open bite, because the maxillary left central incisor was severely intruded (Figs 1 and 2).

The lateral cephalometric analysis showed a mild skeletal Class II anteroposterior discrepancy with an ANB angle of 5.3° (SNA, 78.2°; SNB, 72.9°), and the vertical skeletal pattern was deemed normodivergent as evidenced by the Frankfort mandibular plane angle of 27.4°. The angle between Frankfort horizontal and the maxillary incisor axis of 126.2° indicated the labioulceration of the maxillary ankylosed left central tooth, and the incisor mandibular plane angle of 98.5° reflected the proclination of the maxillary incisors (Table).

The soft-tissue analysis showed mild lip fullness. The posteroanterior cephalogram showed a symmetrical facial contour. Dental asymmetry, in which the maxillary dental midline was shifted to the left of the facial midline, was present and had been caused by the ankylosed maxillary left central incisor causing tipping the adjacent teeth (Fig 3).

The panoramic radiograph showed a full complement of teeth, including developing third molars, and infraposition of the maxillary left central incisor. The alveolar process in this region had a severe deficiency in vertical development (Fig 3). The periapical radiograph and 3-dimensional computed tomography image showed ongoing replacement resorption of the ankylosed maxillary left central incisor, which had been endodontically treated (Fig 4). There were no significant signs or symptoms of temporomandibular disorders.

**TREATMENT OBJECTIVES**

The treatment objectives were to (1) correct the Class II occlusion, (2) correct the axes of the tilted teeth, (3) correct the midline, (4) obtain a normal incisor relationship, (5) improve the smile, and (6) correct the osseous and gingival margins in the ankylosed region (maxillary left central incisor).

**TREATMENT ALTERNATIVES**

Several treatment alternatives were explored in regard to the ankylosed tooth.

1. Extract the ankylosed tooth and close the space orthodontically.
2. Perform an osteotomy distraction osteogenesis and immediately reposition the dentoalveolar structures.
3. Perform an osteotomy of the segment with immediate repositioning of the dentoalveolar structures.

The third treatment plan was chosen for this patient, considering several major factors: the ankylosed tooth, the replacement resorption of root, and the moderate bone defects.

**TREATMENT PROGRESS**

A standard 0.022 × 0.028-in nontipped, nontorqued edgewise appliance was placed in the maxillary arch, and leveling began with a 0.014-in nickel-titanium archwire and an 0.018-in stainless steel archwire. Maxillary posterior microimplants (1.3-1.2 mm in diameter, 8 mm in length; Absoanchor SH1312-08; Dentos, Taegu, South Korea) were placed to maintain the superior archwire and ensure engagement of the posterior teeth. The anchorage microimplants were exposed and unrestored 14 months posttreatment.

3-dimensional computed tomography image showed a 3-dimensional computed tomographic image (D mode) of the ankylosed maxillary left central incisor.

**Table.** Cephalometric measurements

<table>
<thead>
<tr>
<th>Pretreatment</th>
<th>Posttreatment</th>
<th>14 months posttreatment</th>
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</thead>
<tbody>
<tr>
<td>FMA (°)</td>
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<td>53.3</td>
</tr>
<tr>
<td>FMA (°)</td>
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<td>27.2</td>
</tr>
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<td>IMPA (°)</td>
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<td>99.7</td>
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<td>AO-BO (mm)</td>
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<td>3.5</td>
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<td>Occlusal plane angle (°)</td>
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<tr>
<td>FH to U1 (°)</td>
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<tr>
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</tr>
<tr>
<td>U1 (°)</td>
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<td>69.2</td>
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<tr>
<td>Z angle (°)</td>
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<tr>
<td>FHI (PFH/AFH) (%)</td>
<td>67.0 (51.2/76.7)</td>
<td>67.0 (52.0/78.2)</td>
</tr>
</tbody>
</table>

**Fig 4.** Pretreatment periapical radiograph and 3-dimensional computed tomographic image (D mode) of the ankylosed maxillary left central incisor.
Korea) were implanted into the buccal alveolar bone between the maxillary second premolars and first molars. An elastic chain force was loaded immediately after placing the microimplants, from the maxillary posterior microimplants to the canine brackets to distalize the maxillary canines and the posterior teeth and to gain space for repositioning of the ankylosed maxillary left central incisor. Before the surgical intervention, the maxillary dental arch was stabilized by using an 0.018 × 0.025-in stainless steel archwire (Fig 5).

Under local anesthesia, a full-thickness incision was made in the unattached mucosa running horizontally from the maxillary right central incisor to the maxillary left lateral incisor, and the mucoperiosteal flap was reflected to expose the bone around the root of the ankylosed tooth. An osteotomy line was started 4 mm above the central incisor apex and interdentally with a fine round bur. An interdental osteotomy and a subapical osteotomy were performed around the maxillary left central incisor. An overcorrection of 1 mm was planned to account for continued vertical growth of the dentition and the potential for relapse (Fig 6).

The osteotomies were performed through the buccal cortex; the cuts involving the medullary and the palatal bones were completed with a thin osteotome. After adequate mobilization and repositioning of the tooth with the supporting bone through osteotomies, the maxillary left central incisor bracket was ligated onto the 0.018 × 0.025-in stainless steel archwire along the midline. The dento-osseous segment was kept wired to the arch, and a bone graft was performed (Fig 6).

One month after the surgical procedure, postoperative orthodontic treatment was begun and completed with an ideal archwire and an elastomer for closing the space (Fig 6). Twisted 3-strand 0.032-in wires bonded onto the lingual sides of the 4 anterior teeth, and a circumferential clear retainer were placed on the maxillary arch, just before and after removal of the appliances for retention, respectively (Fig 7). Total treatment time was 18 months.

TREATMENT RESULTS

The posttreatment facial and intraoral photographs showed that alignment and leveling of the maxillary
anterior teeth, except for a 1-mm overcorrection of the maxillary left central incisor, had improved the patient’s smile (Fig 7). The posttreatment casts illustrated good interdigitation of the teeth and acceptable overjet and overbite relationships (Fig 8). The posttreatment panoramic radiograph showed that good root parallelism was obtained, and the maxillary left central incisor was optimally positioned (Fig 9).

The periapical radiographs and the computed tomography image showed ongoing replacement resorption of the ankylosed maxillary left central incisor and correction of the bone level relative to the adjacent teeth (Fig 10). The posttreatment lateral cephalometric radiograph showed a well-balanced and harmonious face upon slight retraction of the lips, and the posttreatment posteroanterior cephalometric radiograph showed a coincident dental midline (Fig 9). As shown on the cephalometric superimposition (Fig 11), there were no significant changes in the skeletal measurements, and the maxillary incisors were uprighted to normal values; a good facial profile was obtained after treatment.

Fig 6. Interdental and subapical osteotomy for repositioning of the ankylosed maxillary left central incisor, wiring the dento-osseous segment to the arch and bone, and closing the space with elastomer.
There were no complications. The radiograph taken 14 months after treatment showed good bone and root aspects. The soft tissues were in excellent condition 14 months after the procedure. There was no significant evidence of relapse 14 months after treatment (Figs 11-14).

**DISCUSSION**

Ankylosis, the abnormal fusion of root cementum and surrounding bone, is a relatively common problem encountered in an orthodontic clinic, and it is a difficult problem for the patient and the orthodontist. It has been reported to be caused by endocrine or metabolic diseases, a genetic tendency, or local conditions such as periapical infections, trauma, or previous surgical procedures.

Ankylosis of the tooth root to alveolar bone is the most commonly reported periodontal ligament complication after replantation. Replantation of avulsed teeth is frequently complicated by dentoalveolar ankylosis. When ankylosis of a maxillary incisor that has been replanted after avulsion occurs in a growing patient, the ankylosed tooth fails to move along with the remaining alveolar process during vertical growth. The severity of malocclusion related to ankylosis depends on the developmental stage when ankylosis occurs, the amount of remaining growth, and the timing of treatment.

Ankylosis is diagnosed by a typical metallic sound during percussion, lack of normal mobility, and radiographic absence of the periodontal space. The clinical diagnosis of ankylosis is made when a tooth leaves the plane of occlusion and appears to submerge while all

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**Fig 7. Posttreatment facial and intraoral photographs.**
Fig 8. Posttreatment dental casts.

Fig 9. Posttreatment radiographs.
Fig 10. Posttreatment periapical radiograph and 3-dimensional computed tomographic image (D mode) of the ankylosed maxillary left central incisor.

Fig 11. Pretreatment, posttreatment, and 14-months posttreatment cephalometric superimposition: A, nonankylosed incisor; B, ankylosed incisor.
adjacent teeth continue their normal vertical growth. The diagnosis of ankylosis cannot be made on the basis of clinical or 2-dimensional radiographic evaluation alone, but requires 3-dimensional computed tomography imaging.

In this growing patient, the diagnostic evidence of ankylosis was made by both clinical and radiographic evaluations. The clinical and radiographic evidences of ankylosis were progressive infraocclusion of the ankylosed tooth, tipping of the adjacent teeth, a dental midline shift to the ankylosed side, occlusal disharmony, bone defects, ongoing replacement resorption of the root, and an unesthetic facial appearance during smiling.

Treatment methods for ankylosed teeth include no treatment, extraction and replacement with a prosthetic tooth or orthodontic space closure, surgical luxation, corticotomy, block osteotomy, distraction osteogenesis, and decoronation. Osteocorticotomy, or interalveolar segmental osteotomy, is a surgical technique in which the intact ankylosed tooth and adjacent bone with enough soft tissue to maintain the blood supply are repositioned in 1 step or moved orthodontically. A single-tooth dento-osseous osteotomy is a feasible procedure for maxillary ankylosed teeth, because of the favorable vascularity of the maxilla, and, although it is somewhat more complicated than the conventional replant procedure, it has a high likelihood of success.

Isaacson et al used a repositioning method and mobilized the ankylosed tooth with surrounding alveolar bone, but, because of stretch limitations of the
Fig 13. Posttreatment dental casts at 14 months.

Fig 14. Posttreatment radiographs at 14 months.
attached soft tissue, the segment could not be moved to the desired position. The distraction process was continued with 1-mm extrusion bends placed in the arch and repeated after 2 weeks to bring the segment to the occlusal level. Although distraction osteogenesis could be the most efficient technique in positioning ankylosed teeth, it also has some drawbacks. Distractors are bulky, expensive, and difficult to place in the dental region, and they require a second surgery for removal. Since the bone defect was moderate in the patient described in our study, we decided on the simpler treatment method of single-tooth osteotomy rather than distraction.

Epker and Wolford suggested the use of either a horizontal vestibular incision or multiple vertical incisions. We chose the horizontal incision because the magnitude of dentoalveolar segment displacement and soft-tissue tension would be moderate. The tooth to be repositioned should be in a vertical position, and a minimum space of 2 mm is necessary between its root and the adjacent teeth. Sufficient interdental space is needed to allow for an injury-free fine cut (osteotomy) between adjacent teeth, and to permit mobilization and repositioning of the dento-osseous segment while retaining an adequate amount of attached soft tissue that will maintain the blood supply to the tooth-bone segment. We wanted to gain an interdental space of more than 2 mm and to reduce the slight lip protrusion in our patient. Therefore, we used miniscrew anchorage to distalize the adjacent teeth and provide space to reposition the ankylosed tooth.

Retaining an ankylosed replanted tooth during jaw growth leads to arrested development of the associated alveolar ridge. Therapy is particularly challenging in patients in whom ankylosis of the front tooth occurs during alveolar growth. As the adjacent teeth erupt and the adjacent alveolar ridge develops, the ankylosed tooth is left in infraocclusion. The severity of the resulting ridge defect depends on the amount of facial growth after ankylosis. The extent of the defect correlates with the length of time an ankylosed tooth is retained during rapid growth in adolescence.

Ideally, this type of osteotomy would be performed after facial growth has been completed. However, if we had waited until the end of alveolar growth, the patient’s tooth would not have been in the correct position for at least 2 or 3 years. Since he was still growing, a slight overcorrection would have allowed the bone segment to be at the correct vertical osseous level. However, it was not possible to determine the exact amount of additional dentoalveolar development and overcorrection. Therefore, more long-term studies of dentoalveolar changes after tooth osteotomy in a growing patient are needed.

CONCLUSIONS

Single-tooth dento-osseous osteotomy with the aid of microimplant anchorage seems to be a viable procedure in the treatment of an ankylosed tooth when simpler forms of treatment might not be feasible or have failed. Our short-term results have been favorable.

REFERENCES


