Treatment of ankylosed maxillary central incisors by single-tooth dento-osseous osteotomy and alveolar bone distraction

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When tooth ankylosis occurs in growing children, the ankylosed tooth fails to erupt and gradually positions itself below the occlusal plane. This causes functional and esthetic problems, and orthodontic treatment is often impossible. To clarify this problem, we developed a new treatment protocol for the movement of ankylosed teeth. This consists of single-tooth dento-osseous osteotomy and alveolar bone distraction using orthodontic multibracket appliances. A special distraction device is not required, thus reducing the burden to patients. Two cases in which an ankylosed maxillary central incisor was successfully treated with this protocol are presented. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:561-567)

Traumatic injuries of the incisors often severely damage the periodontal ligament. In case of dental luxation, tooth replantation is usually performed, but the cementum of the affected root and alveolar bone are often fused together in the repair process, resulting in dental ankylosis.1 The denatured periodontal ligament and cementum on the root surface are resorbed by macrophages and osteoclastic cells, and new bone is produced by osteoblasts on the root surface without formation of a normal periodontal ligament. In long-term follow-up, replacement resorption of the affected roots often takes place.2-4 If dental ankylosis occurs in a growing child, the ankylosed tooth is unable to keep pace with the vertical growth of the alveolar bone and with the eruption of the adjacent teeth. This leaves the occlusal plane appearing to be submerged and often causes functional and esthetic problems.

Conventionally, the affected teeth are extracted and restored prosthodontically. Rapid movement of the ankylosed tooth along with the surrounding bone has also been performed by surgical block osteotomy,5-10 but significant gingival recession was reported.11

Recently, alveolar bone distraction was applied to move the ankylosed tooth and successful results were reported.11-13 However, various distraction devices were used in these reports. To clarify these problems, we developed a new treatment protocol for the movement of ankylosed teeth. This protocol consists of a single-tooth dento-osseous osteotomy and alveolar bone distraction using ordinary orthodontic multibracket appliances and not requiring a special distraction device. We also present 2 cases successfully treated with this protocol.

BASIC TREATMENT PROTOCOL

The techniques for surgical osteotomy and alveolar bone distraction are shown in Fig. 1.

Single-tooth dento-osseous osteotomy

Orthodontic multibracket appliances are placed in both maxillary and mandibular dentitions prior to surgery. A single-tooth dento-osseous osteotomy is performed according to Epker and Paulus,8 and often local anesthesia is administered into the labial vestibule and into the area of the nasopalatine nerve. The horizontal incision for the mucoperiosteal flap is made ≥5 mm above the level of the gingival margin of the ankylosed tooth. A mucoperiosteal flap is reflected to expose the anterior maxillary alveolar bone, and an additional 2 subperiosteal tunnels are elevated inferiorly at the mesial and distal sites of the ankylosed teeth to remove the interdental bone. Then vertical osteotomies are performed in the alveolar bone on both sides of the ankylosed tooth by using a small slender fissure bur. These osteotomies are made from the alveolar crest to ~5 mm above the root apex which is determined by the dental radiograph taken before surgery. A horizon-
A horizontal incision of the mucoperiosteal flap is made at least 5.0 mm above the level of the gingival margin of the ankylosed tooth. Preservation of bone under the piriform rim

Vertical osteotomies are performed in the alveolar bone on both sides of the ankylosed tooth and horizontal osteotomy is performed connecting the upper ends of two vertical osteotomies using a small, slender fissure bur.

A spatula osteotome and mallet are used to deepen the osteotomies from the buccal side until the palatal mucosa is revealed and mobility of the dento-osseous segment is secured.

Mobilization by rectangular orthodontic wire with one or two T-loops (force of traction: 300-400 g)

Fig. 1. Schematic illustration of the single-tooth dento-osseous osteotomy and alveolar bone distraction.

Distraction of the alveolar bone segment

Commencement of the alveolar bone segment distraction including the ankylosed tooth occurs 7-10 days after surgery following closure of the soft tissue incision. A rectangular orthodontic wire with 1 or 2 T-loops is applied to the brackets placed before surgery. T-Loops are designed to create distraction forces to move the mobilized segment and are activated ∼3 mm for vertical extrusion. The created force is estimated to be 300-400 g and activated at 1-week intervals. Intermaxillary elastics are used simultaneously to prevent the intrusion of the adjacent teeth when impaction of the adjacent teeth is suspected. The rate of movement of the segment usually decreases with bone healing, and remobilization of the segment with hand instruments under local anesthesia is required several times. After moving to the desired position, a rectangular plane archwire is placed for stabilization.

CASE 1

A 14-year-old female patient with an ankylosed left maxillary central incisor was referred from an orthodontic clinic to extrude the ankylosed left maxillary central incisor. It was positioned 3.0 mm below the other teeth which had been aligned with an orthodontic appliance (Fig. 2, A). The patient had a history of trauma caused by falling at the age of 9 years, and the incisor was injured and luxated. It was replanted immediately after the accident and treated endodontically. Although the periodontal ligament could not be detected in the radiograph taken before treatment, root resorption was not clear (Fig. 3, A). The diagnosis of tooth ankylosis had been confirmed by the inability to respond to orthodontic forces. To improve the anterior occlusion, 3-mm extrusion and 1-mm mesial movement with the surrounding alveolar bone was required, and alveolar bone distraction with single-tooth dento-osseous osteotomy was planned.

Single-tooth dento-osseous osteotomy and alveolar bone distraction were performed, according to the protocol. A mucoperiosteal flap was reflected to expose the anterior maxilla from the right central incisor to the left lateral incisor (Fig. 2, B). Two separate subperiosteal tunnels were created inferiorly on both sides of the tooth, and vertical osteotomies were performed from the alveolar crest 5 mm above the root apex. These vertical osteotomies were in a tapered form, and then horizontal osteotomy was performed. The soft tissue incision was closed with absorbable surgical sutures. A continuous 0.016 × 0.016 stainless steel archwire with 2 T-loops was placed in the brackets (Figs. 2, C, and 3, B).

Ten days after surgery, distraction of the segment including the ankylosed tooth commenced. A 3-mm activation of the loops was given initially and the loops were activated once every 7-14 days. The ankylosed tooth was moved to near the occlusal plane in 6 weeks, but mobility of the segment decreased because of bone healing. Remobilization of the segment with hand instruments under local anesthesia was performed (Fig. 2, D). At this time, the adjacent teeth showed slight intrusion and intermaxillary elastics were given (Fig. 2, E). Ten weeks after the initial surgery, the incisal edge of the tooth reached the desired position and the tooth was stabilized with a plane archwire (Fig. 2, F). Sixteen weeks after the surgery, new bone formation at the distracted site was confirmed in the radiograph (Fig. 3, C).

CASE 2

A 15-year-old male patient with an ankylosed right maxillary central incisor was referred from another orthodontic clinic to extrude the ankylosed tooth. He presented severe...
infraposition of the right maxillary incisor. It was positioned 7 mm apically relative to the adjacent left central incisor and was not fully visible in the oral cavity (Fig. 4, A). There was no apparent history of trauma in this case, but the tooth had not responded to orthodontic force. In this case, replacement resorption of the root was found in the periapical radiograph (Fig. 5, A). Because it was anticipated that extraction of the ankylosed tooth would cause alveolar bone loss, making future implant therapy difficult, we chose to do a single-tooth dento-osseous osteotomy with distraction.

A trapezoidal single-tooth dento-osseous osteotomy was made in the same way as in case 1. In this case, when the mucoperiosteal flap was reflected to expose the anterior maxilla, root resorption and lack of the alveolar bone were confirmed (Fig. 4, B). The resorption was found in the occlusal half of the labial root surface. A 0.016 × 0.022 stainless steel archwire with a T-loop was placed in the bracket was placed for stabilization (Fig. 4, C). After a 7-day latency period, the T-loop was activated and distraction was commenced. The initial amount of loop activation was 3 mm. Eleven days after surgery, movement of the segment slowed and remobilization was performed under local anesthesia. The archwire was changed to a new wire with 2 T-Loops and activated again once per week to extrude the segment (Fig. 4, D). Five weeks after surgery, vertical distraction was completed, and the third wire of the continuous 0.016 × 0.022 stainless steel archwire with 2 vertical-loops was placed for mesial movement of the tooth. The relationship of the 2 central incisors improved at 7 weeks after surgery (Fig. 4, E).

The distracted tooth showed no mobility, and the periapical radiograph revealed new bone formation around the dento-osseous segment (Fig. 5, B). Fifteen weeks after surgery, a TiNi plane archwire was placed and leveling of the maxillary teeth was resumed (Figs. 4, F, and 5, C).

DISCUSSION

Ankylosis of teeth occurs from anatomic fusion of tooth cementum or dentin with the alveolar bone. If dental ankylosis occurs in the growing stage, the ankylosed tooth fails to erupt and positions itself below the
occlusal plane. The symptom of ankylosis is occasionally visible in periapical radiographs as the absence of the periodontal ligament. However, this symptom is not clear if the ankylosed area is small or located on the labial or palatal root surface. Change in the percussion sound has been used to make a clinical diagnosis, but this method has limited objectivity. The most reliable method for diagnosis is application of orthodontic forces to the affected tooth.

The most conventional treatment of an ankylosed incisor is surgical removal of the tooth and replacement with fixed or removable prostheses. However, this method leaves a large alveolar bone defect and tends to be more severe when the ankylosed tooth has been surgically removed in the growing stage. This defect causes esthetic problems during prosthetic replacement and often results in a compromised treatment outcome. Recently, replacement with dental implants has been used for prosthetic restoration. However, this approach faces the same problem of the alveolar ridge defect and may require bone augmentation before implant placement. Surgical augmentation for a horizontal alveolar defect is a well documented procedure with high efficacy and predictability, whereas augmentation for vertical alveolar ridge defects is difficult because of the resistance of soft tissues. Surgical repositioning of the ankylosed tooth with surrounding alveolar bone is an alternative treatment option. However, this method has a limitation in the amount of movement due to the resistance of the attached gingiva. Blood supply for the single-tooth block segment is also another limiting factor. Moreover, recession of the gingiva usually occurs in the long-term follow-up.

Distraction osteogenesis is a technique for new bone formation without bone grafting. It was first reported by Ilizarov in the field of orthopedics in 1971 and introduced in the maxillofacial region by MacCarthy et al. in 1992. Numerous papers have reported using this technique to correct a wide range of facial deformities. In this technique, both hard and soft tissues are gradually stretched and lengthened over a period of the distraction process, and simultaneous soft tissue stretching is one of the advantages of this method. This has been used for alveolar bone augmentation aimed to make good prosthetic restorations with or without dental implants. Favorable clinical results of distraction treatments for dentulous or edentulous alveolar processes have been reported.

Several trials to treat ankylosed incisors using the distraction technique have been reported recently, with successful results. The advantages of distraction are no bone loss and preservation of blood supply via palatal mucoperiosteum. However, large distraction devices were used in those reports, and this required extensive surgical intervention and oral hygiene care after surgery. Surgeons are required to place the distractors accurately, because the available intraoral distractors are devised for linear lengthening and their direction largely affects the new bone formation. If the distractor is placed in the labial surface of the alveolar bone, the resistance of the palatal mucosa may cause a deviation of the distraction axis lingually. Additional
Fig. 4. Case 2 (male patient aged 15 years 4 months with an ankylosed right maxillary incisor). A, Before treatment: The right maxillary incisor was positioned 7 mm below the occlusal plane and half-impacted. B, Surgical procedure: The mucoperiosteal flap was reflected, and trapezoid osteotomy was performed. C, Immediately after osteotomy: A rectangular orthodontic wire with T-loops was used for stabilization first and then activated for vertical distraction at 7 days after surgery. D, Ten days after surgery: The single-tooth segment approached the occlusal plane, but the mobility of this segment decreased; remobilization of the tooth segment was performed under local anesthesia; a new archwire with 2 T-loops was placed. E, Seven weeks after surgery: Vertical distraction was completed, and a new archwire with 2 vertical loops was placed for the mesial movement. F, Fifteen weeks after surgery: The incisor had been moved to the planned position.

Fig. 5. Changes in periapical radiographs in case 2. A, Before treatment: Root resorption in the occlusal half of the root was noted. B, Seven weeks after surgery: Root resorption was clearly recognized. C, Fifteen weeks after surgery: The height of the mesial interdental alveolar bone was good, but it was low in the distal side, probably owing to the root resorption.
detachment of palatal mucosa to prevent this movement is difficult, because it interferes with blood supply to the tooth and alveolar segment.

As for the position control of the distraction, the floating bone concept has been advocated in mandibular distraction. In this concept, the distractors are removed before the final consolidation of newly formed bone, and mandibular position is controlled using intermaxillary elastics. Because the newly formed bone is still malleable at this stage, the mandible can be brought into the desirable position relative to the maxilla. Kinzinger reported application of the floating bone concept to the treatment of ankylosed teeth. The orthodontic force was used for fine adjustment of a postraumatic ankylosed tooth after removal of the distractor, and it showed a good esthetic and functional outcome. Kraft also found that the newly formed soft bone matrix could be slowly moved by applying constant firm pressure with the finger after removing the distractor. However, the alveolar segment sprang back to the palatal direction after this manipulation and miniplate fixation on the buccal side was required. This procedure needs a longer retention phase and another surgery to remove the miniplates.

In the present cases, ordinary orthodontic multi-bracket appliances were used for distraction, and large distractors were not used. Rectangular orthodontic archwires with T-loops were used for stabilization in the consolidation period and then activated for the distraction. The loops were activated at 7- to 14-day intervals. The archwires were replaced by a new one according to the desired direction, and plain rectangular wires were used for stabilization. Vertical elastics were used for the prevention or correction of the impaction of the adjacent teeth. In this technique, large expensive distractors are not used, with advantages in cost, oral hygiene, and patient’s comfort. However, the rate of the movement of the alveolar bone segments became slow with the bone healing and repeated remobilization of the segment under local anesthesia was required.

In the distraction procedure, the dento-osseous segment can be moved through the space where bone resorption is not necessary and the direction of movement is limited by the absence of bone obstruction. Therefore, planning of the osteotomy lines is very important. On the other hand, enough space for osteotomy is required to avoid injuries to the adjacent teeth, and the orthodontist has to provide adequate space for the osteotomies before surgical mobilization of the dento-osseous segment. In the present cases, the orthodontists who asked us for distraction treatment of the ankylosed teeth had prepared adequate space to perform osteotomies before surgery. The osteotomy lines were made in a trapezoid shape to move the segment to the desirable position. The width of the alveolar segment on the occlusal side was broader than that on the apical side.

Another advantage of this method is a good gingival margin of the treated teeth. In the present cases, the vertical level of the gingival margin was good after treatment without denudation of the root, and it harmonized with those in the adjacent teeth. In a one stage movement, severe gingival recession sometimes occurs resulting in severe esthetic problems. However, we found a surplus amount of gingiva after distraction between right and left central incisors in case 2. This was caused by mesial movement of the affected teeth. We plan to perform additional gingivoplasty after a follow-up period, if necessary.

The most important factor is the timing of the treatment during facial growth, because the ankylosed teeth treated by this method show no eruption after this treatment. The treated dento-alveolar segment remains in its position, and further vertical growth of the upper alveolar processes will cause recurrence of the symptoms. Therefore, the vertical alveolar distraction of an ankylosed tooth should not be performed until the patient’s vertical growth is complete. However, the esthetic problem caused by the ankylosed tooth sometimes leads to psychosocial problems. Early distraction might overcome these problems. Information regarding these unfavorable changes after distraction treatment should be given to the patients and their parents when young teenage patients desire to start this treatment. If the change after treatment is small, it could be camouflaged with prosthodontic restoration. However, in the case of large changes, the patient is subjected to the procedure again after completion of the vertical facial growth.

Root resorption is a major problem during the treatment of ankylosed teeth. In case 1, pulpotomy had been performed in the affected tooth, but root resorption was not clear before treatment. On the other hand, severe root resorption was found before treatment in case 2. Replacement resorption of the root frequently occurs in ankylosed teeth. It might occur even in case 1 in the future, and the survival times of the teeth are unpredictable. However, the alveolar bone height improved in our cases, and we consider that it will be helpful for future prosthodontic restoration, especially for the placement of a dental implant.

CONCLUSIONS

This report clearly demonstrates the usefulness of the combined surgical-orthodontic treatment using single-tooth dento-osseous osteotomy and segmental alveolar bone distraction for the treatment of ankylosed maxillary central incisors. This method needs no large distractor devices, and ordinary orthodontic multibracket appliances were used. The advantages of this method were 3-dimensional fine movement of the ankylosed tooth, prevention of alveolar bone loss and recession of
gingival margins, reduced time of the surgical intervention, patient’s comfort, and low cost. However, repeated remobilization of the segment under local anesthesia is required in the distraction procedure. The timing of surgical intervention should be determined carefully in growing children, and good collaboration between orthodontists and surgeons is essential to obtain successful results.

REFERENCES

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