Relocation of Infrapositioned Ankylosed Teeth: Description of Orthodontic Bone Stretching and Case Series

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Different treatments have been proposed to manage the consequences of ankylosed teeth. This clinical report, which includes several different clinical conditions, describes an orthodontic bone-stretching procedure that can be used to relocate ankylosed teeth. The orthodontic bone-stretching technique involves only partial osteotomies, without the mobilization or repositioning of the alveolar segment, combined with orthodontic forces. The applied force facilitates tooth movement to the occlusal plane and can modify the axis of the ankylosed tooth. This relocation is possible because of a bone-stretching phenomenon in the surgical area. In all of the cases, relocation of the ankylosed teeth was successfully performed and the gingival margins were corrected to improve the esthetic results.

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Severe injuries of the periodontal ligament, frequently the permanent maxillary incisors in children, may lead to the ankylosis phenomenon, resulting in fusion between the mineralized root surface and the alveolar bone.1,2 Such ankylosis disturbs dentoalveolar development during growth. In fact, an ankylosed tooth in a growing child does not erupt, resulting in a vertical insufficiency of osseous growth, which can lead to infraclusion, an esthetic smile, and occlusal disharmony. Therefore, a patient with an ankylosed tooth might require treatment for infraclusion and alveolar bone deficiency.

Ankylosis is clinically diagnosed by acute sound percussion (tooth resounding like crystal) and lack of mobility in comparison with dull sound percussion and physiological mobility of the adjacent unaffected teeth (the periodontal ligament absorbs sound and allows mobility). A Periotest device (Siemens AG, Bensheim, Germany) is an instrument for the quantification of tooth mobility and can be used to confirm ankylosis. An electronic tapping head percusses the teeth. Ankylosed teeth have a shorter contact time, resulting in lower Periotest values than those for intact or mobile teeth.3 Ankylosis also can be discovered or confirmed during orthodontic treatment by tooth immobility under an applied orthodontic force. Moreover, ankylosis can be confirmed by radiographic evaluation, showing a lack of ligament space.

Several alternatives exist to treat the consequences of ankylosed teeth. The first solution is extraction of the ankylosed tooth. Rehabilitation can be conducted with a bridge, but periodontal surgery (gingival graft) might be necessary to improve the mucosal volume of the ridge.4 Treatment using a dental implant also can be used after extraction. However, bone regeneration with grafting may be necessary for vertical and...
lateral bone augmentation before implant placement.\textsuperscript{5,6} This surgical treatment represents the best management for ankylosed teeth with severe root resorption, root fracture, or infection, usually leading to a poor prognosis.

A second treatment option involves the conservation of ankylosed teeth on the arch. However, relocation to a correct position needs a surgical option because orthodontic treatment alone cannot correct the position of the ankylosed tooth. Surgical luxation,\textsuperscript{7} segmental osteotomy with distraction,\textsuperscript{8,10} and segmental osteotomy with repositioning\textsuperscript{11} are possible alternative treatments. However, de Souza et al\textsuperscript{12} reported the lack of a high level of evidence for treatment options and the management of ankylosed anterior teeth.

Recently, a new orthodontic technique using bony block movement was presented for the treatment of ankylosed teeth with promising results.\textsuperscript{13} The aim of this clinical report is to describe an alternative surgical technique of orthodontic bone stretching (OBS) for the management of ankylosed teeth in different clinical situations.

The surgical procedure is performed using a Satelec Piezotome 2 with BS1 or BS5 slim tips (Acteon Group, Mérignac, France). One buccal vertical interdental osteotomy cut is performed on either side of the ankylosed tooth in the same axis of the root maintaining a safe distance from the adjacent teeth. Next, the 2 vertical cuts are connected through a third cut that is positioned in a subapical manner to the root apex of the ankylosed tooth.

The osteotomy involves the buccal cortex and cancellous bone preserving the palatal cortex intact. Therefore, no mobility of the sectioned dento-osseous complex is observed (Fig 1). For occlusal movement, ultrasonic cuts are generated on the buccal side. In contrast, for palatal movement, the cuts are generated on the palatal side. The mucoperiosteal flap is repositioned and sutured (Vicryl No. 4-0 and 5-0; Ethicon, Issy-Les-Moulineaux, France).

Immediately after the surgical procedure, heavy orthodontic traction on the ankylosed tooth is performed. It is important to know the precise direction of the movement executed on the dento-osseous complex, which must be in the same axis of the corticotomies. The force must not exceed the anchorage value of the adjacent teeth.

The patient is prescribed amoxicillin (1 g 2 times a day for 6 days), prednisolone (60 mg for 3 days), acetaminophen (1 g 3 times a day for 3 days), and a 0.12% chlorhexidine solution (rinsing twice a daily starting 24 hours after surgery for 10 days). The sutures are removed after 10 days. Continuous force must be applied to the ankylosed tooth, and the patient undergoes traction reactivation every 2 weeks until tooth repositioning is achieved. Movement of the dento-osseous complex is observed after 1 to 4 weeks. When the ankylosed tooth reaches the occlusal plane, an arch wire retainer is inserted for a period of 6 months to monitor the evolution. After removal of the appliance, a wire is bonded to the incisors and canines, including the ankylosed teeth.

The presurgical preparation

First, orthodontic treatment was conducted for dysmorphosis correction, excluding ankylosed teeth. Second, a specific orthodontic preparation was performed before the surgical treatment (anchorage control, generation of an open space around the ankylosed tooth, and alignment of the anterior gingival margins).

Before surgery, dental computed tomography must be performed to evaluate the position of the roots in 3 dimensions for surgical planning. The distance of the ankylosed tooth from the adjacent teeth, the axis of the ankylosed tooth, and the bone volume are important factors for positioning the corticotomy. Bone density and cortical thickness are evaluated to secure the osteotomy, which extends through the cortical bone, penetrating into the cancellous bone. Before surgery, an orthodontic attachment is bonded to the labial or palatal crown surface of the ankylosed tooth.

The surgical procedure

With the patient under local anesthesia, a buccal sulcular incision and 1 or 2 vertical releasing incisions are made on the distal side of the teeth adjacent to the ankylosed tooth. A full-thickness mucoperiosteal flap is reflected to expose the alveolar bone.

**FIGURE 1.** Schema showing partial buccal cuts: frontal view and lateral view. The corticotomies run deep, but the palatal cortical bone is preserved.

CASE 1

A healthy 15-year-old boy was referred for ankylosed upper left central incisor repositioning. He had intrusion of the tooth at the age of 12 years followed by immediate repositioning and splinting for a few weeks and subsequent endodontic treatment. At age 14 years, the tooth was diagnosed as ankylosed to the maxilla during subsequent orthodontic treatment.

Plaque control was not ideal, but there was no periodontal disease, except for gingivitis located in the maxilla (Fig 2). After clinical diagnosis, cone-beam computed tomography (CBCT) radiographs confirmed the ankylosis (Fig 3).

After orthodontic preparation, with exclusion of the ankylosed tooth (Fig 4), a dysmorphosis correction led to the infraclusion of the ankylosed central incisor. A rate of 3 mm with an index of infraposition of 2 (moderate) according to the Malmgren and Malmgren classification was diagnosed. The treatment plan included ankylosed tooth repositioning with OBS after orthodontic preparation (anchorage and generation of an open space to facilitate tooth repositioning without obstruction). CBCT was used to diagnose the ankylosis, resorption area, and apical fenestration under the nasal spine, as well as to determine the ideal space to relocate the ankylosed tooth. The tooth axis indicated vertical and low palatal traction.

Before surgery, orthodontic brackets were bonded onto the labial and palatal crown surfaces to facilitate immediate tooth traction. OBS was performed as described previously: One vertical osteotomy on each side of the roots was performed, and a horizontal osteotomy was made apically connecting the 2 vertical

FIGURE 2. Intraoral photograph before orthodontic treatment in case 1.

FIGURE 3. Cone-beam computed tomography of left central incisor in case 1. Ankylosis was confirmed. A, anterior; P, posterior.
osteotomies (Fig 5). The depth of the corticotomies was increased to decrease the strength of the block and to facilitate movement. Immediately after surgery, orthodontic traction was introduced with a correct axis. Palatal and vestibular strengths were used alternately or in combination (Fig 6). No complications were encountered during or after surgery or during the orthodontic traction period. After 2 months of reactivation, the ankylosed tooth was correctly repositioned and orthodontic retention was performed (Figs 7A, B). Importantly, vertical bone augmentation was achieved with simultaneous soft tissue augmentation with optimal gingival margin alignment. Plaque control was improved to produce healthy periodontal tissues (Fig 7C).

CASE 2

A 17-year-old boy was treated for an anterior open bite with atypical swallowing and a mouth-breathing habit. When orthodontic treatment began, the right maxillary incisors were immobile despite the application of orthodontic forces, leading to maxillary arcade intrusion (Fig 8). The dental history included trauma to the right maxillary incisors from a bicycle fall at the age of 14 years. CBCT imaging showed root resorption and lack of the periodontal ligament to the right maxillary incisors, confirming ankylosis of the teeth (Fig 9). The diagnosis was ankylosis of the right maxillary incisors with apical and internal resorption of the central incisor. The results of vitality tests were positive. After an endodontic consultation, it was decided to monitor the evolution of the resorption and to relocate the teeth.

In a first step, the treatment objectives included correction of the posterior crossbite, Class II malocclusion, and tongue thrust, as well as obtaining a normal incisor relationship. A leveling process and an alignment phase were completed, with exclusion of the 2 ankylosed teeth (Fig 10). The index of infraposition was 4 (extreme). The second step included repositioning of the ankylosed incisors with OBS.

Immediately before surgery, a stainless steel arch wire was placed on the maxilla and on the mandible. Moreover, a nickel-titanium arch wire (round, 0.016 × 0.016 inch) was placed on both of the maxillary ankylosed teeth and was superimposed on the main arch. This arch wire applied a continuous orthodontic force to the ankylosed teeth. With the patient under local anesthesia, the mucoperiosteal flap was reflected, and the same surgical procedure (OBS) was conducted. The mucoperiosteal flap was repositioned and sutured (Fig 11). The appliance was activated immediately and every 2 weeks. When the ankylosed teeth reached the occlusal plane and when the orthodontic treatment was concluded, a final 0.021 × 0.025-inch stainless steel arch wire was inserted and retained for a period of 6 months (Fig 12).

The total treatment time to relocate the teeth to the occlusal plane was 4 months, followed by 6 months of
retention. After removal of the appliance, the anterior maxillary teeth were stabilized with a lingual bonded retainer. The maxillary anterior gingival margins were improved, and alignment and leveling were completed in both arches. A normal overjet and overbite improved the midline coincidence, and Class I molar and canine relationships were obtained. The post-treatment panoramic radiograph showed that the roots of the teeth were relatively parallel with stable root resorption, except for the upper right canine,


which presented moderate external apical root resorption. The superimposition of the pretreatment and post-treatment lateral cephalometric tracings showed an overall vertical increase of the alveolar segment, and point A could not be considered because it was supported by the corticotomy (Fig 13). In addition, the right maxillary incisors were retroclined and extruded because of the alveolar segment movement.

At the 24-month post-treatment visit, the treatment result was stable with some gingival recession (<0.5 mm) on the right central incisor. The periodontal status did not show pathology, but the lack of plaque control aggravated the existing enamel defects. Cosmetic treatment of the anterior maxillary teeth was performed (Fig 14). A 2 years’ follow-up, CBCT comparison showed interdental alveolar bone movement to the occlusal plane and stable root morphology with internal resorption (Fig 15).

CASE 3

A 12-year-old girl presented with immobility of the maxillary central incisors despite active orthodontic treatment (Fig 16A). The OBS procedure was performed after flap elevation (Fig 16B). In this case, the intended movement was in the labial and distal direction. The bone cuts separating the 2 teeth were thin for the interdental corticotomy (BS1 and RD2 tips; Acteon Group), and the bone cuts were broader for the distal and apical corticotomies to improve movement (SL1 tip; Acteon Group). Immediately after surgery, a spring was placed between the central incisors. After 1 month of application of orthodontic forces, the space between the 2 incisors...
was increased and the incisors were correctly repositioned (Figs 16C, D).

Despite the teaching of oral hygiene technique, plaque control remained very poor, with the consequent occurrence of gingivitis. A temporary esthetic treatment of the crowns was performed with composite restoration. The gingival defect was corrected with papilla regeneration (Fig 17). Comparison of the
panoramic images showed interdental alveolar bone stretching and movement of the teeth (Fig 18).

Discussion

Extraction of ankylosed teeth does not compensate for the alveolar hypo-development resulting from lack of growth and can lead to a complex bony ridge defect. For esthetic rehabilitation, vertical bone augmentation by tissue regeneration or bone grafting is often necessary. These techniques have not shown reproducible or optimal results. Given the low number of patient treatments reported in the literature, the use of such vertical bone augmentation is limited. Conserving the tooth on the arch and moving it to the occlusal plane could be a better treatment option.

For the relocation of ankylosed teeth, a segmental osteotomy is performed, as shown in case reports. The immediate mobilization and repositioning of the alveolar segment, associated with or without bone grafts, comprise a different technique with good results. For this procedure, maintenance of the soft tissue attachment to the bone is an important limiting factor for vascularization and immediate movement of the dento-osseous complex. To enable a gradual and slower soft tissue stretching, an osteotomy associated with a distraction device has been proposed to treat ankylosed teeth. Although adequate results have been reported, these techniques use a specific device that is sometimes complex and constraining. Furthermore, distractors have a unidirectional impact with heavy strengths (distraction rate of 0.5 to 1 mm/d); these techniques poorly predict movement in the sagittal direction and can lead to incorrect distraction vectors.

In OBS the osteotomy is limited to the buccal side of the alveolar bone. Vascularization is ensured by the presence of the palatal bone and the attached soft tissues. The surgical area is completely immovable because the osteotomy is not complete. This less traumatic technique facilitates the movement of ankylosed teeth toward the occlusal plane, reflecting several phenomena. The cortical section decreases the resistance of the dental bone block. Before surgery, the orthodontic force does not move the ankylosed teeth and can lead to the intrusion of adjacent teeth. The anchorage of the arch is too low, and the resistance of the ankylosed tooth is too high. The partial buccal osteotomies facilitate the effect of orthodontic forces on the palatal cortical bone. In accordance with the Frost principle of the healing response, the relocation of the ankylosed tooth without ligament movement is permitted by bone movement. The OBS technique appears to be a bone-stretching phenomenon using ankylosed teeth as anchorage points.

This result is different from bone distraction. Indeed, in OBS it is important not to wait for the formation of bone callus in the area of the partial osteotomies. The applied forces are immediate and continuous, preventing healing in the area of the bone cuts and stretching the residual palatal bone. The use of a system to stabilize the block is not necessary, and the attached orthodontic device only induces and directs the movement into the desired axis.
Animal studies showed that a corticotomy increased the turnover of alveolar bone. Sebaoun et al.\textsuperscript{22} reported that catabolic and anabolic activities were 3 times greater in the area adjacent to the cut. The osteoclast count and quantity of bone apposition were higher in this area. Bone fill increased using the Piezotome compared with conventional instrumentation (bur or saw blade), leading to considerably higher bone activity and mineral density.\textsuperscript{22} This phenomenon is biological, but the clinical effect was not demonstrated and clinical studies are needed to confirm differences. An increase in the expression of the genes involved in

\begin{figure}
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\includegraphics[width=\textwidth]{figure14.png}
\caption{A, B, Intraoral photographs at 24 months after treatment in case 2: frontal view (A) and occlusal view (B). C, Photograph after esthetic treatment of enamel defects.}
\end{figure}

\begin{figure}
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\includegraphics[width=\textwidth]{figure15.png}
\caption{Cone beam radiographs after surgery and at 2 years after treatment in case 2. The interdental alveolar bone around the right incisors was moved using the orthodontic bone-stretching technique.}
\end{figure}
bone healing also was reported. This modification of activity is important for rapid orthodontic movements. Wilcko et al. used these techniques and proposed that during the healing process, rapid tooth movement results from bone remodeling and pressure on the periodontal ligament and its hyalinization, facilitating tooth movement in bone.

For the relocation of ankylosed teeth by the OBS technique, with the lack of the periodontal ligament, only the biological bone phenomena associated with ultrasonic corticotomy may be present near partial osteotomies and can accelerate the bone-stretching movement in the area of the cuts, near the preserved cortical bone. The result of this strict bone movement is repositioning of the tooth in the arch through orthodontic traction. In the block of 2 ankylosed teeth (case 2), the right interincisor crestal level moves with the block, and this phenomenon was confirmed after comparison of the CBCT radiographs. The slow bone movement (approximately 2 mm per month) allows for the adaptation of the soft tissue.


FIGURE 17. Intraoral photographs after relocation of maxillary central incisors, as well as temporary esthetic treatment for crown reconstruction, in case 3. A, Frontal view. B, Occlusal view.


Orthodontic preparation is essential and is associated with the adequate management of the tissue around the ankylosed tooth. On the basis of our experience, we think that more than 2 mm between the roots of adjacent teeth should be sufficient to allow for thin partial osteotomies, while leaving enough bone on each side to prevent vascularization of the septum. The use of an ultrasonic saw with a slim profile is preferred for precise surgery.

As the maxilla grows in the vertical direction, the ankylosed tooth and alveolar segment remain in infraclusion in most cases because there is no additional alveolar growth at the ankylosed tooth site. After orthodontic treatment of an ankylosed tooth, the functional and esthetic results may not remain stable over time if the jaw continues to grow. The continuous growth of a patient must be considered when planning the treatment. The degree of such infraclusion depends on individual growth, age, and gender.25 Slight overtreatment could be a solution to compensate for this phenomenon.

The OBS technique is a viable procedure for the treatment of ankylosed teeth. This surgical procedure seems to facilitate tooth positioning in 3 dimensions. Gingival margins can be corrected as necessary for improving esthetic results. Clinical trials are necessary to support clinical practice and to compare OBS, osteotomy, and distraction.

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