Rapid Orthodontics with Alveolar Reshaping: Two Case Reports of Decrowding

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Two case reports demonstrate a new orthodontic method that offers short treatment times and the ability to simultaneously reshape and increase the buccolingual thickness of the supporting alveolar bone. A 24-year-old man with a Class I severely crowded malocclusion and an overly constricted maxilla with concomitant posterior crossbites and a 17-year-old female with a Class I moderately to severely crowded malocclusion requested shortened orthodontic treatment times. This new surgery technique included buccal and lingual full-thickness flaps, selective partial decortication of the cortical plates, concomitant bone grafting/augmentation, and primary flap closure. Following the surgery, orthodontic adjustments were made approximately every 2 weeks. From bracketing to debracketing, both cases were completed in approximately 6 months and 2 weeks. Posttreatment evaluation of both patients revealed good results. At approximately 15 months following surgery in one patient, a full-thickness flap was again reflected. Visual examination revealed good maintenance of the height of the alveolar crest and an increased thickness in the buccal bone. The canine and premolars in this area were expanded buccally by more than 3 mm, and yet there had actually been an increase in the buccolingual thickness of the overlying buccal bone. Additionally, a preexisting bony fenestration buccal of the root of the first premolar was covered. Both of these findings lend credence to the incorporation of the bone augmentation procedure into the corticotomy surgery because this made it possible to complete the orthodontic treatment with a more intact periodontium. The rapid expansive tooth movements with no significant apical root resorption may be attributed to the osteoclastic or catabolic phase of the regional acceleratory phenomenon. Instead of bony “block” movement or resorption/apposition, the degree of demineralization/remineralization might be a more accurate explanation of what occurs in the alveolar bone during physiologic tooth movement in these patients. (Int J Periodontics Restorative Dent 2001;21:9–19.)

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The nature of orthodontic tooth movement needs to be revisited in light of our research and development of a new treatment method combining selective alveolar decortication, alveolar augmentation, and orthodontic treatment. (The method of Accelerated Osteogenic Orthodontics, AOO, is patented by Wilckodontics.) Remarkable decreases in orthodontic treatment times and no significant apical root resorption using this innovative technique are a cause for reflection on the influence of transient osteoporosis secondary to the corticotomy surgery.

In an evaluation of this new method, a recent Master's thesis demonstrated significantly reduced treatment times, the total treatment time being only ¼ to ⅓ that of routine nonextraction and extraction orthodontic therapies. Hajji1 studied the effects of eliminating mandibular anterior dental arch crowding by comparing nonextraction (n = 30), extraction (n = 34), and corticotomy-facilitated nonextraction (n = 20) orthodontic therapies. Four dental arch dimensions and 11 mandibular incisor position measurements were...
analyzed using study casts and lateral cephalometric radiographs. There were no posttreatment differences between the nonextraction and the corticotomy-facilitated nonextraction samples for any of the study’s 15 variables. In contrast, mean active treatment time for the corticotomy-facilitated group was 6.1 months, versus 18.7 months for nonextraction orthodontics and 26.6 months for extraction therapy. How can this be explained?

The conventional view of orthodontic tooth movement is that of a cell-mediated process orchestrated predominantly within the periodontal ligament (PDL). Sustained force on a tooth translates into a PDL cell population shift wherein pleomorphic fibroblasts are converted to osteoblasts, and osteoclasts are derived from the influx of blood-borne monocytic precursors. With time, the lamina dura undergoes osteoclasts in the area of PDL “pressure,” and bone apposition occurs in the areas of PDL “tension.” It is well known that massive cell death and hyalinization occur within the PDL during routine orthodontic tooth movement but can be minimized by judicious application of light forces. It typically takes from 3 to 5 weeks for this zone of sterile necrotic tissue to be eliminated and repaired, during which time tooth movement by frontal resorption is virtually at a standstill. Rygh and Brudvik cited accumulating evidence suggesting an association between orthodontic root resorption and the presence and removal of necrotic hyalinized PDL tissue. They observed that the initial attack of root resorption follows a consistent pattern, starting at the periphery of the main hyalinization zone and occurring some days later beneath the main hyalinization zone. Brezniak and Wasserstein discussed the multitude of factors affecting root resorption. They pointed out that in the older individual, the PDL becomes less vascular, aplastic, and narrower; the bone becomes more dense, avascular, and aplastic; and the cementum becomes wider. They speculated that these changes are reflected in a higher susceptibility to root resorption in adults.

Osteoporosis is a condition defined by calcium depletion and reduced bone density, conditions that can affect tooth movement. In 1984, Goldie and King enhanced tooth movement and decreased root surface resorption after creating an osteoporotic condition in rats. The test animals were lactating females fed a calcium-deficient diet; the control group was nonlactating animals on a balanced diet. Following a 60-g force used to tip the maxillary molars mesially, the test group demonstrated significantly greater tooth movement. The authors surmised that increased parathyroid hormone secretion in the test group led to increased osteoclasts (an observation later confirmed by Horowitz et al) and loss of bone mineral, resulting in osteoporosis. The increase in bone metabolism and decrease in bone density were responsible not only for enhanced tooth movement in the rats, but also for a decrease in the area of root surface resorption.
Regional acceleratory phenomenon

Orthopedist Harold Frost recognized that surgical wounding of osseous hard tissue results in striking reorganizing activity adjacent to the site of injury in osseous and/or soft tissue surgery. He collectively termed this cascade of physiologic healing events the regional acceleratory phenomenon (RAP).6,7 RAP healing is a complex physiologic process with dominating features involving accelerated bone turnover and decreases in regional bone densities. Following surgical wounding of cortical bone, RAP potentiates tissue reorganization and healing by way of a transient burst of localized hard and soft tissue remodeling.8

RAP occurring in the mandibular bone was reported by Yaffe et al.9 In rats, they reflected mucoperiosteal flaps that were allowed to readapt without sutures. Evidence of RAP was first observed after 10 days of healing, and there was almost complete recovery after 120 days. The authors suggested that RAP in humans begins within a few days of surgery, typically peaks at 1 to 2 months, and may take from 6 to more than 24 months to subside. They characterized the initial phase of RAP as an increase in cortical bone porosity because of increased osteoclastic activity and speculated that bone dehiscences might occur after periodontal surgery in an area where cortical bone is initially thin. They surmised that RAP might be a contributing factor to increased mobility of the teeth after periodontal surgery, a supposition consistent with a report by Pfeifer10 of increased osteoclastic activity along the PDL surface following surgery. There is strong indirect evidence that the physiologic events associated with RAP following surgery, ie, calcium depletion and diminished bone densities, result in rapid tooth movement.

Corticotomy-facilitated orthodontics

Several authors have described rapid tooth movement in conjunction with corticotomy surgery as movement by bony “block.” In 1959, Köle11 reported combining orthodontics with corticotomy surgery and completed the active tooth movement in adult orthodontic cases in 6 to 12 weeks. The interproximal corticotomy cuts were extended through the entire thickness of the cortical layer, just barely penetrating into the medullary bone. These vertical cuts were connected beyond the apices of the teeth with a horizontal osteotomy cut extending through the entire thickness of the alveolus, essentially creating blocks of bone in which one or more teeth were embedded. Using the crowns of the teeth as handles, Köle believed that he was able to move the blocks of bone somewhat independently of each other because they were only connected by the less-dense medullary bone. He found no incidence of root resorption, no loss of tooth vitality, and no pocket formation.

In 1991, Suya12 reported surgical orthodontic treatment of 395 adult Japanese patients with an improved surgical procedure that he referred to as “corticotomy-facilitated orthodontics.” Suya’s surgical technique differed from Köle’s with the substitution of a supraapical horizontal corticotomy cut in place of the horizontal osteotomy cut beyond the apices of the teeth. Like Köle, Suya did not report luxating any of the corticotomized blocks of bone. He completed most cases in less than 12 months and showed examples of cases completed in 6 months. Suya contrasted his technique with conventional orthodontics as being less painful, producing less root resorption, and exhibiting less relapse. He, like Köle, believed that the tooth movements were made by moving blocks of bone using the crowns of the teeth as handles. He recommended completing the major active tooth movements in 3 to 4 months, after which time he surmised that the edges of the blocks of bone would begin to fuse together.

In 1986, Anholm et al13 reported the treatment of a 23-year-old man with a severe malocclusion using corticotomy-facilitated orthodontics. The case was nonextraction, and active treatment was completed in 11 months. The periodontium remained healthy, with no significant attachment loss or gingival changes that would contraindicate the use of the corticotomy procedure. In 1990, Gantes et al14 reported treating five adult patients, 21 to 32 years of age, using Suya’s corticotomy-facilitated orthodontic procedure. The cases
included some difficult space clos-
ing where the buccal and lingual
cortical plates were removed over
the extraction sites. Mean treatment
time was 14.8 months for the exper-
imental group and 28.3 months for
the control group. Some apical root
resorption was observed, but there
was no loss of tooth vitality, and no
adverse periodontal effects were
clinically noticeable. They reported
only minimal gingival recession and
no attachment loss of clinical signif-
icance, with posttreatment attach-
ment levels in 88% of the sites within
1 mm of the pretreatment values; interdental papillae were preserved,
resulting in good esthetic results.

The present study replicated
Suya’s corticotomy-facilitated ortho-
dontics procedure to resolve dental
arch crowding and achieved similar
results: markedly decreased treat-
ment times, no loss of tooth vitality,
no significant apical root resorption,
and no periodontal pocketing. Com-
parison of pretreatment and post-
treatment computed tomographic
(CT) scans, however, indicated a de-
mineralization of the alveolar bone
over the root prominences of moved
teeth. CT scan analysis at 2 years
posttreatment indicated varying
degrees of remineralization of the
alveolar bone. The demineralization/
remineralization finding strongly
suggests that rapid tooth movement
was because of RAP,6–8 not bony
“block” movement.

New discoveries can often clar-
ify earlier concepts. RAP now ex-
plains how damaged bone can re-
pair itself in a timely fashion through
increased cellular activity, initially
manifesting with demineralization
but resolving with remineralization.
Osteoclasts are capable of de-
mineralizing bone via a proton
pump.15 It has been demonstrated
that parathyroid hormone can act on
the remodeling system to encourage
osteoclast formation.5 Additionally,
prostaglandins have been shown to
produce an increase in osteoclast
numbers in long-term feline and
murine marrow cultures, presumably
through enhanced fusion of osteo-
clast precursors.16,17 Urist18 demon-
strated that decalcified bone matrix
can induce new cartilage and bone
formation when implanted at non-
bone sites. It was later shown that
protein extracts from the decalcified
bone matrix are responsible for the
new bone formation.19 A key factor
in bone morphogenesis appears to
be bone morphogenetic proteins
(BMP), which influence primitive
uncommitted stem cells to become
the more specific cell types that par-
ticipate in bone formation.20 More
recently, recombinant human bone
morphogenetic protein-2 (rhBMP-2)
has been shown to induce new bone
formation.21

Case reports

Case 1

A 24-year-old man (Fig 1) presented
with a Class I severely crowded mal-
occlusion with an overly constricted
maxilla and concomitant posterior
crossbites. Consequently, he exhib-
ited concave lateral midfacial fea-
tures from a frontal perspective. The
patient lamented that he had not
been able to have orthodontic work
when he was younger.

The estimated length of treat-
ment using conventional orthodon-
tics was 2 to 2.5 years, and orthog-
nathic surgery would have most
likely been necessary to open the
midline palatal suture to assist in the
expansion of the maxillary arch.
Even though the patient was ex-
tremely self-conscious of what he
perceived to be very crowded teeth
and a “skinny” face, as an adult he
would not be receptive to under-
going orthodontic treatment for 2 or
more years. When presented with
the option of completing the ortho-
dontic treatment in about ¼ to ⅓ of
the time needed for conventional
orthodontic treatment, he readily
accepted the new treatment
method. He had no objection to the
inclusion of a periodontal plastic sur-
gical procedure with resorbable
grafting materials. He had been
treated a year earlier for gener-
alized incipient periodontitis with
deep scaling and root planing that
resulted in posttreatment probing
depths no greater than 3 mm. Radi-
ographically, there appeared to be
a small amount of horizontal bone
loss that was most noticeable in the
mandibular anterior area, and there
also appeared to be a shallow ver-
tical osseous defect mesial of the
maxillary left first molar. It was sus-
pected that there was no more than
Class I furcation involvement in any
of the erupted molars. Even though
the impacted third molars and
supernumerary teeth had suppos-
edly been removed following the
periodontal work, there was still one supernumerary tooth distal of the maxillary left second molar. It was decided not to remove this tooth. There was only slight gingival recession (1 to 2 mm) facial and lingual of some of the mandibular anterior teeth and premolars. Because of the scarcity of attached fibrotic gingiva, the prominence of the roots, and the fact that these teeth would be expanded facially, free gingival grafting buccal of these teeth was deemed advisable. It was hoped that the increased zone of attached fibrotic gingiva would lessen the likelihood of significant additional gingival recession. It was, however, explained to the patient that because of the reduction in the height of the crestal bone that had resulted from the earlier periodontal disease, in some areas he might experience some additional gingival shrinkage. All teeth registered vital to ice. The orthodontist designated all of the erupted teeth for expansive movement (decrowding). The orthodontic treatment plan included maxillary and mandibular braces and pure orthodontic expansion of the arches to assist in correcting both the crowding and crossbites.
Fig 1f  Pretreatment radiographs of patient 1.

Fig 1g  Posttreatment radiographs of patient 1.

Fig 1h (left)  Buccal corticotomy cuts and perforations in the maxillary left quadrant in patient 1.

Fig 1i (right)  Grafting mixture covers the selective decorticating buccal of the teeth in the maxillary left quadrant in patient 1.

Fig 1j (left)  Reentry of the maxillary left quadrant in patient 1 about 8.5 months after debracketing.

Fig 1k (right)  Same area seen in Fig 1j following the removal of the superficial Osteograft/N-300 particles that were not incorporated into the new layer of buccal bone.
Case 2

A 17-year-old female (Fig 2) presented with a Class I moderately to severely crowded malocclusion. When she was approximately 13 years of age, she was given the opportunity to have conventional orthodontic treatment performed. At that stage of her life she was not in favor of having to wear braces for a couple of years and consequently declined the needed treatment. She was now getting ready to begin her senior year in high school and was more self-conscious of her “crooked” teeth, which detracted from her self-esteem. She had 2 requests, however, that would have been difficult to accomplish with conventional orthodontic treatment: (1) to have the orthodontic treatment completed before she graduated from high school, which was less than a year away; and (2) to complete treatment with not only straight teeth, but with a more prominent smile. Unfortunately, the estimated length of treatment using conventional orthodontics was approximately 2 years. Second, it would not be possible to take advantage of her rapid growth phase because that had already passed. Without being able to modify the skeletal growth to aid in treatment, extractions would have to be seriously considered, limiting the ability to provide her with a more prominent smile. When it was explained that there was a new orthodontic method that would make it possible to complete her case in less than 8 months, and that even though she was past the rapid growth phase extractions could be avoided, making it possible to provide her with a more prominent smile, she immediately accepted this treatment option. The orthodontic treatment plan included maxillary and mandibular braces and
orthodontic expansion of the arches to assist in correcting the crowding. All teeth were designated for expansive movement by the orthodontist. Both the patient and her mother found the proposed periodontal plastic surgical procedure with the incorporation of resorbable grafting material to be acceptable.

The periodontal evaluation revealed a healthy scenario. Clinically, there was no periodontal pocketing, and the zone of attached gingiva was deemed adequate. Radiographic examination revealed no significant bone loss, and all of the erupted permanent teeth registered vital to ice. The mandibular right second premolar was congenitally missing, and there was a temporary stainless steel crown on the primary molar that had not yet been exfoliated. It was decided to try to retain the primary molar until the completion of the orthodontic work. It was understood that a replacement would be needed for the second premolar in the future. The unerupted third molars would also likely need to be removed following the completion of the orthodontic work.
Technique

Braces were placed on both patients, and the archwires were engaged during the week preceding the surgery. Standard braces, archwires, and normal orthodontic force levels were used. Surgery was performed under intravenous sedation and local anesthesia, with surgery performed on the maxillary and mandibular arches at the same appointment in patient 2 and at 2 separate appointments, 2 days apart, in patient 1. After making sulcular incisions, full-thickness (mucoperiosteal) flaps were reflected on both the buccal and lingual aspects of all maxillary and mandibular teeth. Special care was taken not to perforate the flaps, and any interdental papillary tissue that remained interproximally was left in place. The flaps were reflected beyond the apices of the teeth if possible. Because the palate typically begins leveling out coronal to the apices of the maxillary teeth, flap reflection beyond the apices of the maxillary teeth was not possible on the palatal aspect. Care was exercised not to damage any of the neurovascular bundles exiting the bone and not to disturb the genioglossus attachment. Following flap reflection, the selective decortication (bone activation) was performed both buccally and lingually around all teeth in both cases. Vertical corticotomies were made just short of the alveolar crest were made between the roots of the teeth; these cuts were connected beyond the apices of the teeth (where possible) with a scalloped horizontal corticotomy cut, and numerous corticotomy perforations were made in the cortical layer (Fig 1h). The design of the selective decorticating was more to maximize the marrow penetration and bleeding than to create blocks of bone. The corticotomy cuts and perforations extended just barely into the medullary bone. Care was taken not to sever the potential anterior loop of the inferior alveolar nerve that could extend mesial to the mental foramen and be positioned just beneath the buccal cortical plate. No luxation was performed following the partial decortication.

An established augmentation procedure using resorbable materials was then performed over the partially decorticated areas. In patient 1, an equal mixture by volume of demineralized freeze-dried bone allograft (DFDBA) from the Mile High Transplant Bank and bovine bone (Osteograf/N-300, CeraMed) were used (Fig 1i); in patient 2, PerioGlas (US Biomaterials) was used. There were no significant bony fenestrations or dehiscences in patient 2. Generally, when there are bony fenestrations and dehiscences in patient 2. An advantage of its potential inductive properties. In both cases, the grafting materials were wet with a clindamycin phosphate solution (approximately 10 mg/mL) just prior to placement. Care was taken not to place an excessive amount of grafting material, as this might interfere with replacement of the flaps. It is best not to use a lubricant on the lips. If, however, a lubricant is used, care must be taken to thoroughly remove it prior to placement of the grafting material. Contamination of the grafting material with lubricant could lead to failed augmentation. The mucoperiosteal flaps were sutured with interrupted loop 4-0 nonresorbable sutures, being careful to preserve the interdental papillae; the sutures were removed 2 weeks postsurgery. Silk suture material was used in patient 1, and Gore-Tex suture material (3i/WL Gore) was used in patient 2, the Gore-Tex having the advantage of no wicking action. Each patient was seen about 2 weeks postsurgery for the first orthodontic adjustment. The intervals for the orthodontic adjustments averaged 2 weeks, ranging from 1 to 3 weeks. From bracketing to debacketing in patient 1 was 6 months and 2 weeks, with 12 orthodontic adjustment appointments; patient 2 was completed in 6 months and 2 weeks, with 11 orthodontic adjustment appointments. Removable retainers were placed immediately following the removal of the braces.

During the active tooth movement, both patients were checked by the periodontist at least once each month, and no significant periodontal problems were noted. Posttreatment evaluation of both patients revealed no probing depths greater than 3 mm, good preservation of the interdental papillae, no loss of tooth vitality, no significant reduction in the radiographic height of the crestal bone, and no radiographic evidence of any significant apical root resorption. No gingival
recession was noted in patient 2. Only a small amount of additional gingival recession (at most between 1 and 2 mm) was noted in a few mandibular anterior areas of patient 1, but the patient was aware of this possibility because of the preexisting horizontal bone loss. According to her mother, patient 2 smoked between one and two packs of cigarettes a day, but this did not appear to have any significant adverse effects. Both patients were pleased with the esthetic results.

Reentry

At approximately 15 months following the selective decortication/augmentation surgery and 8.5 months after debracketing, patient 1 was reentered. A full-thickness flap was again reflected buccal of the maxillary left posterior teeth and canine (Fig 1j). In comparison to the observations of the initial surgery (Fig 1h), there was a substantial increase in the thickness of the buccal bone and good maintenance in the height of the alveolar crest. There were particles of the Osteograf/N-300 on the surface of the bone that were not incorporated into the new layer of bone. These particles were simply wiped off with a piece of gauze, revealing a layer of bone with a marbleized appearance (Fig 1k). It is worth noting that the intercanine distance in the maxillary arch was increased by more than 7 mm, which translates to more than 3 mm of buccal expansion in the canine-premolar area on each side. Even with this rather large amount of buccal expansion, there was actually an increase in the posttreatment buccolingual thickness of the overlying buccal bone. Additionally, the fenestration buccal of the root of the first premolar was covered. These observations certainly lend credibility to the inclusion of the augmentation procedure at the time of the corticotomy surgery. Without the inclusion of the augmentation procedure, the best that one could hope for would be not to lose the preexisting bone. There would be no possibility of covering preexisting fenestrations, and remineralization of the soft tissue matrix of the preexisting bone might not be complete, leading to dehiscence formation, especially in areas of preexisting fenestrations.

Discussion

We have developed a new orthodontic method that includes the advantages of corticotomy surgery and alveolar augmentation. An evaluation of this method in nonextraction orthodontics for decrowding with normal orthodontic forces demonstrated dramatic decreases in treatment times and an increased thickness of alveolar bone at the cephalometric landmark B point. This new method is not only safe, but has made it possible to help maintain and even thicken the layer of pretreatment bone over the prominences of the roots. Fenestrations can be covered, and consequently the likelihood of dehiscence formation can be reduced where there is still a vital root surface. Not only can the teeth be moved rapidly, but this can be accomplished without significantly jeopardizing root length. A local, transient, clinically induced osteoporosis can be used to facilitate tooth movement.

Trauma to cortical bone has been shown to be a potentiating factor in producing a localized osteoporosis. Surgery invokes an RAP wherein both hard and soft tissue reorganization is potentiated, leading to a transient catabolic condition. For bone, this transient osteoporosis means increased mobilization of calcium, decreased bone density, and increased bone turnover, all of which would facilitate more rapid tooth movement. Osteoporosis provides a favorable environment for increasing the rate of tooth movement without increasing the risk of root resorption in rats. Moreover, it has been demonstrated that the residual soft tissue matrix has the ability to induce remineralization after the cessation of tooth movement. All of this suggests that the dynamics of the physiologic tooth movement in these patients might be more appropriately described as a demineralization/remineralization process, rather than bony block movement or resorption/apposition. This perspective is substantiated by the fact that there is a growth protein component in the soft tissue matrix of bone. Following cessation of the active tooth movement, this growth protein component may assist in stimulating an increase in
osteoblastic activity, resulting in remineralization of the soft tissue matrix.

Full-thickness flap surgery is necessary for good visualization when performing the selective partial decortication of the alveolar bone. This provided the opportunity to incorporate an established bone augmentation procedure at the time of the surgery. The reshaped alveolar bone provides additional support for the roots of the teeth and perioral musculature at the completion of treatment and diminishes potential dehiscence formation where there are preexisting fenestrations and where remineralization of the bone over the prominence of a root may not otherwise be complete.

By combining the talents of the periodontist and the orthodontist, we now have a viable and safe orthodontic treatment that can be completed in a fraction of the time required for conventional orthodontics. With surgical intervention, an osteoporotic situation that is favorable for rapid orthodontic tooth movement can be induced within the alveolar bone without increasing the risk of apical root resorption. The alveolar bone can be simultaneously augmented and reshaped.

References