

Accelerated Osteogenic Orthodontics Technique: A 1-Stage Surgically Facilitated Rapid Orthodontic Technique With Alveolar Augmentation

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Purpose: Demineralization of a thin layer of bone over a root prominence after corticotomy surgery can optimize the response to applied orthodontic forces. This physiologic response is consistent with the regional acceleratory phenomenon process. When combined with alveolar augmentation, one is no longer strictly at the mercy of the original alveolar volume and osseous dehiscences, and fenestrations can be corrected over vital root surfaces. This is substantiated with computerized tomographic and histologic evaluations. Two case reports are presented that demonstrate the usefulness of the accelerated osteogenic orthodontics technique in de-crowding and space closing for the correction of dental malocclusions.

Materials and Methods: Orthodontics is combined with full-thickness flap reflection, selective alveolar decortication, ostectomy, and bone grafting to accomplish complete orthodontic treatment.

Results: Rapid tooth movement was demonstrated in both cases and stability up to 8 years of retention.

Conclusion: The accelerated osteogenic orthodontics technique provides for efficient and stable orthodontic tooth movement. Frequently, the teeth can be moved further in one third to one fourth the time required for traditional orthodontics alone. This is a physiologically based treatment consistent with a regional acceleratory phenomenon and maintaining an adequate blood supply is essential.

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Historical Review

For over half a century there have been reports of increased tooth movement after corticotomy surgery.¹⁻⁵ It was believed that the rapid tooth movement after corticotomy surgery was due to the movement of small outlined blocks of bone. The resistance of the cortical layer of bone was presumably eliminated with the circumscribing corticotomy cuts. The only resistance to the tooth movement would thus be provided by the less dense medullary bone. It was thought that in this manner the slow periodontal ligament (PDL)-

mediated process of traditional orthodontics could be overcome because presumably the tooth-PDL complex was being moved with the block of bone and not through the bone.

In 2001, Wilcko et al⁶ suggested that, because of computed tomographic studies, the rapid tooth movement associated with corticotomy-facilitated orthodontics was more likely the result of a demineralization/remineralization process consistent with the initial phase of regional acceleratory phenomenon, namely an increase in cortical bone porosity and a dramatic increase of trabecular bone

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surface turnover due to increased osteoclastic activity.

Concepts and Indication

Wilcko et al⁶⁻⁹ and Ferguson et al¹⁰ reported on a new in-office technique that is a combination of “bone activation” (selective alveolar decortication, osteotomies, and bone thinning with no osseous mobilization), alveolar augmentation using particulate bone grafting material, and orthodontic treatment. It is called the accelerated osteogenic orthodontics (AOO) technique or periodontally AOO technique. Connective tissue grafting for root coverage has been shown to be feasible with full-thickness flap reflection and bone activation¹¹ and can be included in the surgery or performed after the debracketing.¹²

The potential advantages of the treatment in comparison with traditional orthodontics are:

1. Enhanced scope of malocclusion treatment (ie, an increase in the limits of tooth movement and a decreased need for extractions).

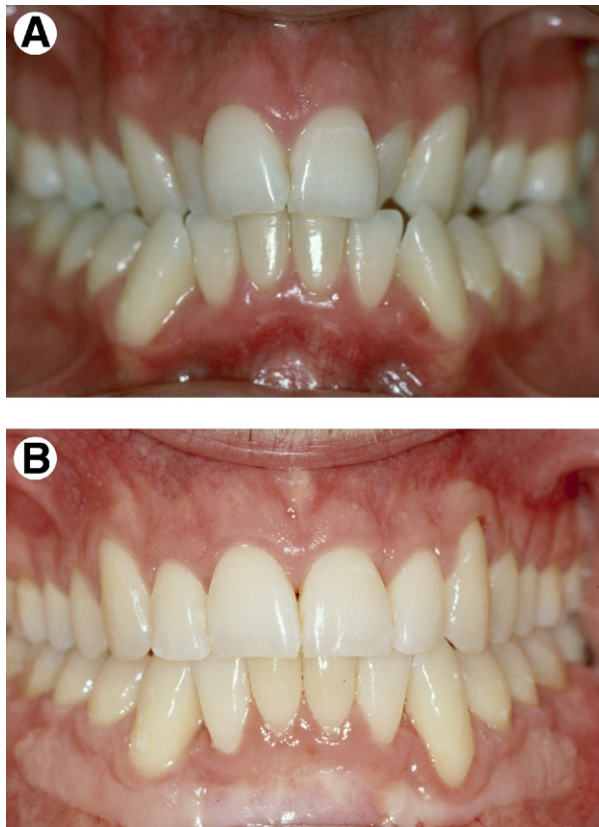


FIGURE 1. Patient 1, male, age 23 years. *A*, Before treatment, anterior view. *B*, After treatment, total AOO treatment time 6 months 2 weeks, anterior view.

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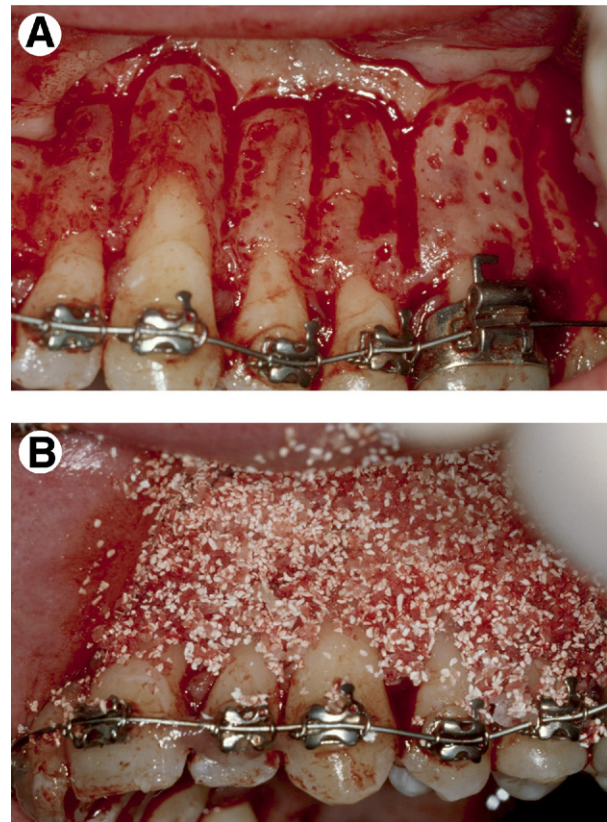


FIGURE 2. *A*, After bone activation using circumscribing corticotomy cuts and intramarrow penetrations, left lateral view. *B*, Bone grafting mixture placed over the activated bone, left lateral view.

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2. Decreased treatment times (increased rate of tooth movement).
3. Increased alveolar volume and a more structurally complete periodontium (correction of pre-existing bony dehiscences and fenestrations).
4. Alveolar reshaping for the subtle enhancement of a patient's profile when indicated. (The alveolar chin prominence cannot be advanced except by genioplasty.)
5. Simultaneous rapid recovery of shallow unerupted teeth (deep impaction cases must be done in stages).

The principal object of the AOO surgery is the creation of a relatively thin layer of bone (≤ 1.5 mm) over the root prominence in the direction of the intended tooth movement. In addition, adequate osseous insult is needed in close approximation to all aspects of this thin layer of bone to ensure adequate demineralization. Thick exostoses overlying the root prominences in the direction of the intended tooth movement are decreased in thickness. The design of the corticotomy cuts, perforations, etc, is irrelevant

but must perforate the cortical layer of bone and extend only into the superficial aspect of the medullary bone. No luxation is performed. Mesial to the mental foramen, care is taken to avoid injury to a possible anterior loop of the inferior alveolar nerve. Similar care is taken to avoid injury to the roots of the teeth. Circumscribing corticotomies in the labial and lingual plates of bone provide a maximum amount of osseous insult to the interradicular areas where there is minimal chance of impinging on the roots of the teeth.

Lino et al¹³ found that the insult of circumscribing corticotomy cuts alone will not elicit an osseous response that is sustainable enough to permit tooth movement through a large thickness of bone in the mesiodistal orientation of the alveolus. In space clo-

sure or where tooth uprighting is needed in a mesiodistal orientation within the confines of the long axis of the alveolus, the bone thinning is accomplished with an ostectomy through the entire thickness of the alveolus to include the labial and lingual cortical plates and interspersed medullary bone.^{8,14} Care is taken to ensure that there is only a thin layer of medullary bone and the underlying lamina dura remaining over the root prominences in the direction of the intended tooth movement as diagrammed by Köle.¹

AOO Surgical Technique

A treatment plan is developed by the orthodontist/surgeon team to determine the teeth that will undergo bone activation, the teeth that will be used for

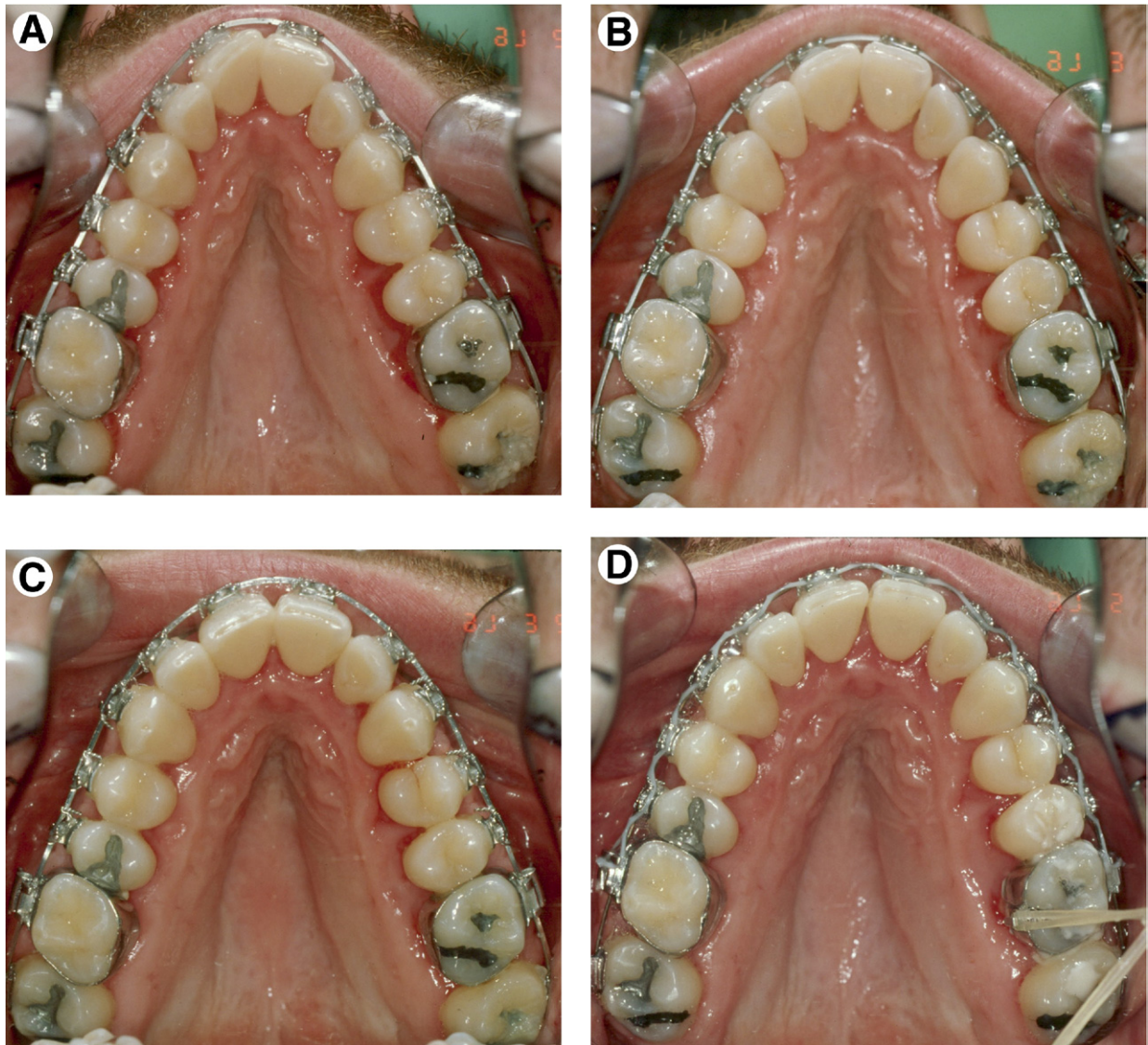


FIGURE 3. Patient 1 (A) 4, (B) 8, (C) 11, and (D) 16 weeks after AOO surgery.

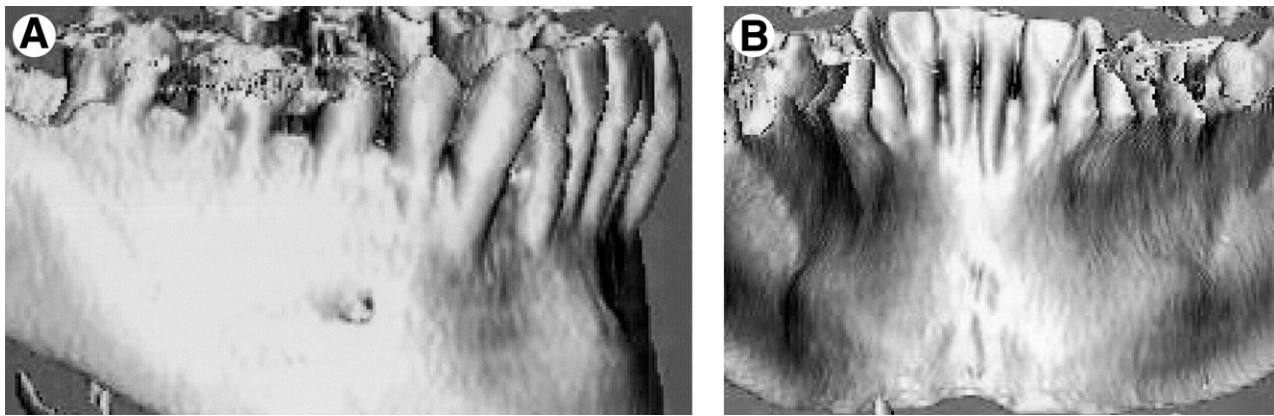


FIGURE 4. Patient 1. A, Pretreatment surface computed tomographic scan, right oblique view of lower arch. B, Pretreatment surface computed tomographic scan, lingual view of lower arch.

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anchorage, and the teeth that will need to be extracted. Occasionally, temporary anchorage devices (tads), miniscrews or plate-retained fixtures, are included in the treatment plan. The team must also orchestrate the sequencing of the different aspects of the treatment, such as the inclusion of forced eruptions, orthognathic surgery, and post-treatment prosthetics.

Typically, the orthodontic brackets are placed and a light wire engaged sometime during the week before the surgery with the subsequent orthodontic adjustments being made at 2-week intervals. A full case in which upper and lower arches are treated surgically can require 3 to 4 hours to complete and is usually performed under intravenous or oral sedation. In general, full-thickness flaps are reflected labially and lingually using a sulcular releasing incision. The interdental papillae can be reflected with the flaps or left in place.¹⁴ Our preference is to reflect the interdental papillae with the full-thickness flaps except

between the upper central incisors. Here the lingual portion of the interdental papilla is not reflected because the nasopalatine foramen precludes the need for bone activation in this immediate area. The releasing incision can also be made within the thickness of the gingival attachment or at the base of the gingival attachment (mucogingival junction).¹⁵ Vertical releasing incisions can be used, but should be positioned at least 1 tooth beyond the “bone activation,” especially if a large amount of bone grafting material is used. The flap reflection is carefully extended beyond the apices of the teeth to avoid damaging the neurovascular complexes exiting the alveolus.

After bone activation the resorbable particulate bone grafting material is layered over the activated bone. This bone grafting material is typically first wet with a clindamycin phosphate/bacteriostatic water solution of approximately 5 mg/mL. Wetting the grafting material facilitates the ease of placement. The particulate bone grafting material can also be wet

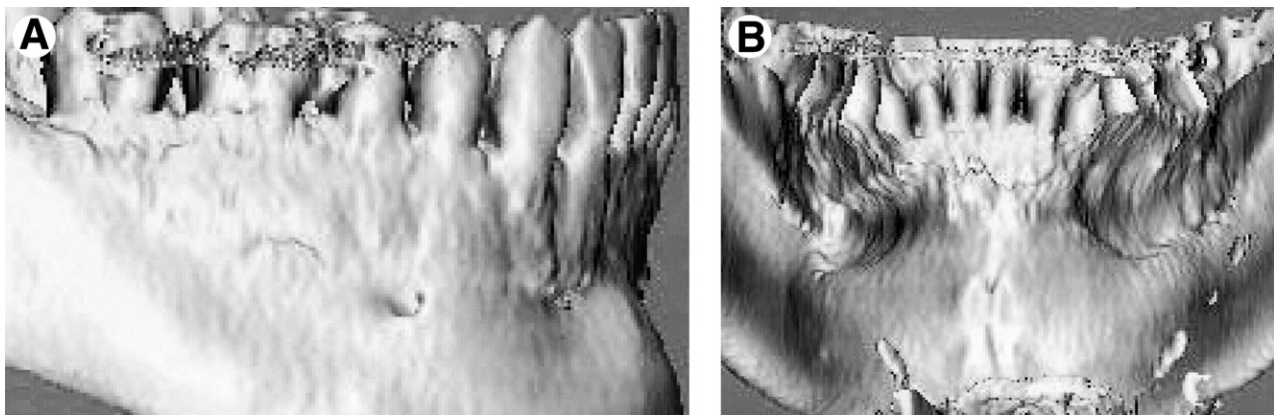


FIGURE 5. A, Post-treatment surface computed tomographic scan, right oblique view of lower arch. B, A 2.5-years post-treatment surface computed tomographic scan, lingual view of lower arch.

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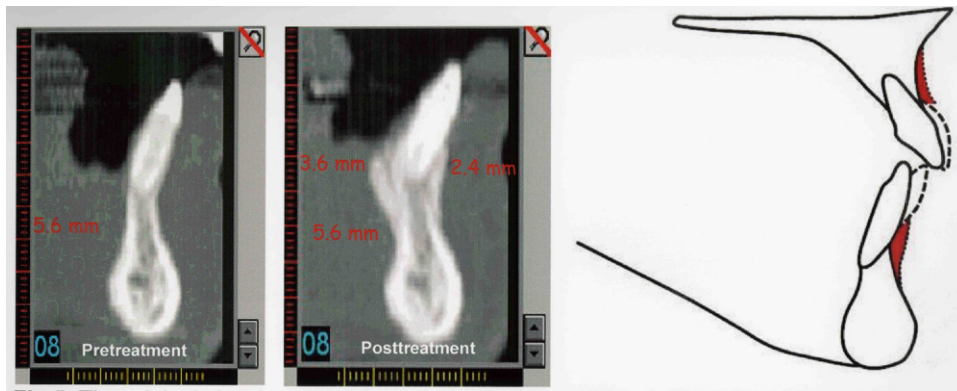


FIGURE 6. The original alveolus was 5.6 mm in width. The grafting created 2.4 mm of additional labial bone at B-point and 3.6 mm of new bone lingually. A composite shows the dentoalveolar defecting that has been filled with new bone.

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with platelet-rich plasma, which does not appear to inhibit tooth movement (personal communication, Dr Chuck White, Bentonville, AR). The use of resorbable particulate grafting materials is preferred. The grafting material can be 100% demineralized freeze-dried bone allograft (DFDBA), a mixture of DFDBA and bovine bone, or a mixture of DFDBA and mineralized freeze-dried bone allograft. The amount of bone grafting material used depends on the amount of pre-existing bone, the severity of the crowding that needs to be resolved, the severity of the anticipated dentoalveolar defect, the number and extent of the osteotomies required, and the amount of intended subtle facial reshaping. The amount of particulate bone grafting material that is used can vary from 0.25 to 1 cc or more per activated tooth. During the conversion of the grafting material to bone, there will be a reduction in the original volume by 50% or more. Although resorbable membranes can be used to increase the resulting bone volume, we limit their use to areas that may receive an implant fixture after de-bracketing. The particulate grafting material is maintained in the desired positioning by the full-thickness flaps. The use of releasing incisions at the base of the flaps (for very passive adaptation) is typically only done in the areas where a connective tissue graft is being used for root coverage.

After the full-thickness flaps are coronally advanced to cover the grafting materials, they are sutured with an interrupted loop nonresorbable suture material such as Gortex (W.L. Gore & Associates, Inc, Flagstaff, AZ) or Cytoplast (Osteogenics Biomedical, Inc, Lubbock, TX). Large bites of the gingival attachment are taken to lessen the likelihood of the sutures pulling out. The patient is checked 4 to 5 days postoperatively to ensure that flaps have not separated. The sutures are left in place for a minimum of 2 weeks. Sufficient time must be allowed for the epithelial attachment to re-establish itself, especially if a sulcular

releasing incision is used. When more than 0.5 cc of bone grafting material is used per tooth, the sutures are retained in place for 3 weeks. Premature suture removal can result in flap displacement, opening of

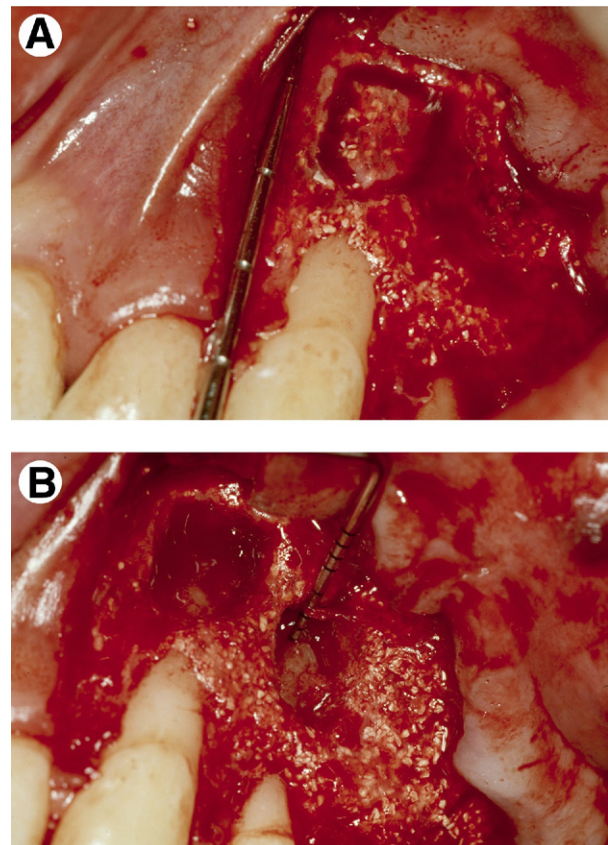


FIGURE 7. A, At 14.5 months after AOO surgery, the bone biopsy has been outlined on the facial of the upper left canine. B, The bone biopsy has been removed from the facials of the upper left canine and the upper left first bicuspid; there is now 3- to 4-mm thickness of bone over the root prominence of the upper left first bicuspid where there was little or no bone originally.

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interproximal embrasures (dark triangles), and gingival recession.

Case Reports

PATIENT 1: NONEXTRACTION TREATMENT OF A SEVERELY CONSTRICTED MAXILLA AND SEVERE UPPER AND LOWER CROWDING

A 23-year old man presented with Class I molar and canine relations (Fig 1A). In addition to upper and lower arch crowding, there was severe upper arch constriction in the anterior/bicuspid areas with bilateral crossbites in the anterior and posterior areas. Because this patient's teeth were not already tipped facially, this treatment was a viable option. The patient was given the option of orthognathic surgery (expansion of the midpalatal suture) or the AOO treatment. His case was completed in 6 months and 2 weeks from bracketing to de-bracketing (Fig 1B). The total amount of cross-arch expansion in the upper canine areas was 8 mm.

The bone activation was performed labially and lingually around all the remaining upper and lower teeth using circumferential corticotomy cuts and intramarrow penetrations (Fig 2A). The activated bone was then covered with a particulate bone grafting mixture consisting of 50% DFDBA and 50% bovine bone (Fig 2B). Twenty-four cubic centimeters of the bone grafting material was used (1 cc per tooth).

Because the maxillary constriction was most pronounced mesial to the molars, it was possible to expand and round out the maxillary arch form with solely archwire therapy. This required approximately 12 weeks with the adjustments being made at 2-week intervals (Figs 3A-D). Had there also been significant constriction in the upper molar areas,

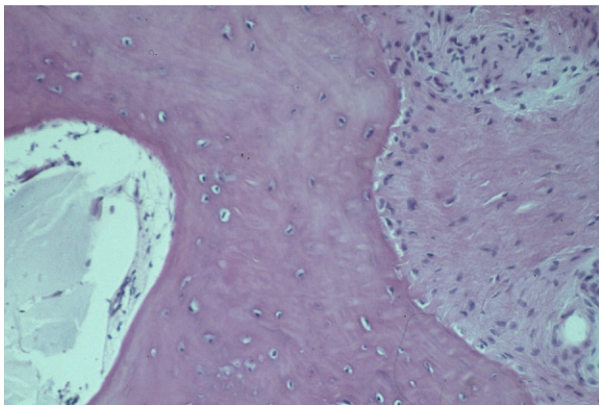


FIGURE 8. Histology of bone biopsy from the upper left first bicuspid. PDL (right), particle of un-resorbed bovine bone (left), and interspersed medullary bone with osteocytes in lacunae. Hematoxylin and eosin, $\times 200$, routine light normal.

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FIGURE 9. Patient 2, female, age 47 years. A, Before treatment, left lateral view. B, Eight years' retention; total AOO treatment time had been 7 months.

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the use of an adjustable orthopedic device would have been needed.¹⁶

The alveolar augmentation can provide for an increased alveolar volume to help support the teeth after treatment. The ability to increase the alveolar volume is readily apparent in a comparison of the pretreatment (Figs 4A,B) and post-treatment (Figs 5A,B) surface computed tomographic scans of the lower arch. A pretreatment and post-treatment cross-sectional analysis of the computed tomographic scan through the lower left central incisor shows an increase in the alveolar bone width of 2.4 mm at B-point and 3.5 mm lingually (Fig 6). The bone grafting has eliminated the dentoalveolar deficiency (red area in composite drawing in Fig 6) that is created when the teeth are tipped labially during de-crowding. This increased thickness of cortex will help provide for increased stability after treatment. To ascertain if what appeared to be an increase in the alveolar volume radiographically was actually bone, this case was re-entered at 8 months after de-bracketing (14.5 months after AOO surgery). The increase in the thickness of the alveolar housing is readily apparent at the

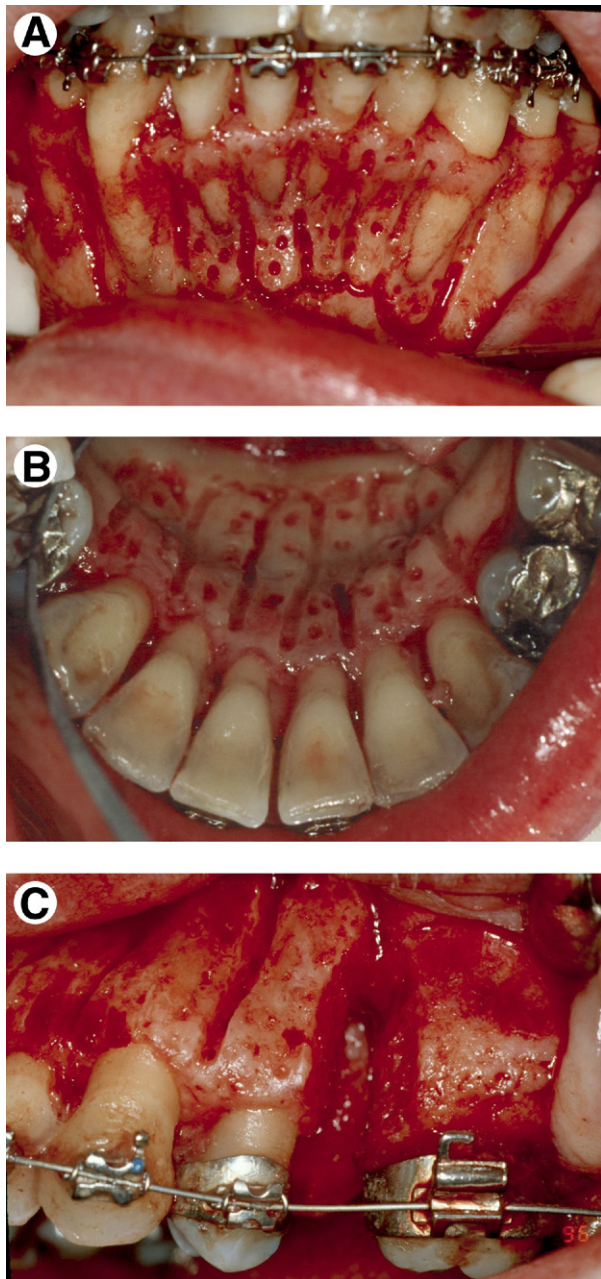


FIGURE 10. Bone activation from the lower right canine to the lower left canine using circumscribing corticotomy cuts and intra-marrow penetrations. A, Lower anterior facial view. B, Lower anterior lingual view. C, Osteotomy at upper left second bicuspid site, upper left lateral view.

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bone biopsy site on the facial of the upper left first bicuspid (Figs 7A,B). Where there was little or no bone initially (Fig 2A), there was now a thickness of 3 to 4 mm of new healthy bone, the histology of which can be seen in Figure 8. Note that there is a particle of bovine bone that has not yet completely resorbed, surrounded by healthy lamellar bone. Because of the alveolar augmentation, the roots of the teeth postop-

eratively are confined labially and lingually between 2 uninterrupted layers of bone.

PATIENT 2: TREATMENT FOR UNILATERAL SPACE CLOSING IN AN ADULT

A 47-year-old healthy woman presented with moderate anterior crowding, a 4-mm overjet (underbite), Class I molar relation on the right side, Class II molar relation on the left side, and a missing upper left second bicuspid (Fig 9A). The total treatment time from bracketing to de-bracketing was 7 months. The occlusion has remained stable at 8 years of retention (Fig 9B).

The treatment plan included space closing at the site previously occupied by the upper left second bicuspid and expansion to correct the anterior crowding. Full-thickness flaps were reflected facially and lingually from second molar to second molar. In the lower arch, the bone was activated labially and lingually from the lower right canine to the lower left canine (Figs 10A,B). In the upper arch, the bone was activated facially and lingually from the upper right canine to the upper left first bicuspid with an osteotomy at the upper left second bicuspid site (Fig 10C). The activated bone was then covered with the bone grafting material facially and lingually. The orthopedic retractor was inserted in the upper arch at 1 month after surgery (Figs 11A). The space was closed over the following 3 weeks, at which time the retractor was removed (Figs 11B-D).

At 17 months after surgery, the lower left area was re-entered. The bony fenestrations that were present at the time of the initial surgery (Figs 10A, 12A) were completely filled in with new bone. Bone biopsies taken from the facials of the lower left canine and lower left lateral incisor (Fig 12C) were each 2 to 3 mm in thickness. The histology shown in Figure 13 is consistent with healthy bone.

At 8 years after surgery, the lower right area was re-entered. At the time of the initial surgery, there was a bony dehiscence on the facial of the root of the lower right canine that extended almost to the apex of this tooth (Fig 14A). This dehiscence was now completely filled in with bone. A bone biopsy was removed from the facial of this tooth (Fig 14B). The histologic findings were consistent with healthy lamellar bone.

Manner of Tooth Movement

In corticotomy-facilitated orthodontics, the optimal tooth movement seemingly occurs when only a thin layer of bone overlies the root prominences in the direction of the intended tooth movement in close approximation to the osseous insult.^{8,14} This thin layer of bone will demineralize and the remaining soft

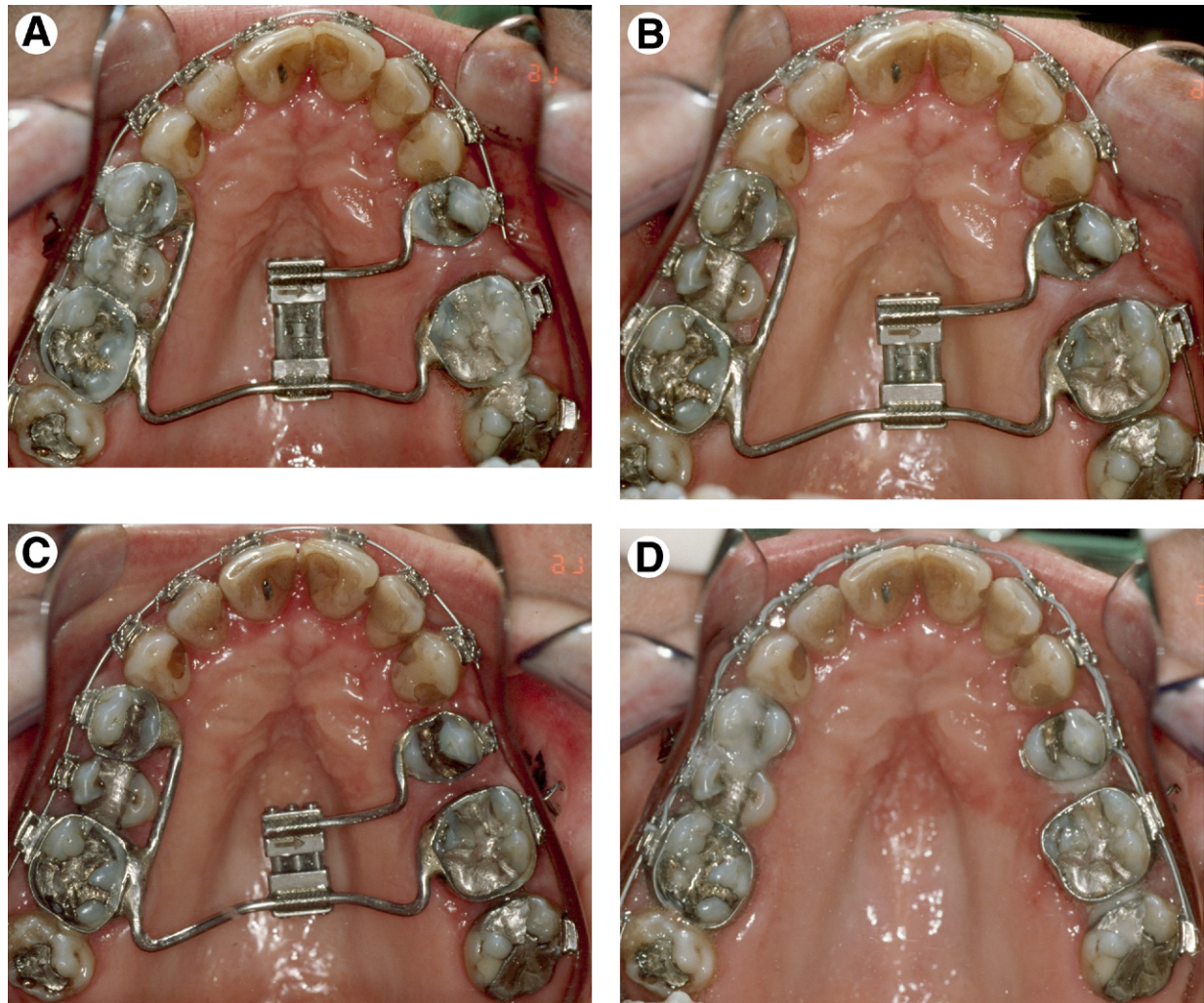


FIGURE 11. A, Orthopedic retractor inserted. B, One week after insertion. C, Two weeks after insertion. D, Three weeks after insertion, orthopedic retractor removed.

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tissue matrix and islands of osteoid transported with the root surfaces where the bone matrix will remineralize at the completion of the orthodontic therapy. The rapid tooth movement after corticotomy-facilitated orthodontics would thus more appropriately be described as “bone matrix transportation” and not “bony block movement.” In adolescents, the demineralization/remineralization of the alveolar housing is seemingly complete, without a net tissue loss. In the adult population, however, the remineralization is less complete, albeit to a clinically insignificant degree.^{8,14} This is likely attributable to the decreased vitality of adult tissues in comparison with adolescent tissues. The tooth movement in this treatment is merely the result of a physiologic process and not the repositioning of segments of bone. An uninterrupted blood supply is essential.

Lee et al¹⁷ and Sebaoun et al¹⁸ reported systemic and histologic evidence to support the hypothesis

originally proposed by Wilcko et al⁶ that the facilitated tooth movement after corticotomy surgery is attributable to a demineralization/remineralization phenomenon rather than “bony block movement.” Sebaoun et al reported that, in a rat model, selective alveolar decortication resulted in a 3-fold increase in the catabolic and anabolic processes at 3 weeks after surgery that dissipated to normal steady state by 11 weeks after surgery.¹⁸ Luxation of outlined segments of bone as in the 1-stage periodontal AOO surgery with the reflection of labial and lingual flaps is contraindicated.¹⁹ Conversely, in dental distraction osteogenesis, the outlined segments of bone can be luxated (green stick fractured), but in this situation a flap of tissue remains attached to the segment of bone.²⁰

The movement of the teeth in the AOO treatment is accomplished through tipping and then uprighting, and thus the pretreatment angulations of the teeth weigh heavily on the amount of tooth movement that

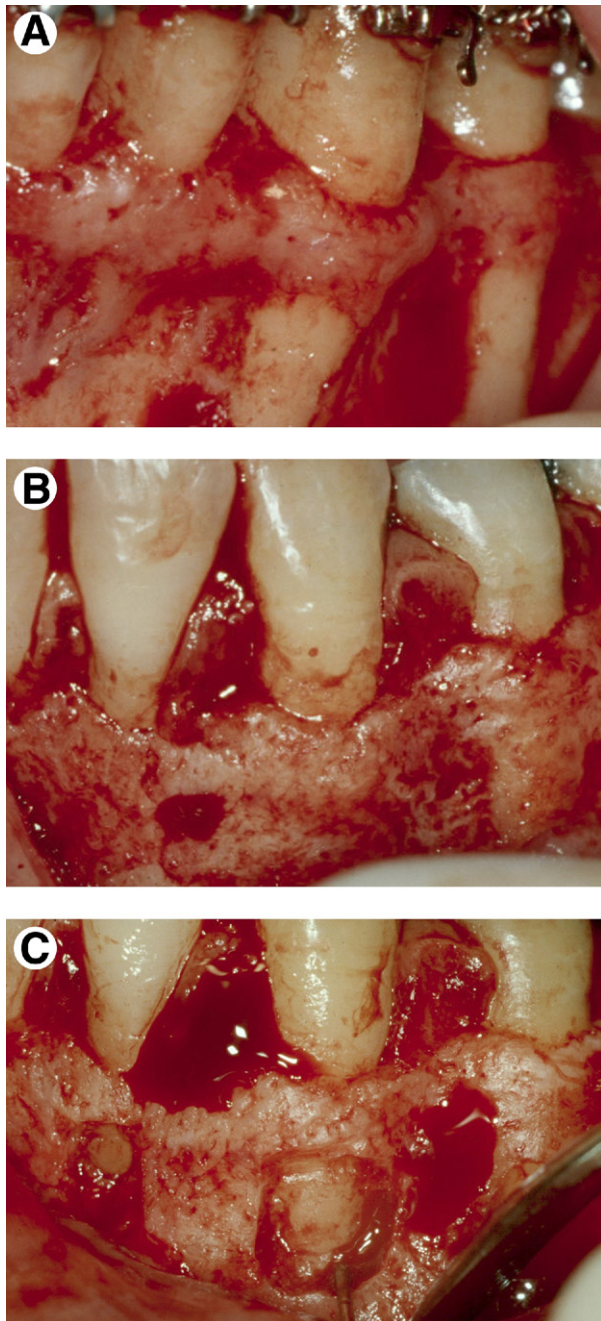


FIGURE 12. A, After full-thickness flap reflection and before bone activation, there is a fenestration on the facial of the lower left canine that extends almost to the apex of the root, lower left anterior view. B, Re-entry by a full-thickness flap 17 months after AOO surgery (10 months after de-bracketing); the bony fenestrations are filled in with new bone, lower left anterior view. C, After removal of cores of bone from the facials of the lower left canine and lower left lateral incisor, where there had originally been no bone due to the facial fenestrations, there is now 2- to 3-mm thickness of bone, lower left anterior view.

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can be expected. If the teeth are tipped away from the direction of the intended tooth movement at pretreatment, greater amounts of correction can be accomplished than if the teeth are tipped in the same

direction of the intended tooth movement at pretreatment.

Alveolar Augmentation

Rothe et al,²¹ in a study of mandibular relapse, reported that patients with thinner mandibular cortices are at greater risk for mandibular relapse. The AOO technique addresses this consideration with the inclusion of alveolar augmentation.

The inclusion of bone augmentation with 1-stage corticotomy surgery and orthodontic tooth movement is a new concept^{6-9,14} and has made it possible to provide for an increased alveolar volume to help support the teeth in their straightened position. However, bone induction techniques are not new and have evolved over the past 4 decades. Urist²² in 1965 was the first to demonstrate that decalcified bone matrix could induce new cartilage and bone formation.

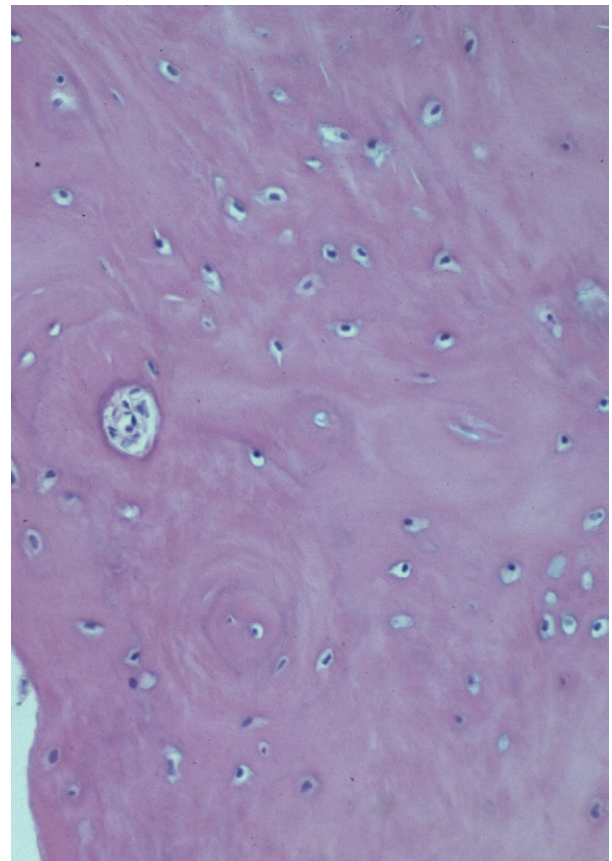


FIGURE 13. Histology of the demineralized core of bone removed from the facial of the lower left canine. Note that there are osteocytes in the lacunae. Hematoxylin and eosin, $\times 200$, routine light.

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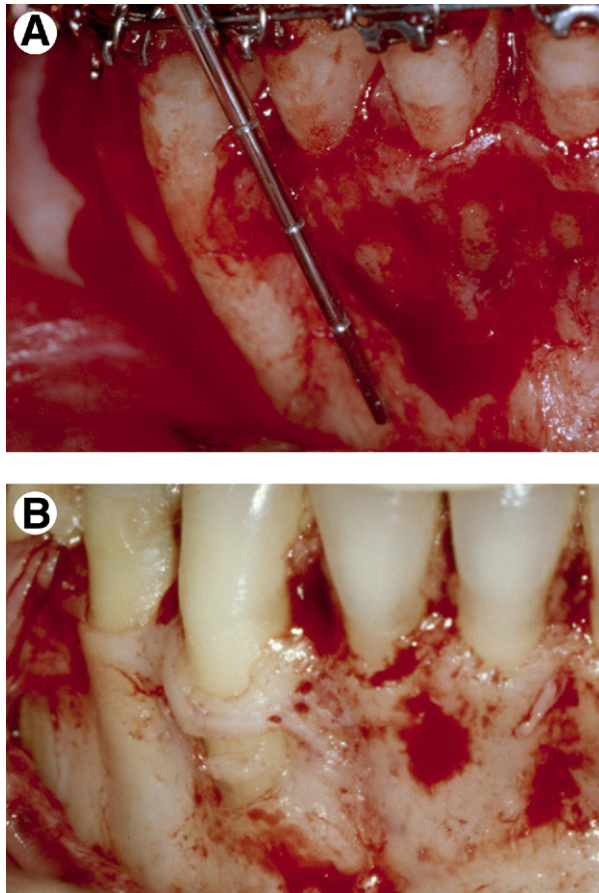


FIGURE 14. A, After full-thickness flap reflection and before bone activation at the time of the AOO surgery, note the dehiscence on the facial of the lower right canine that extends almost to the apex of the root. B, Re-entry at 7.5 years of retention, the bony dehiscence on the facial of the lower right canine has been completely repaired. A core of bone has been removed facially, where there had originally been no bone due to the dehiscence that almost reached the apex of the root.

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Special Considerations and Limitations

The AOO treatment has been performed successfully on healthy adolescents and adults. It has provided an alternative treatment for a population of patients who would have otherwise not pursued any treatment at all. Many situations may, however, be potentially problematic and include, but are not limited to, patients who have been on long-term corticosteroid therapy and may have devitalized areas within the bone and as such are not good candidates for the treatment. Patients who are taking any of many medications that slow bone turnover are likely not suitable for this treatment. Bisphosphonates can have a half-life exceeding a decade, and even after cessation of therapy these patients are not candidates. The nonsteroidal anti-inflammatory drugs are prostaglandin inhibitors, and their usage will lead to decreased

osteoclastic activity. The use of nonsteroidal anti-inflammatory drugs in the amount needed for pain control should be avoided during the active treatment, but nonsteroidal anti-inflammatory drug analgesics can be prescribed for the first week after surgery. Any pre-existing oral infections should be resolved before treatment. Retaining teeth with unresolved endodontic problems can be especially problematic and must be avoided.

Summary

The AOO treatment provides for an optimal response to applied forces because it is mediated by the PDL and spongiosa. Compared with traditional orthodontic treatment, this treatment has the obvious advantage of dramatically shorter treatment times, an attractive alternative for many patients. This convenience, however, is far outweighed by the ability to move teeth farther and yet provide a greater alveolar volume for increased post-treatment stability with decreased side effects. The treatment is delivered in an in-office setting and may attract a new population of patients who would have otherwise avoided needed orthodontic treatment.

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