Case Report

Moving an Ankylosed Central Incisor Using Orthodontics, Surgery and Distraction Osteogenesis

Robert J. Isaacson, DDS, MSD, PhD[a]; Robert A. Strauss, DDS[b]; April Bridges-Poquis, DDS[c]; Anthony R. Peluso, DDS[d]; Steven J. Lindauer, DMD, MDSc[e]

Abstract: When a dentist replants an avulsed tooth, the repair process sometimes results in the cementum of the root and the alveolar bone fusing together, with the replanted tooth becoming ankylosed. When this occurs, the usual process of tooth movement with bone deposition and bone resorption at the periodontium cannot function. If dental ankylosis occurs in the maxillary incisor of a growing child, the ankylosed tooth also cannot move vertically with the subsequent vertical growth of the alveolar process. This results in the ankylosed tooth leaving the plane of occlusion and often becoming esthetically objectionable. This report describes a 12-year-old female with a central incisor that was replanted 5 years earlier, became ankylosed, and left the occlusal plane following subsequent normal vertical growth of the alveolar process. When growth was judged near completion, the tooth was moved back to the occlusal plane using a combination of orthodontics, surgical block osteotomy, and distraction osteogenesis to reposition the tooth at the proper vertical position in the arch. This approach had the advantage of bringing both the incisal edge and the gingival margin of the clinical crown to the proper height in the arch relative to their antimeres. Previous treatment procedures for ankylosed teeth have often involved the extraction of the affected tooth. When this is done, a vertical defect in the alveolar process results that often requires additional bone surgery to reconstruct the vertical height of the alveolar process. If the tooth is then replaced, the replacement tooth must reach from the final occlusal plane to the deficient ridge. This results in an excessively long clinical crown with a gingival height that does not match the adjacent teeth. (*Angle Orthod* 2001;71:411–418.)

Key Words: Distraction osteogenesis; Ankylosis; Incisor; Gingival height

INTRODUCTION

Ankylosis is defined as a stiffness or fixation of a joint. The periodontium is a joint, and dental ankylosis is the inability of a tooth to move at the periodontal articulation. This condition results from the fusion of some portion of the cementum of the root, no matter how small, to some portion of the adjacent alveolar bone. In an area of ankylosis, the cementum of the root and the alveolar bone microscopically appear as one continuous structure.

[a] Professor, Department of Orthodontics, Virginia Commonwealth University, Richmond, Va.

[b] Associate Professor, Department of Oral and Maxillofacial Surgery, Virginia Commonwealth University, Richmond, Va.

[c] Private practice, Richmond, Va.

[d] Private practice, Virginia Beach, Va.

[e] Norborne Muir Professor and Chair, Department of Orthodontics, Virginia Commonwealth University, Richmond, Va.

Corresponding author: Robert J. Isaacson, Department of Orthodontics, School of Dentistry, 520 North 12th St, Richmond, VA 23298-0566.
(e-mail: risaacson@vcu.edu).

Accepted: February 2001. Submitted: December 2000.

The clinical diagnosis of ankylosis can be made only when the affected tooth gives positive evidence of an inability to move. The inability to move is demonstrated either as a failure of the tooth to move with normal vertical dental alveolar growth or a failure of the tooth to move when the tooth is subjected to an orthodontic force system. The clinical diagnosis of ankylosis is made when a tooth leaves the plane of occlusion and appears to submerge while all of the adjacent teeth continue their normal vertical growth. This gives the clinical impression of the ankylosed tooth submerging into the alveolar process.

Theoretically, ankylosis should be visible on a dental radiograph as an interruption in the periodontal membrane space. However, claims that dentists can positively diagnose dental ankylosis on 2-dimensional radiographs have not been reproducibly documented. The area of ankylosis can be very small and easily located elsewhere on the root surface than the minimal area visible in a 2-dimensional radiograph.

The development of 3-dimensional imaging systems, such as computer-assisted tomography, offers an expectation of the ability to see small areas of cementum and root fusion, but this technology is not in wide-scale use.[1] The claims that changes in the sounds associated with the percussion of ankylosed teeth can be used to diagnose ankylosis have never been objectively documented.

The process of ankylosis appears to involve inflammation of the periodontal membrane, with the repair process involving an invasion by osteoclastic cells that resorb areas on the root surface. The subsequent repair of these areas may result in a fusion between the alveolar bone and the root surface. Ankylosis is a common complication associated with the replantation of an avulsed maxillary incisor.

In the past, an ankylosed permanent incisor was often surgically resected and replaced with a fixed or removable prosthetic tooth. Since the diagnosis of ankylosis is made subsequent to the failure of vertical alveolar growth, a significant vertical alveolar defect was often present by the time the diagnosis was made. Such a vertical alveolar defect makes an esthetic prosthetic replacement difficult and often results in a compromised esthetic outcome. More recently, replacements are being done with dental implants. This approach faces the same clinical vertical alveolar ridge defect problem and may require reconstruction and augmentation of the alveolar ridge to obtain acceptable esthetic results.

Other methods of treating ankylosed teeth have included surgical luxation to attempt to break the fusion between the cementum and the bone. While conceptually valid, this approach is followed by a repair process that usually results in a recurrence of the ankylosis as the surgical luxation is repaired.

The use of surgical block osteotomies to allow rapid movement of a tooth or teeth in a block of bone has been reported a number of times in the literature.[2–7] Another surgical approach that has been reported involves corticotomies, where only the cortex of the bone is cut and orthodontic appliances are used to move the tooth over a period of a few weeks following the surgery.[8–10] This approach is very similar to and could be easily considered the harbinger of recent distraction osteogenesis procedures.

This article presents the case of a 12-year-old female with a maxillary left central incisor that had left the occlusal plane and had a history of trauma 5 years earlier. The traditional option of extraction and prosthetic replacement was rejected in favor of an attempt to reposition the tooth using orthodontics, surgery and contemporary distraction osteogenesis techniques.

The patient was followed until physical growth appeared to be slowing and, at that point, orthodontic appliances were constructed. Following treatment of other unrelated orthodontic problems and orthodontic surgical preparation, the ankylosed tooth was treated.

The ankylosed tooth was surgically mobilized with dental burs and chisels and repositioning attempted. However, the tooth could not be moved the entire distance necessary to reach the occlusal plane due to the limitations of the stretch of the attached soft tissue. Additional undermining of the soft tissue was not an option due to the risk of interfering with an adequate blood supply to the individual tooth and alveolar segment. An arch wire was modified, placed in the bracket on the partially repositioned tooth, and the soft tissue was closed.

The arch wire was similarly modified again after a 2-week interval to gain further vertical repositioning of the tooth and bony segment. The arch wire modifications were simple 1-mm extrusive steps designed to create distraction osteogenesis forces able to move the mobilized tooth and bony segment before the bone at the surgical site was healed. After reaching the desired vertical position, the tooth was stabilized with the arch wire. The spaces associated with the adjacent teeth that had been clinically repositioned to facilitate the surgery were then closed to complete the orthodontic treatment.

CASE REPORT

A 12-year-old female presented with a severely ankylosed left maxillary central incisor (tooth 21), displaced 4 mm apically relative to the adjacent central incisor. The clinical diagnosis of ankylosis was confirmed by the inability of the tooth to respond to orthodontic forces.

The patient had a history of trauma to this tooth. At age 7, she had avulsed the tooth and her general dentist replanted it within 30 minutes of the accident. Her other orthodontic problems included bilateral palatally impacted maxillary canines, 13 and 23, and mild crowding of the upper and lower dentition (Figure 1A–F).

The presurgical orthodontic treatment plan included surgical exposure and placement of orthodontic appliances to move the palatally impacted maxillary canines into the arch. Standard preprogrammed 0.018″ edgewise appliances were placed in both arches and routine orthodontic leveling and alignment of the arches accomplished. The palatal canines were brought into the arch with long arms in the form of segmented arch wires (Figure 2A,B).[11] When this was complete, the roots of the canines were torqued facially over the next 15 months of treatment with torquing springs (Individual Root Torquing Auxiliary, TP Orthodontics, Le Port, Ind) placed in vertical slots in the brackets.

During the initial orthodontic treatment, the primary goal was to bring the palatally impacted maxillary canines into the arch. The ankylosed left central incisor, 21, was used as an anchor while gaining space for the extrusion of the left canine. Power chains were placed between the ankylosed left central incisor and the left lateral incisor, 22, to pull tooth 22 to the mesial and away from the extruding canine (Figure 2A). Tooth 21 did not move during this time, confirming the clinical diagnosis of ankylosis.

Prior to the osteotomy, a push coil was placed between teeth 11 and 22, by-passing the ankylosed tooth, to create extra space to facilitate the surgeon's osseous cuts (Figure 3A,B). This flared the adjacent teeth and created excess overjet at teeth 11 and 22. A 0.16″ × 0.22″ titanium mo-

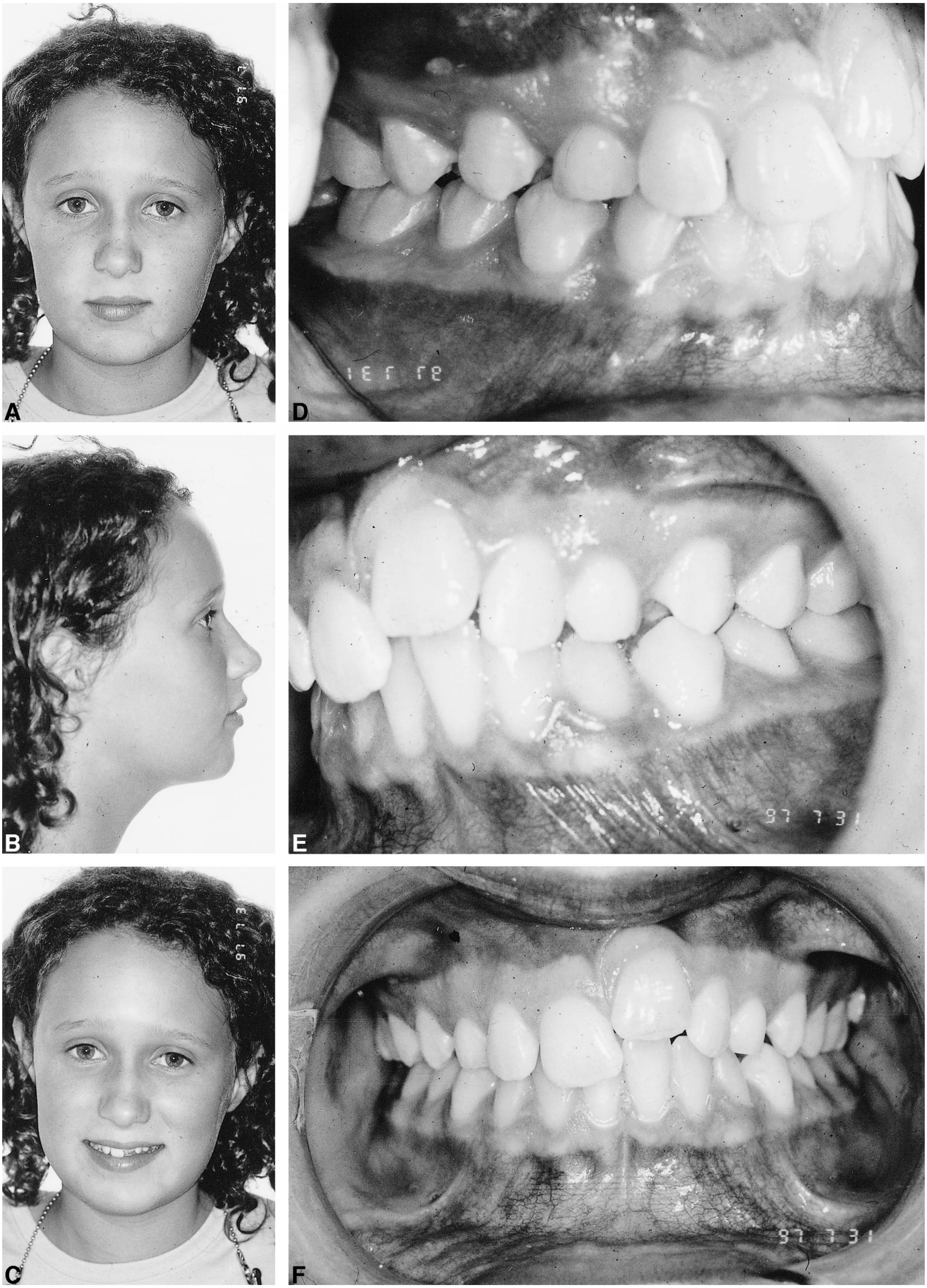

FIGURE 1. Starting records: (A) full face, (B) profile view, (C) smiling full face, (D) dentition, right lateral view, (E) dentition, left lateral view, (F) dentition, frontal view.

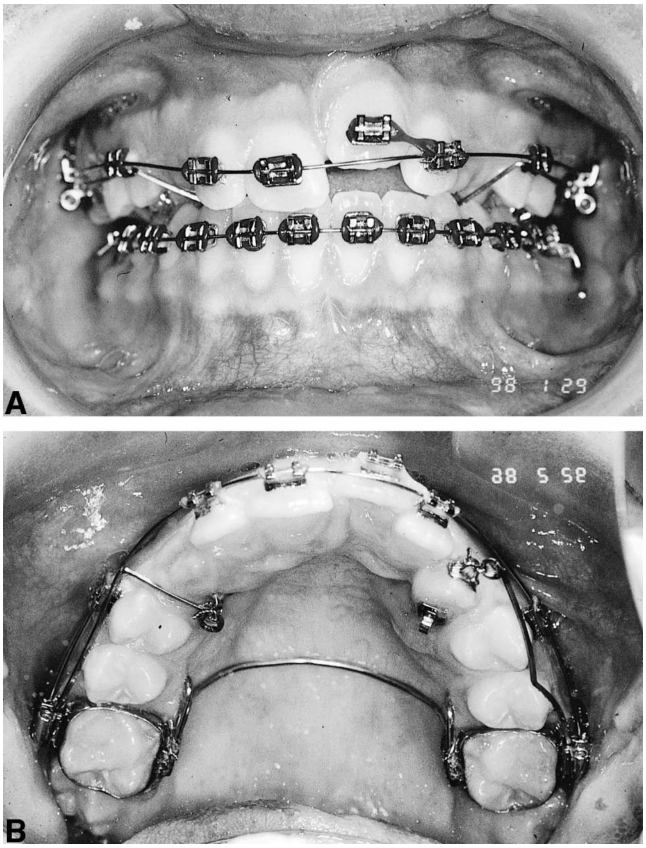

FIGURE 2. Long arm segments bringing in palatally impacted canines.[11] (A) Frontal view, (B) Occlusal view. Note ankylosed central incisor being used as a fixed point to move the lateral incisor mesially to make extra arch perimeter space for the left canine.

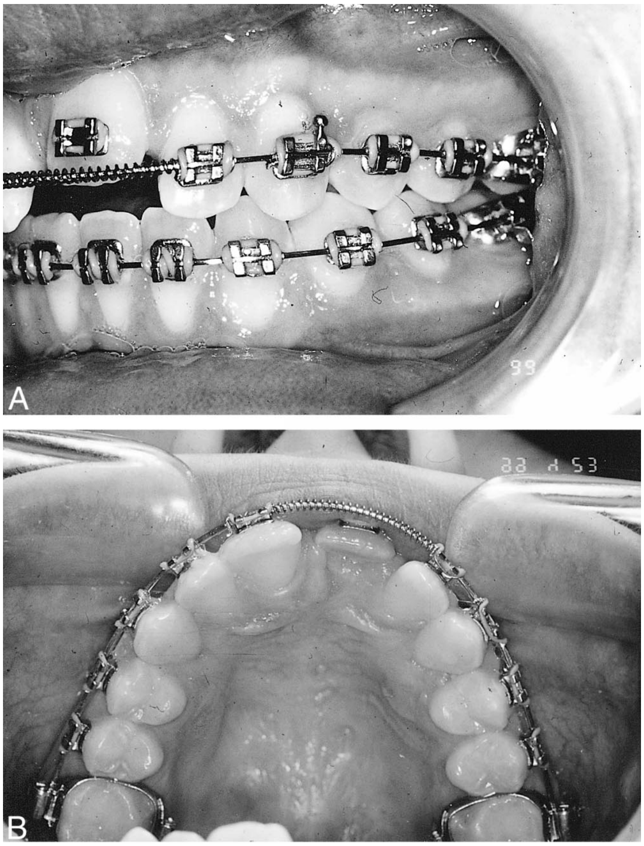

FIGURE 3. Dentition prepared for surgery. Note the additional space made for the vertical alveolar osteotomies mesial and distal to the ankylosed central incisor. (A) Left lateral view, (B) Occlusal view.

lybdenum arch wire was constructed with lingual steps to place tooth 21 in an ideal postsurgical overjet relative to the overadvanced positions of teeth 11 and 22. The lingual steps were necessitated by the presurgical advancement of teeth 11 and 22 to provide extra space required for the surgical bur cuts to avoid the adjacent dental roots. After 23 months of orthodontic treatment, cephalometric radiographs and hand wrist films provided evidence that the patient's growth had markedly slowed, and the decision was made to proceed with surgery.

The patient came to the oral maxillofacial surgery outpatient clinic and was sedated with intravenous fentanyl, midazolam, and brevital. The surgeon administered local anesthesia by infiltration into the labial vestibule and into the area of the nasopalatine nerve.

A full-thickness horizontal incision was made in the unattached mucosa from the right maxillary lateral incisor (12) to the left maxillary canine (23) (Figure 4). Vertical release incisions extending up into the unattached tissue were made at both ends. The mucoperiosteal flap was reflected to expose the anterior maxilla up to the piriform aperture. The nasal mucosa was elevated posteriorly from the nasal floor for approximately 1 cm with a Freer elevator.

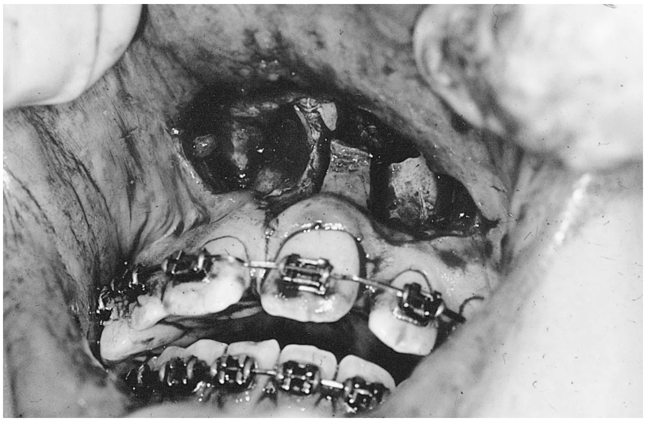

FIGURE 4. Vertical and occlusally diverging vertical alveolar osteotomies at the time of surgery.

The roots of the teeth were easily identifiable in the buccal plate of bone. Starting at the horizontal incision, 2 separate subperiosteal tunnels were elevated inferiorly. One tunnel was to the mesial of tooth 21 and the other was to the distal. The tunnels were placed in order to expose the interdental bone on both sides of tooth 21 to the crest of the ridge. A small fissure bur was used in these tunnels to create vertical osteotomy cuts mesial and distal to tooth 21. The mesial cut was made from the crest of the alveolar ridge to the nasal floor. The distal cut was made from the crest of the alveolar ridge toward the maxillary sinus wall lateral to the piriform rim. A horizontal cut was made to connect the distal vertical cut to the piriform rim, and this cut was continued along the floor of the nasal cavity to connect with the mesial vertical cut. These cuts were made as deeply into the bone as the bur would allow.

A spatula osteotome and mallet were used to deepen the vertical cuts from the buccal until the osteotome could be felt under the palatal mucosa. A curved osteotome was placed in the cut in the nasal floor and the mallet used to deepen the cut and wedge the single tooth segment until it was mobilized. Care was taken to insure that the palatal and buccal attached gingival tissues were maintained since these tissues were critical to providing the blood supply to the segment.

The segment was mobilized and repositioned incisally as far as the attached soft tissues would allow, which was still 2 mm short of the occlusal plane. This positioning of the segment was limited by the stretch of the attached soft tissues and the need to ensure the integrity of the blood supply to the single-tooth alveolar segment. The arch wire was adjusted to this position, seated in the bracket on the ankylosed tooth, and stabilized in the bracket with a ligature wire, thereby positioning the tooth at the limits of the soft tissue stretch. Since the arch wire stabilized the segment, no further fixation was needed and the soft tissue wound was closed with 4-0 chromic gut sutures in a running fashion.

The patient was awakened from anesthesia and sent home after 30 minutes of recovery time. One day following surgery, the patient was seen for examination and the segment was noted to be stable, pink, and viable with an intact blood supply.

Two weeks after surgery, the postsurgical distraction osteogenesis of tooth 21 and its osseous block segment was begun. At this time, the tooth-bone segment displayed Class III mobility and needed an additional 2 mm of extrusion to reach the occlusal plane (Figure 5A,B). A 1-mm vertical extrusion bend was placed in the arch wire to produce distraction osteogenesis. Two weeks later, this step as repeated, and at 4 weeks, extrusion was complete. After the extrusion was complete, the patient remained in a passive arch wire for 6 weeks to allow bone segment healing. At this time, tooth 21 was in its proper position, but the adjacent teeth, 22 and 11, were still in the facially advanced position in which they had been placed presurgically to facilitate the vertical surgical cuts (Figure 6A,B).

Six weeks after surgery, a power chain was placed over the upper arch to close the surgical spaces and decrease the overjet at teeth 11 and 22 (Figure 7A,B). After space closure and detailing, the appliances were removed and upper and lower Hawley retainers were delivered (Figure 8A,F).

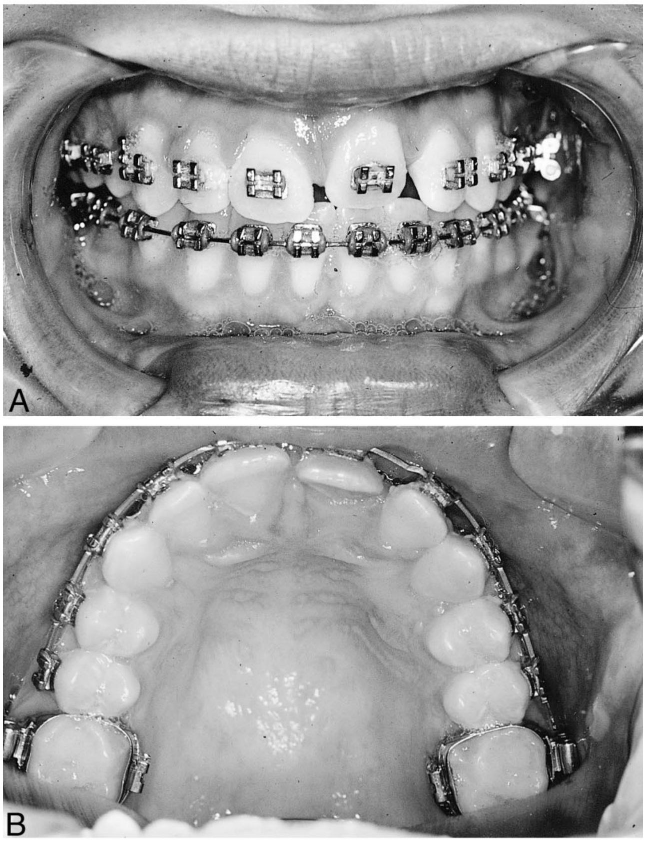

FIGURE 5. Position of the ankylosed tooth postoperatively: (A) frontal view, (B) occlusal view.

DISCUSSION

This combined approach using orthodontics, surgery, and distraction osteogenesis requires some special considerations not normally involved in the routine use of any of these approaches alone.

Growth is of special concern. Since the approach treats the symptoms of ankylosis and does not correct the ankylosis itself, further vertical growth of the alveolar processes will naturally produce further vertical deficiency, the same as seen originally. The growth curves for males and females clearly differ, but most extend beyond 14 years 3 months of age, when this patient was fully corrected. It is very possible that the patient will have some further vertical growth and the ankylosed tooth will leave the plane of occlusion again. The patient elected to proceed with the procedure at that time with informed consent and awareness that small changes could be corrected restoratively but that larger changes could require repeating the procedure after all vertical growth had ceased.

Young teenaged patients are anxious to get treatment completed. It is the orthodontist's obligation to provide the best possible information regarding the prognosis for treatment and the timing of treatment relative to the maturity of the each patient's respective growth potential.

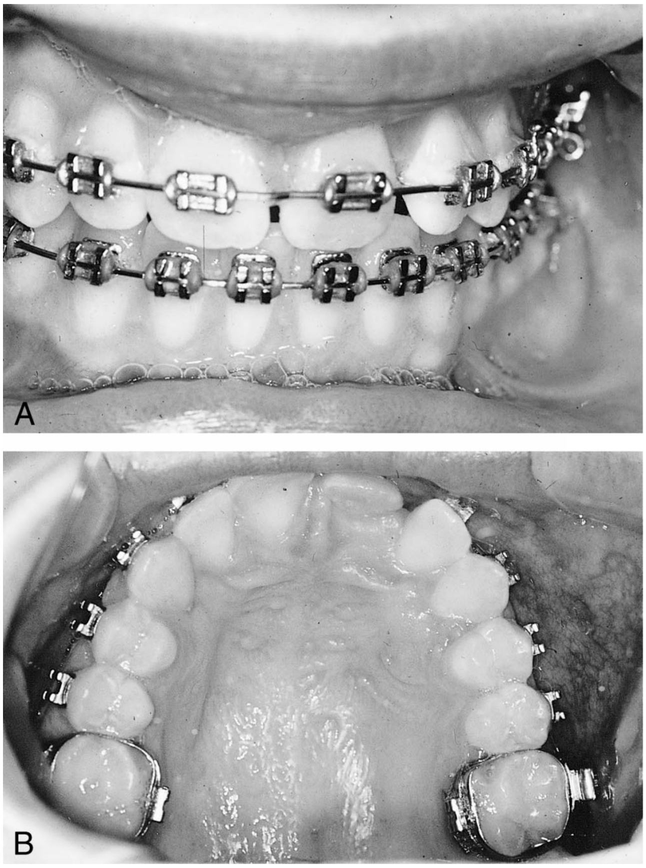

FIGURE 6. Position of the ankylosed tooth after 4 weeks of distraction osteogenesis: (A) Frontal view, (B) Occlusal view.

FIGURE 7. Tooth positions after proximal space closure with power chain. (A) Frontal view; (B) Occlusal view.

Some technical notes regarding the procedure itself are also pertinent. It is important to provide the surgeon with adequate access to the surgical site, including the separation of the adjacent teeth, as was done here. The smaller the block of teeth, the more limited the blood supply, and the blood supply is critical to the preservation of vitality in the single-tooth block segment. A sloughing of the entire segment could result from a major interference with the blood supply to the segment.

The distraction osteogenesis undertaken postsurgically was uncomplicated and probably should be undertaken at even a faster rate than was done here. It should be remembered that bone segments form a callous and show microscopic union about 6 weeks after fixation. When bone healing produces a bony union of the separate parts, further distraction osteogenesis is not possible. Like all distraction osteogenesis procedures, the rate of movement is determined by the ability of the attached soft tissues to proliferate. Distraction osteogenesis is indicated where the amount of movement of the bony segments needed exceeds the amount of movement that the attached soft tissues will allow as determined by the blood supply. Thus, the rate-limiting factor of the distraction osteogenesis is the proliferation of the attached soft tissues.

It is also important for the orthodontist to be aware of the special 3-dimensional problems of this approach. Distraction osteogenesis moves both a tooth and bony segment through space only in directions where bone resorption is not required. The rate of movement is limited by the need to maintain the vitality of the attached soft tissues. The direction of movement is limited by the absence of physical interferences. Therefore, the movement of tooth/bone segments by distraction osteogenesis is limited to directions that are not obstructed by other bone.

In the case of the patient reported here, the tooth and alveolar segment can be moved vertically only if the surgical cuts are parallel or diverge occlusally. In order for the procedure described here to work at all, it is critical that the vertical bony cuts are parallel or diverge occlusally. This is fundamental to the vertical distraction osteogenesis and the procedure's success.

Similarly, in the case of this patient, the third-order rotation or torque control was markedly limited because the angle of the vertical alveolar cuts limited the ability of the distraction osteogenesis process to allow lingual root torque (Figures 5B, 6B, 7B). If the angle of cuts were to diverge from facial to lingual, more lingual root movement might be possible. This is difficult to achieve clinically and the result is that further lingual root movement of this tooth

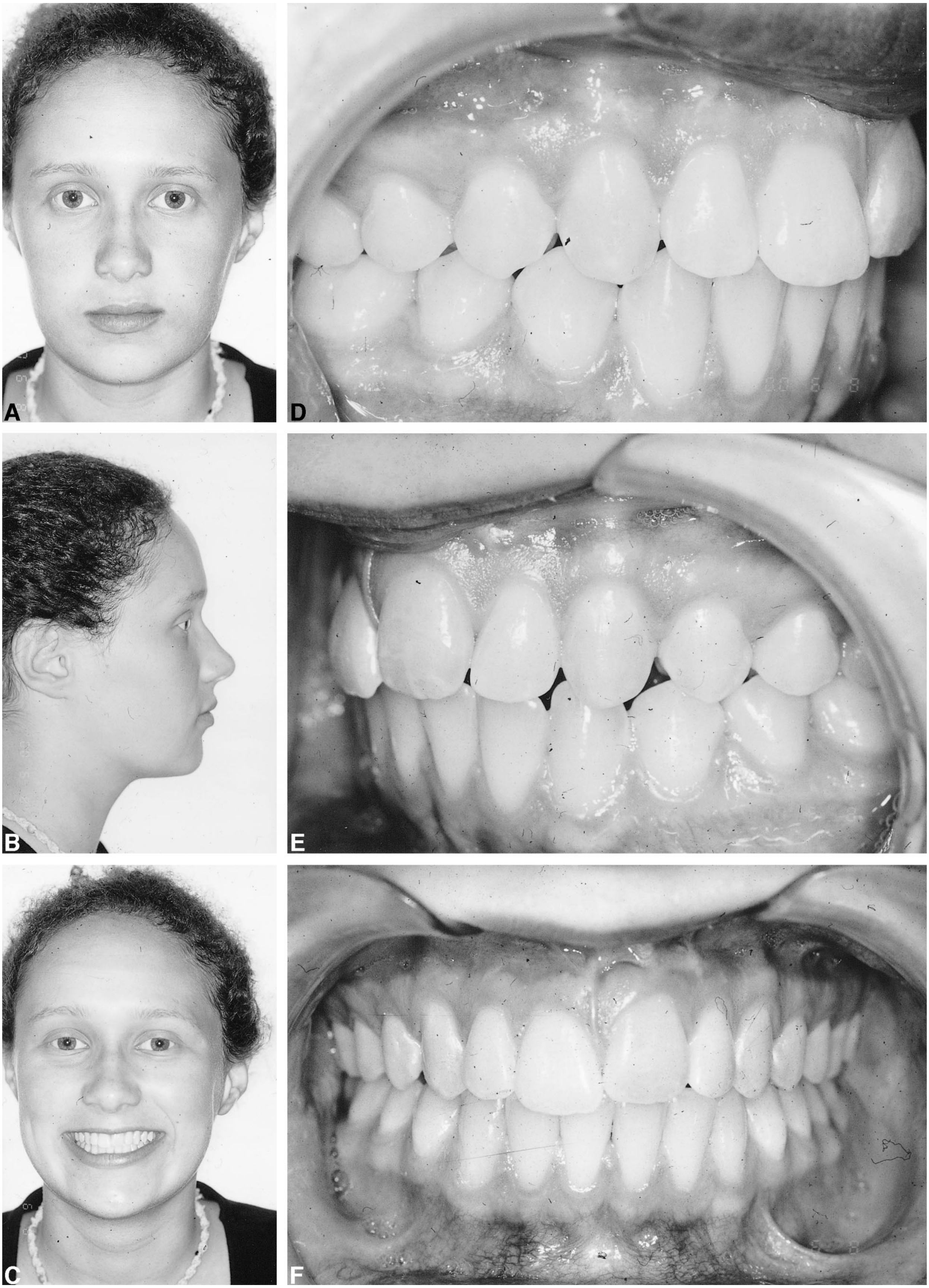

FIGURE 8. Debonding records: (A) full face, (B) profile view, (C) smiling full face, (D) dentition, right lateral view, (E) dentition, left lateral view, (F) dentition, frontal view.

was not possible for this patient. Any lingual root movement that was achievable would be of the entire block of tooth and bony segment and not just the tooth root alone. The finished records shown in Figure 8 were taken 6 months after debonding. A 0.25 mm discrepancy was present when retainers were inserted at debonding. The patient lost her retainers immediately after insertion and did not return for remakes for three weeks. At this time the 1 mm discrepancy shown was present. No further change has occurred.

Finally, some question may exist regarding the pulpal vitality of the teeth treated by this type of procedure. Steiner and West[12] recently reported a review of these problems. We have not run vitality tests on this tooth. The tooth has shown no symptoms of vitality loss or periapical involvement. It is still prudent to inform the patient of the potential for the interruption of the pulpal blood supply and the possibility of the future need for root canal therapy and/or root resorption.

REFERENCES

1. Ericson S, Kurol J. Resorption of incisors after ectopic eruption of maxillary canines: a CT study. *Angle Orthod.* 2000;70:415–423.
2. Kole H. Surgical operations on the alveolar ridge to correct occlusal abnormalities. *Oral Surg.* 1959;12:515–524.
3. Merrill RG, Pedersen GW. Interdental osteotomy for immediate repositioning of dento-osseous elements. *J Oral Surg.* 1976;34:118–212.
4. Burk JL, Provencher RF, McKean TW. Small segment and one tooth ostectomies to correct dentoalveolar deformities. *J Oral Surg.* 1977;35:452–460.
5. Epker BN, Paulus PJ. Surgical-orthodontic correction of adult malocclusions: single-tooth dento-osseous osteotomies. *Am J Orthod.* 1978;74:551–563.
6. Medeiros PJ, Bezera AR. Treatment of an ankylosed central incisor by single tooth dento-osseous osteotomy. *Am J Orthod Dentofac Orthop.* 1997;112:496–501.
7. Martin RJ, Goupil MT, Goldschmidt M. Single implant segmental osteotomy: a case report. *Int J Maxillofac Implants.* 1998;13:710–712.
8. Goldstein L, Reck JV. Surgical-orthodontic treatment of malposed cuspids. *J Clin Orthod.* 1987;21:847–851.
9. Phelan MK, Moss RB, Powell RS, Womble BA. Orthodontic management of ankylosed teeth. *J Clin Orthod.* 1990;24:375–378.
10. Cheng-yi C, Zen EC, Su CP. Surgical-orthodontic treatment of ankylosis. *J Clin Orthod.* 1997;31:375–377.
11. Lindauer SJ, Isaacson RJ. One-couple orthodontic appliance systems. *Sem Orthod.* 1995;1:12–24.
12. Steiner DR, West JD. Orthodontic-endodontic treatment planning of traumatized teeth. *Sem Orthod.* 1997;3:39–44.