Treatment of a severely ankylosed central incisor and a missing lateral incisor by distraction osteogenesis and orthodontic treatment

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Ankylosis is the fusion between the mineralized root surface and the alveolar bone. Tooth trauma is a common etiologic cause of ankylosis. In young patients, the ankylosed teeth fail to erupt along with the remaining alveolar process during vertical facial growth, resulting in submerged teeth and defects in the alveolar process. Extraction of the ankylosed teeth followed by prosthetic replacement is a common option for treatment. This case report presents the treatment of a woman with an anterior open bite and an ankylosed central incisor due to replantation of a traumatized tooth. We treated this ankylosed central incisor with subapical osteotomy and distraction osteogenesis for better tissue regeneration. After active orthodontic treatment and prosthetic restoration, her open bite was corrected, and she had a harmonious smile line. (Am J Orthod Dentofacial Orthop 2010;138:829-38)

Ankylosis is defined as the fusion of the mineralized root surface (cement or dentin) with the alveolar bone. Tooth ankylosis can occur in the deciduous or permanent dentition. Several factors, such as endocrine or metabolic diseases, periapical infections, trauma, and previous surgical procedures, are possible etiologies of ankylosed teeth. 1, 2 Severe luxation injuries such as avulsion or intrusion, which compromise periodontal ligament integrity, are the major etiologies of permanent incisor ankylosis. 3 Ankylosed central incisors at a young age can become a restorative nightmare in later years. As the alveolus grows around the ankylosed teeth, both incisal and gingival discrepancies occur. 4 Upon loss of these teeth, due to internal and external resorption, a large alveolar defect can remain and be an esthetic concern for both the patient and the restorative dentist.

There are several methods to treat tooth ankylosis: surgical resection and replacement with a fixed prosthetic tooth, implants, space closure through orthodontic tooth movement, surgical luxation to attempt to break the fusion between the cementum and the bone, 5 and surgical block osteotomies to allow rapid movement of a tooth or teeth with the block of bone. 6-10 However, with a severely ankylosed tooth, the tooth cannot be moved the entire distance necessary to reach the occlusal plane because of the limitations of the adjacent attached soft tissue. Therefore, surgical osteotomies in a severely ankylosed tooth are often followed by distraction osteogenesis. Distraction osteogenesis is a biologic process of new bone formation. This bone formation is between the surfaces of the bony segments, which are separated gradually by incremental traction. Distraction procedures can be used to reconstruct alveolar and gingival deformities with high efficiency and predictability. Bone regeneration can be also accomplished by moving the precut sections in any of the 3 dimensions.

DIAGNOSIS AND ETIOLOGY

A 21-year-old woman came to our orthodontic department with a chief complaint of an anterior open bite. She had no apparent medical problems; however, she had a history of facial trauma when she was 8 years old. Her maxillary left lateral incisor was missing at that time. Avulsion of the maxillary right and left central incisors occurred from this trauma. These teeth were replanted and fixed with wire and resin.

This patient had a slightly convex facial profile with a recessive chin. She also had insufficient lip closure and an asymmetric smile caused by ankylosis of the maxillary left central incisor (Fig 1). Intraorally, she
had Class I molar and Class II canine relationships on both sides, with 0.5 mm of overjet and a 9-mm anterior open bite. Her maxillary arch form was ovoid, and the mandibular arch form was square. The maxillary dental midline was 1 mm to the left of the mandibular dental midline, which was coincident with the facial midline. There were 5 mm of spacing in the maxillary arch and 1.5 mm of spacing in the mandibular arch. Anterior open bite and uneven gingival margin levels from the maxillary right lateral incisor to left canine were noted. Crown fracture and tooth discoloration were seen on the maxillary right central incisor (Figs 2 and 3). Ankylosis, infraocclusion, minimal buccal plate, and thin-scallop gingival biotype were noted with the maxillary left central incisor. The ankylosed tooth was displaced 9 mm short of the occlusal plane. Lack of a periodontal space was noted radiographically surrounding the maxillary left central incisor root (Fig 4). The residual ridge in the maxillary left lateral incisor area was thin, and there was no vertical development of the surrounding alveolar process and soft tissue from the maxillary right central incisor to the left canine.

The cephalometric analysis (Table) showed a skeletal Class I relationship (ANB angle, 3°) and mildly recessive chin (Pg-NB, –1 mm) with an average mandibular plane angle (FMA, 25°). The maxillary and mandibular incisors were relatively proclined compared with the cranial base. The soft-tissue analysis showed a slightly retrusive upper lip position relative to Ricketts’ esthetic line (E-line, –3 mm) and a slightly protrusive position of the lower lip relative to the E line (E-line, 1.5 mm). The periapical radiographs showed that the maxillary right and left third molars and the mandibular right third molar were impacted. Normal root length and bone heights were present except around the ankylosed tooth (Fig 4).
TREATMENT OBJECTIVES

Our treatment objectives were to (1) correct the anterior open bite and dental midline by extrusion of the maxillary anterior teeth, (2) achieve a dental Class I relationship in the canines, (3) obtain a normal incisor relationship, and (4) improve anterior esthetics by correcting the alveolar and gingival margins in the ankylosed region.

TREATMENT ALTERNATIVES

The patient’s chief complaint was an anterior open bite, and it was mainly due to ankylosis of the maxillary
left central incisor. There were 3 treatment alternatives for the ankylosed tooth: (1) extraction, (2) surgical luxation followed by orthodontic treatment, and (3) distraction of the tooth after single-tooth osteotomy.

Because the ankylosed tooth was in a high position with a thin buccal plate and a thin-scalloped gingival biotype, extraction of this tooth could have exaggerated the bone and soft-tissue deficiency. Moreover, it is an esthetic challenge to restore such a severe loss of bone and soft tissue in the maxillary anterior region.

Surgical luxation of this ankylosed tooth with an eruptive orthodontic force could also allow tooth movement. However, the tooth could reankylose even if the orthodontic force was applied immediately after surgical luxation. Therefore, a second surgery to loosen the ankylosed tooth would be needed.

Distraction of the ankylosed tooth after single-tooth osteotomy could bring the tooth and the adjacent alveolar process into the proper position. This procedure could solve the problems with the osseous and gingival margins. After the distraction and orthodontic treatment, a prosthesis could restore the maxillary anterior region to improve the patient’s smile.

After thorough deliberation of the advantages and disadvantages, the patient chose the third option.

### TREATMENT PROGRESS

Fixed preadjusted edgewise brackets with 0.022-in slots were placed on all teeth in both arches, with bands on the maxillary and mandibular first and second molars. A 0.016-in nickel-titanium archwire was placed for initial leveling, and elastomeric chains were used for space closure and consolidation. After alignment and stabilization of both dental arches, Class II elastics were worn to correct the Class II canine relationship. An open-coil spring was used to create adequate space (3 mm) between the roots of the maxillary right and left central incisors for interdental osteotomies. To ensure that the space for surgery was sufficient, a dental cast was fabricated before surgery.

Dental computed tomography was performed for preoperative evaluation and surgical planning in the Department of Oral and Maxillofacial Surgery of Chang Gung Memorial Hospital in Tao Yuan, Taiwan. The length of the maxillary left central incisor was 15.47 mm (Fig 5, B), and the distance between the root apex of the maxillary left central incisor and the floor of the nasal cavity was 10.1 mm (Fig 5, A). The horizontal cut (subapical osteotomy) was planned at the midpoint of the root apex and the floor of the nasal cavity (5.05 mm above the root apex; Fig 5, C).

A single-tooth osteotomy was performed under local anesthesia (Fig 6). After disinfection of the oral mucosa, a horizontal incision was made from the maxillary right lateral incisor to the maxillary left canine on the alveolar mucosa above the mucogingival junction. A full-thickness mucoperiosteal flap was reflected to expose the alveolar bone around the ankylosed tooth. Two vertical cuts were made divergent occlusally and facially (interdental osteotomy) between the maxillary left canine and the right central incisor. Then, the 2 vertical cuts were connected by a third cut (subapical osteotomy), positioned horizontally 5 mm above the root apex (20.52 mm from the incisor edge) by using a micro-sagittal saw (Micro-Saw System, ACE Surgical Supply, Brockton, Mass) (Fig 6, B).

During the cutting procedure, great care was taken not to injure the palatal mucosa. The alveolar segment was mobilized with an osteotome. After the ankylosed tooth was mobilized, a preshaped beta-titanium archwire with a 5 mm step-up bend was placed in the brackets of the partially repositioned tooth. The maxillary left central incisor was moved coronally by engaging the archwire (Fig 6, C). The mucoperiosteal flap was then closed and sutured (Fig 6, D).

After a 1-week latent period, the distraction procedure was started by adjusting the step bend in the archwire, application of a rubber band, and a change to

### Table. Cephalometric norms for a woman and the patient’s measurements before and after treatment

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Norm</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
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<td></td>
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<tr>
<td>SNA (°)</td>
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<tr>
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<td>3</td>
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<td>–2</td>
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<tr>
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<td>–1.5</td>
</tr>
<tr>
<td>Pog-NB (mm)</td>
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<td>–1</td>
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<td>Dental</td>
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<td>Lower lip to E-line (mm)</td>
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a nickel-titanium archwire for extrusion of the dento-osseous block (Fig 7). As the desired vertical position was reached (5 weeks after surgery), fine alignment was performed by using the “floating bone” concept. Then the surgical block was maintained with a 0.017 × 0.025-in stainless steel archwire with interdental elastics for 6 weeks. Endodontic treatment of the maxillary left central incisor was performed after a consolidation period. Crown lengthening was then performed over the maxillary right and left central incisors and the maxillary right canine to obtain a harmonious gingival line. The brackets and bands were removed after 23
months of active treatment. A single crown was placed on the maxillary right central incisor, and a bridge was fabricated between the maxillary left central incisor and the canine. Invisible retainers were placed in both arches immediately after debonding and debanding.

**TREATMENT RESULTS**

The posttreatment photographs (Figs 8 and 9) and dental casts (Fig 10) show normal overbite and overjet with a Class I occlusion. The dental midline was corrected after treatment. This patient was pleased with
her smile because of the open bite correction and the alignment of the maxillary anterior teeth. The periapical radiographs (Fig 11, B) show that the bone levels of the maxillary left central and lateral incisors relative to the adjacent teeth were corrected by the distraction osteogenesis. The panoramic radiograph confirmed that the roots of all teeth were parallel (Fig 11, C). The pre-treatment and posttreatment lateral cephalometric
radiographs were traced and superimposed (Fig 12) and show the dentoalveolar changes achieved with the os-
teotomy, distraction, and orthodontic treatment (Table).

The occlusion currently is stable with no anterior open bite 17 months after appliance removal (Figs 13 and 14).

DISCUSSION

Ankylosis often can be identified by the metallic sound when percussing the teeth, the lack of mobility, and the lack of periodontal space on the radiographic examination. Therefore, ankylosis should be suspected when an interruption in the periodontal membrane space is detected on a radiograph. However, if the area of ankylosis is small or located on the buccal or lingual surface of the tooth, it is difficult to identify on a 2-dimensional radiograph. By using digital sound wave analysis, the ankylosed incisors will exhibit a higher proportion of their signal energy in high-frequency bands, and this can be used for detection of the sound. But most of the time, the change in the percussion sound is hardly distinguishable. In addition, Periotest (Siemens/Medizintechnik-Gulden, Bensheim, Germany) can be used to assess tooth mobility. Ankylosed incisors have lower Periotest values. Unfortunately, clinical diagnosis of ankylosis, by mobility and percussion tests, is only reliable when at least 20% of the root surface is affected. The inability for the tooth to move is demonstrated as a failure of eruption during normal vertical growth. Vertical defects will then be found in the alveolar process and soft tissues surrounding the affected tooth.

In the past, an ankylosed permanent incisor was often treated with extraction and fabrication of a fixed or removal prosthesis or orthodontic space closure. However, removal of an ankylosed tooth is frequently accompanied by extensive loss of alveolar bone, particularly with a thin maxillary buccal plate. In this situation, the vertical defect of the adjacent tissue compromises the esthetics of prosthetic rehabilitation. Surgical osteotomies followed by distraction osteogenesis help to redevelop the alveolar process and the soft tissues in the correct position.

Previous reports have shown that distraction can be achieved with either an internal distraction device or orthodontic appliances to produce osteogenesis. Bone is deposited gradually in the former method, and the latter is performed in several larger steps. Although the tooth could not be moved the entire distance necessary to reach the occlusal plane because of the stretching limitations of the attached soft tissue during the surgery, additional undermining of the soft tissue was not an option because of the risk of interfering with the blood supply to the tooth and the alveolar

Fig 12. A, Superimposition of the initial and final cephalometric tracings; B, superimposition of the initial and final maxilla tracings; C, superimposition of the initial and final mandibular tracings.
The traction of the single-tooth osteotomy block can be repositioned to the desired position immediately by vertical extrusion bends, vertical elastics, a coil spring, a nickel-titanium wire, or a simple distraction device. In this case report, we used a nickel-titanium archwire to produce vertical repositioning of the tooth and the bony segment. A nickel-titanium alloy has excellent superelastic properties and can deliver a relatively constant and light force for physiologically desirable tooth movement.

When we treat an ankylosed tooth in a young adolescent, growth is a special concern. Since the approach treats the symptoms of anklylosis and does not correct the anklylosis itself, further vertical growth of the alveolar processes will naturally produce a further vertical deficiency. However, our patient was an adult with a severe ankylosed central incisor and a missing lateral incisor. Overcorrection was not necessary, since her facial growth had ceased. During the surgical osteotomy procedure, the smaller the block of teeth, the more limited the blood supply. The blood supply is critical to the preservation of vitality in a single-tooth block segment. For our patient, there was adequate space for the vertical and horizontal osteotomies at the surgical site because of the missing lateral incisor. The dental-osseous block in our patient was relatively larger in volume compared with segments reported in other articles to increase the blood supply and vertical bone volume augmentation in the affected area (9 mm vertical alveolar and soft-tissue defects).

Another issue in distraction is the 3-dimensional problem of moving a dental-osseous segment. In this patient, the bony cuts were slightly divergent occlusally and facially, so the segment could be rotated to obtain adequate anterior labial root torque. Moreover, we could change the inclination of the maxillary left central
incisor as desired. Additionally, bone segments form a callus and show microscopic union about 6 weeks after fixation. If healing produces a bony union of the separate parts, further distraction osteogenesis is not possible.

After distraction osteogenesis and orthodontic treatment, a 3-unit bridge from the maxillary left central incisor to the canine was fabricated to restore the missing maxillary left lateral incisor. There were 2 reasons for using a bridge to restore the missing tooth instead of an implant: the bone thickness in the missing tooth area was thin, and moreover, we could use the bridge to increase the stability of the maxillary left central incisor.

CONCLUSIONS

This case report illustrates the combination of single-tooth distraction osteogenesis and orthodontic treatment to treat a severely ankylosed maxillary left central incisor and a missing lateral incisor. The vertical deficiency of the alveolar process and soft tissues adjacent to the teeth were reconstructed by the distraction osteogenesis. Thereafter, a more esthetic prosthesis could be fabricated to obtain a better smile.

REFERENCES