CASE REPORT

Guided bone regeneration to repair an osseous defect

Roberto S. Carvalho, DDS, MSc, PhD,[a] Donald Nelson, DDS, MMSc,[b] Hans Kelderman, DDS, MMSc,[c] and Roger Wise, DDS[d]
Boston, Mass, and Amsterdam, The Netherlands

The ultimate goal of orthodontic therapy is to establish functional and esthetic dental relationships in a balanced facial pattern. In patients with compromised periodontal support, the use of multidisciplinary treatment plans is essential in attaining these goals. This case report includes a thorough documentation of the orthodontic and periodontal treatments to demonstrate the effectiveness of guided bone regenerative procedures combined with a bone allograft to aid in correcting a dental malocclusion. (Am J Orthod Dentofacial Orthop 2003;123:455-67)

Often in the orthodontic treatment of adults, pretreatment periodontal conditions can include infrabony defects, furcation involvement, interproximal craters, and hard and soft tissue dehiscences.[1] Althugh some controversy persists on whether it is possible to move teeth in a compromised periodontium without further attachment loss, consensus exists that the risks of orthodontic tooth movement in adults with these clinical findings rise significantly. With more adults seeking orthodontic correction, practitioners must treat malocclusions with diverse aggravating periodontal conditions ranging from localized single-tooth lesions to advanced generalized periodontal disease. Concomitantly, the globalization of orthodontics into multispecialty practices and the proliferation of litigation have contributed to careful planning of multidisciplinary treatment in difficult cases. A common multidisciplinary approach is to combine periodontal corrective procedures before, during, or after orthodontic treatment. Although absolute reduction in bone attachment levels does not contraindicate orthodontic correction, it does increase the difficulty of delivering controlled orthodontic mechanics that would potentially minimize further bone loss.[2]

[a]Assistant professor, Department of Orthodontics, Boston University School of Dental Medicine.
[b]Assistant professor, Department of Orthodontics, Harvard School of Dental Medicine, Boston.
[c]Private practice, Amsterdam, The Netherlands.
[d]Lecturer, Department of Orthodontics, Harvard School of Dental Medicine, Boston.
Reprint requests to: Roger Wise, DDS, Department of Orthodontics, Harvard School of Dental Medicine, 188 Longwood Ave, Boston, MA 02115; e-mail, office@pericopc.com.
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It has been shown that it is possible to regain bone attachment levels lost to periodontitis or trauma.[3,4] In 1976, Melcher[5] suggested that the healing of the periodontium was determined by the cell type that repopulated the wound surface. This concept of selective cell population influenced Nyman et al[6] to use occlusive barriers in the periodontal healing studies that formed the basis for a technique later known as guided tissue regeneration (GTR). Essentially, GTR is used in different types of periodontal defects (1-, 2-, and 3-walled lesions) to attempt to regenerate lost periodontal structures through differential tissue response. This is accomplished with a barrier membrane to prevent the cells from the gingival connective tissue and the epithelium (fast proliferative capacity) from colonizing the decontaminated root surface in the belief that these interfere with regeneration.[1,7] This allows for the proliferation (slow turnover) of cells derived from the residual periodontal ligament (PDL) and from bone marrow spaces to promote periodontal regeneration with subsequent matrix deposition and bone mineralization.[3,8,9] Regeneration is a very complex phenomenon that depends on a coordinated response from several cell types that produce a wide range of extracellular matrix proteins.

Historically, certain types of bony defects have been successfully treated with bone grafts.[10] Becker et al[11] reported various treated teeth with different degrees of furcation and vertical bony defects. After surgical reentries later, these authors noticed a significant attachment gain in firmly attached tissue that had the consistency of bone; however, this new tissue, termed "open probing new attachment," lacked the histological characteristics of bone.[11] Subsequent reports by Bowers et al[12-14] suggested that the use of

Table. Cephalometric norms and pretreatment and posttreatment values for white people

			Records	
Area of Study	*Measurement*	*Standard*	*A*	*B*
Cranial base	SNH	9°	7°	7°
Maxilla to cranial base	HNA	90°	89°	89°
	SNA	80.5°	82° (80°)	82° (80°)
Mandible to cranial base	SNB	78°	78.5° (76.5°)	78° (76°)
	SNPg	80°	80° (78°)	79.5° (77.5°)
	Pg-NB	2.5 mm	3 mm	3 mm
Basal arch relationships	ANB	2.5°	4°	4°
	AB distance	4.5 mm	6 mm	6.5 mm
	Wits	0/-1 mm	4 mm	4 mm
Vertical relationships	NF-H	0°	2°	2°
	NF-MP	26°	20°	20°
	SN-MP	37°	31° (33°)	31°
	OP-MP	18°	19°	19°
	LFH/TFH	55%	54%	54%
	Y-Axis	90°	83°	83°
Dental positions	UI-NA	22° (4 mm)	31° (12 mm)	21° (2 mm)
	LI-NB	25° (4 mm)	20° (3 mm)	26° (5 mm)
	LI-APg	2.5 mm	0 mm	2 mm
	IMPA	90°	90°	97°
	UI/LI-A	130°	125°	129°
Soft tissue	NLA	102°	110°	104°
	UL-BEline	3 mm	1 mm	3°
	LL-REline	−4 mm	−9 mm	−6°

bone analogs, mostly decalcified freeze-dried bone allografts (DFDBA), induced significant gains in new bone formation in areas of periodontal defects. Comparing nondeclacified freeze-dried bone with decalcified freeze-dried bone showed that using both forms of allografts equally resulted in reducing mean probing depths and gingival recession and an overall gain in attachment levels.[15] The use of such bone grafts combined with GTR membrane might serve as a scaffold for clot formation and stability, and as a support for the surgical flap itself.[12]

Studies have shown that using GTR and DFDBA enhanced the cellular events in the bone induction process when compared with GTR alone.[12] This function could also contribute to the successful regeneration process and new attachment.[16] The treatment of severe periodontal defects by Schallhorn and McClain[17] showed that the combination of the regenerative membrane with a composite osseous grafting material produced better clinical results (72% in cases of advanced furcation lesions) than membrane only. In fact, these authors suggested that GTR is a misnomer when used alone, because the entire attachment apparatus is not replaced.

The impact of GTR to patients before, during, or after orthodontic treatment has been occasionally reported in the literature.[18-24] Similarly, there is little information on the effects of osseous defects such as dehiscences, fenestrations, and localized ridge deformities in the orthodontic treatment plan. To repair these localized bony ridge defects, a similar technique to GTR has been called guided bone regeneration (GBR), because its main purpose is not to induce new tissue around a tooth, but to regain an adequate bony alveolar ridge.[7,23]

This article describes the orthodontic treatment of an adult who underwent GBR and DFDBA to repair an osseous defect caused by the extraction of a premolar before orthodontic tooth movement. This report and similar reports should reinforce the concepts of regenerative procedures as possible complements to specific orthodontic treatment plans.

Fig 1. Pretreatment intraoral photographs.

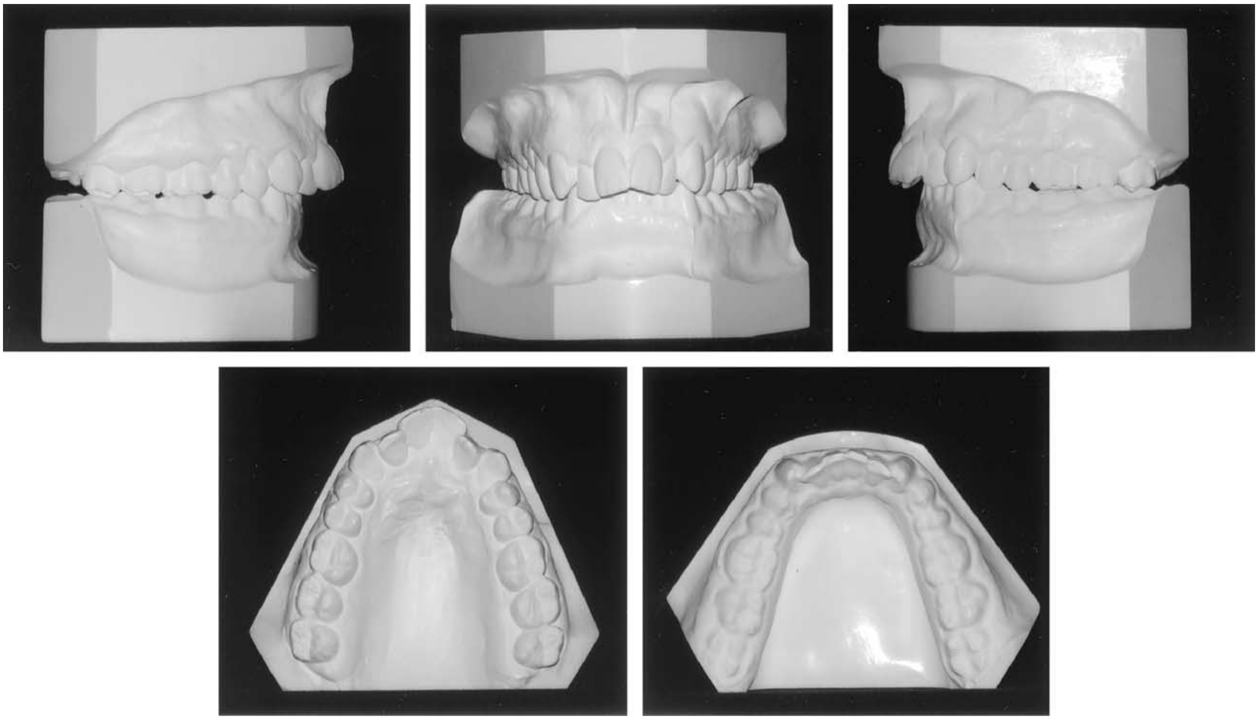

Fig 2. Pretreatment dental casts.

DIAGNOSIS AND ETIOLOGY

The patient, a healthy 37-year-old white man, came to the Orthodontic Department of Harvard School of Dental Medicine chiefly concerned that "my teeth are moving. Because of cosmetic reasons, I want my teeth to be straight." His medical history was unremarkable, but his dental history was remarkable for trauma to his maxillary right central incisor with subsequent discoloration of facial enamel, which had previously received endodontic treatment. In addition, he had generalized gingival recessions in both maxillary and mandibular teeth and poorly adapted amalgam restorations in the posterior teeth.

The diagnosis of this patient included a convex profile with slight mandibular retrognathism. The skeletal pattern showed a maxilla within normal limits and a slightly retrognathic mandible in the anteroposterior direction (Table). The dental records showed a Class II molar relationship with proclined maxillary incisors, retroclined mandibular incisors, a deep curve of Spee, an overjet of 8 mm, an over bite of 4 mm, and moderate crowding in both arches (Figs 1 and 2). Transversally, his maxilla was narrow, but this was considered to be of dental origin. Thus, his most significant findings were not skeletal, but dental. Detailed cephalometric values are shown in the Table. The pretreatment cephalometric x-ray and tracing are shown in Figure 3 and the pretreatment panoramic x-ray in Figure 4.

ORTHODONTIC TREATMENT OBJECTIVES

Initial treatment objectives for this patient were straighforward. Because he had a skeletal pattern within normal limits (except for a small mandibular retrognathism), the objectives centered on eliminating the crowding in both arches, reducing over bite and overjet, achieving a more stable dental arch form, and establishing a functional and flatter curve of Spee. The original goals were to improve the occlusion, esthetics, and long-term dental health by reestablishing normal function with balanced excursive movements. To achieve these goals, the orthodontic treatment plan called for extracting 2 maxillary first premolars, with maximum anchorage in the maxillary arch by means of a palatal bar. This plan did not include extractions in the mandibular arch; crowding there would be relieved by judicious reproximation (stripping) of the mandibular incisors, canines, and premolars. It was expected that some space would be gained in the mandibular arch by proclination of the incisors, because they were in a retroclined position (Table). The overall prognosis for this patient was good.

PROGRESS OF TREATMENT

Full banded and bonded maxillary and mandibular appliances (0.018 × 0.025-in slot straight wire) were placed. The following wire sequence was used: maxilla: 0.016-in nickel-titanium (NiTi), extraction, periodontal consult, 0.016-in stainless steel (SS), 0.018-in SS, 0.017 × 0.025-in TMA T-loops; mandible: 0.016-in NiTi, 0.016-in SS, 0.016 × 0.022-in SS, 0.016 × 0.022-in TMA. Interproximal enamel reduction took place during round wires 0.016-in NiTi and 0.016-in SS in the mandibular arch. At initial stages of treatment, a porcelain crown was placed on the maxillary right central incisor. This was not part of the original plan, and it was thought that this definitive restoration would have been more indicated after active orthodontic tooth movement, but the patient opted to proceed and had the crown cemented by his general dentist.

During the extraction of the maxillary premolars, the apical third of the maxillary right first premolar was fractured and remained in the bone. When the patient returned to the oral surgeon to have the apex of the fractured tooth removed, the entire buccal plate of bone was fractured, leaving a considerable defect in the alveolar bone (described below). Shortly after that, he was referred for periodontal consultation (see periodontal treatment plan). After the bone fracture and the periodontal procedures on the maxillary right quadrant, 5 months passed before any tooth movement was attempted into the affected area. The patient responded well to treatment and was very cooperative in terms of elastic wear. Overall, crowding was resolved in both arches without excessive proclination of the incisors and with no adverse effects on soft tissue esthetics, and no other complications occurred.

PERIODONTAL TREATMENT PLAN

After the extraction of the maxillary right and left first premolars, the patient's periodontal condition was evaluated. As described above, the accidental fracture of the entire buccal bone of the area correspondent to the maxillary right first premolar created a significant bony defect (Fig 5).

After the fracture of buccal bone, the initial treatment objectives, which included maximum retraction of the maxillary incisors to correct the over bite and the overjet, become significantly more difficult, if not totally unviable. As a result, a decision was made to place a DFDBA (obtained from the bone bank in Miami, Fla) in conjunction with a GBR protocol using a nonresorbable polytetrafluoroethylene (Gore-Tex, W. L. Gore, Flagstaff, Ariz) membrane combined with titanium (to enhance the structural integrity to the membrane).

The reason for this combined procedure was to prevent any further loss of critical supporting buccal alveolar bone after the distalization of the right maxillary canine into a nonregenerative buccal ridge defect. The expectation was that, by using GBR, the ridge defect would be lessened or eliminated, and, consequently, any further damage to the buccal alveolus supporting the distalized canine would also be minimized. This case report is unique because the PDL had not been violated (ie, no attachment loss), and the defect was primarily one of loss of the buccal plate from an inadvertent traumatic procedure. The surgical protocol is shown in detail in Figure 6.

The GBR surgery was accomplished 2 months after the extraction site healed (Fig 6, *A* and *B*) and 2.5 months before starting distalization mechanics of the maxillary right canine. Two months after the GBR procedure, the membrane was surgically removed via

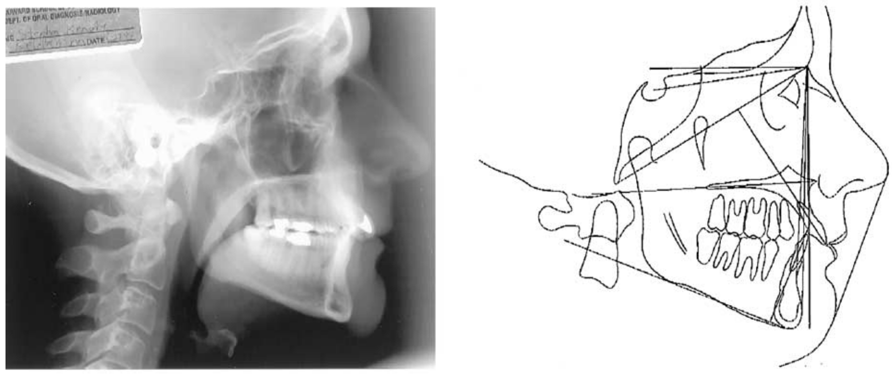

Fig 3. A, Pretreatment cephalometric x-ray and, **B,** pretreatment cephalometric tracing.

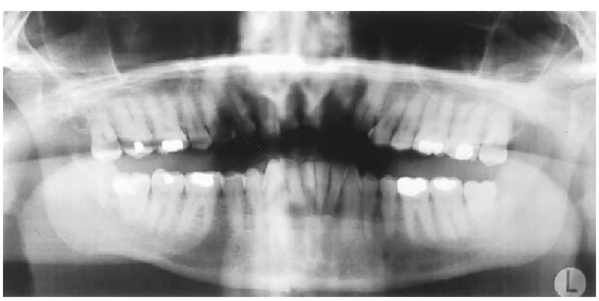

Fig 4. Pretreatment panoramic x-ray.

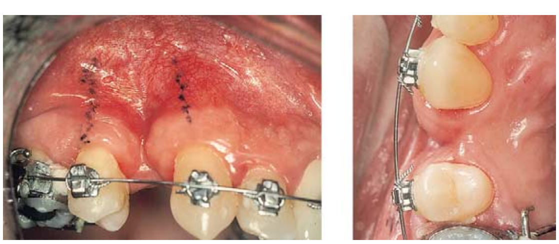

Fig 5. A, Buccal and, **B,** occlusal views of alveolar bone defect after extraction of remaining root fragment. Note complete absence of buccal plate on area correspondent to maxillary right first premolar.

flap opening and closure (Fig 6, *D*); the so-called "new bone" was observed at this time. This tissue was most likely a composition of nonmineralized organic bone matrix known as the regenerate. Two weeks after removal of the membrane, the distalization of the canine was started by using the available regenerated extraction site in its entirety. Because the regenerated defect was very immature, the intent was to take advantage of any buccal expansion of the healing regenerated area during canine distalization to enhance the bone-healing process. Figure 7 shows a comparison of the occlusal view of the extraction site in the maxillary arch before (Fig 7, *A*) and after (Fig 7, *B*) the retraction of the canine.

At 18 months, and after a 4-month retention period of the canine in its new distalized position, the patient consented to a surgical reopening of the same site so that the amount of buccal bone remaining could be clinically determined (Fig 8). The result was favorable because the buccal bone height was found to be 2 mm from the cementoenamel junction (CEJ) of the canine. Allowing 1 mm of connective tissue fiber attachment above the bony crest in a normal periodontium,[25] the actual loss in bone height was only 1 mm (Fig 8, *B*). After active treatment, the untreated (periodontally) contralateral side was also surgically exposed (Fig 8, *C*), and this site had a buccal bone height of 2 mm from the CEJ of the left canine. Interestingly, Sanavi et al[26] observed that the level of the bone crest is situated an average of 1.5 to 2 mm from the CEJ on a natural tooth. Figure 9 shows the periapical x-rays of the maxillary right quadrant immediately after the buccal plate fracture (Fig 9, *A*), after the GBR procedure (Fig 9, *B*), and after the canine retraction (Fig 9, *C*).

ORTHODONTIC TREATMENT ALTERNATIVES

This case was unique because of the changes in the patient's condition between the formulation of the original orthodontic treatment plan, before the maxillary premolars were extracted, and the revised plan, after the accidental fracture of the buccal plate correspondent to the area of the maxillary right first premolar. Thus, any treament plan would have to consider the latter as the patient's real need.

Unfortunately, this midtreatment scenario of a large bony defect made the continuation of treatment difficult for 2 main reasons: (1) it would be imprudent to attempt any tooth movement of the maxillary right canine into the extraction area (as originally planned), because this

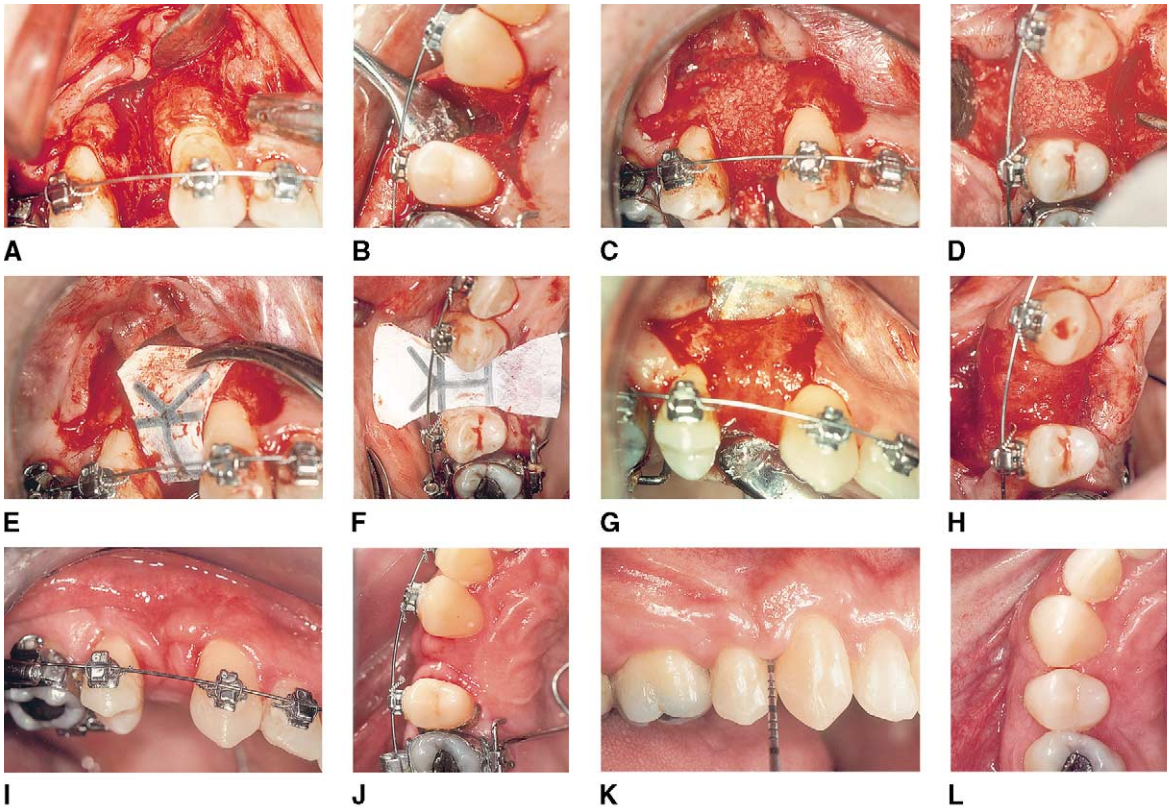

Fig 6. Buccal and occlusal views of extraction site. **A** and **B**, Surgical flap exposing buccal ridge defect. Bone height at canine was at 1 mm to CEJ before distal movement. Periosteum was removed over ridge defect, and bone was decorticated before DFDBA. Note extent of osseous damage in extraction site. **C** and **D,** DFDBA to rebuilt buccal plate. **E** and **F,** Placement of membrane with titanium reenforcement for GBR. **G** and **H**, removal of GBR membrane 2 months postoperative showing regenerate. **I** and **J,** Two weeks healing after membrane removal. **K** and **L**, One month after debonding. Note bone level on buccodistal surface of canine as shown by periodontal probe.

would only magnify the problem with potentially further loss of bone, and (2) if the canine would not be moved (retracted into the extraction site), it would arguably be impossible to reduce the patient's over bite and overjet, improve esthetics, and reestablish ideal function.

However, possible alternate options for treatment were the following:

1. Stop orthodontic treatment while the area healed. Then reanalyze the case and decide whether to discontinue orthodontic treatment; in that case, a prosthetic replacement of the extracted premolars would be required.
2. Attempt canine retraction on the left side only with minimal retraction of the right canine, proceeding with the inital treament objectives very cautiously. Then the mandibular arch could be treated as initially planned.
3. Disregard the bony defect, wait for healing, and treat the patient as originally planned.

With the poor long-term prognosis, and because it would be impossible to achieve a stable and satisfactory result with any of these alternate plans, it was decided to proceed with the modified plan and add the GBR procedure as described above in detail.

ORTHODONTIC RESULTS

The final results can be seen in Figures 10-14. Skeletally, there was almost no change in the position of the maxilla or the mandible in any plane of space. The maxillary dentition was successfully treated by resolving the crowding with a more stable arch form. The same was achieved for the mandibular dentition. The maxillary incisors were retroclined, and the mandibular incisors were proclined to positions within the cephalometric norms. The occlusion obtained is a

Fig 7. Occlusal view of extraction sites in maxillary arch **A,** before and, **B,** after canine retraction. Note excessive concavity of right extraction site.

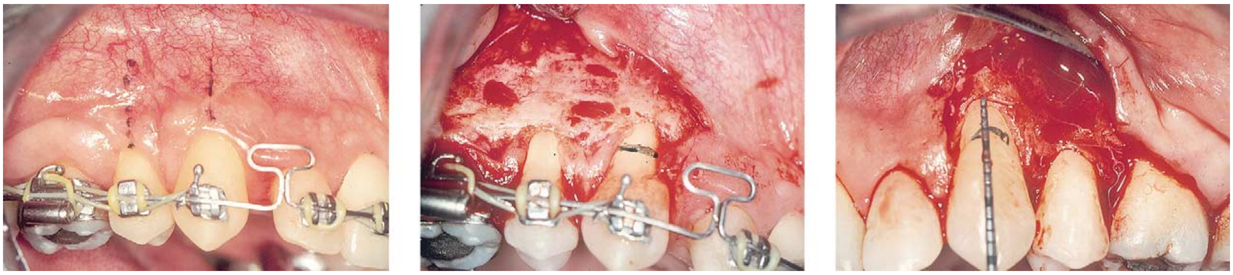

Fig 8. A, Maxillary right quadrant 18 months after start of canine retraction into area of new bone formation. **B,** Same site after reopening surgical flap to evaluate cervical level and quality of new bone formation. Note level of bone on premolar and canine. **C,** Buccal view of untreated contralateral side at end of active treatment. Periodontal surgical flap was performed to evaluate bone level and compare with treated side (*right*). Note that CEJ to osseous crest is 2 mm (similar to right side that received GBR of ridge defect).

Fig 9. A, Periapical film of defect created by extracting maxillary right first premolar and fracture of adjacent buccal plate. **B,** Vertical septal bone enhancement before distalization of maxillary right canine. **C**, Same area 18 months after tooth movement into maxillary right extraction site. **D,** Same area 1 month after debonding. **E,** Untreated left side. Note similarity in septal bone levels between right and left sides.

stable Class II molar relationship with a canine neutroclusion in both sides. Both over bite and overjet were improved within cephalometric norms (Table). All remaining teeth were leveled and aligned, including the maxillary and mandibular third molars. Dental esthetics were considerably improved, and some improvement in the patient's profile was also noted. Overall, at the end of treatment, there were neither balancing interferences nor any evidence of temporomandibular dysfunction. Superimpositions for skeletal and dental changes are shown in Figures 12 and 14. Total treatment time, including periodontal procedures, was 37 months.

DISCUSSION

The combination of orthodontic and periodontal procedures led to a significant improvement in the dental and occlusal relationships for this patient. Although his face was convex at initial examination, this was not his chief concern; at the end of treatment, the convexity was maintained, although minor changes

Fig 10. Posttreatment intraoral photographs.

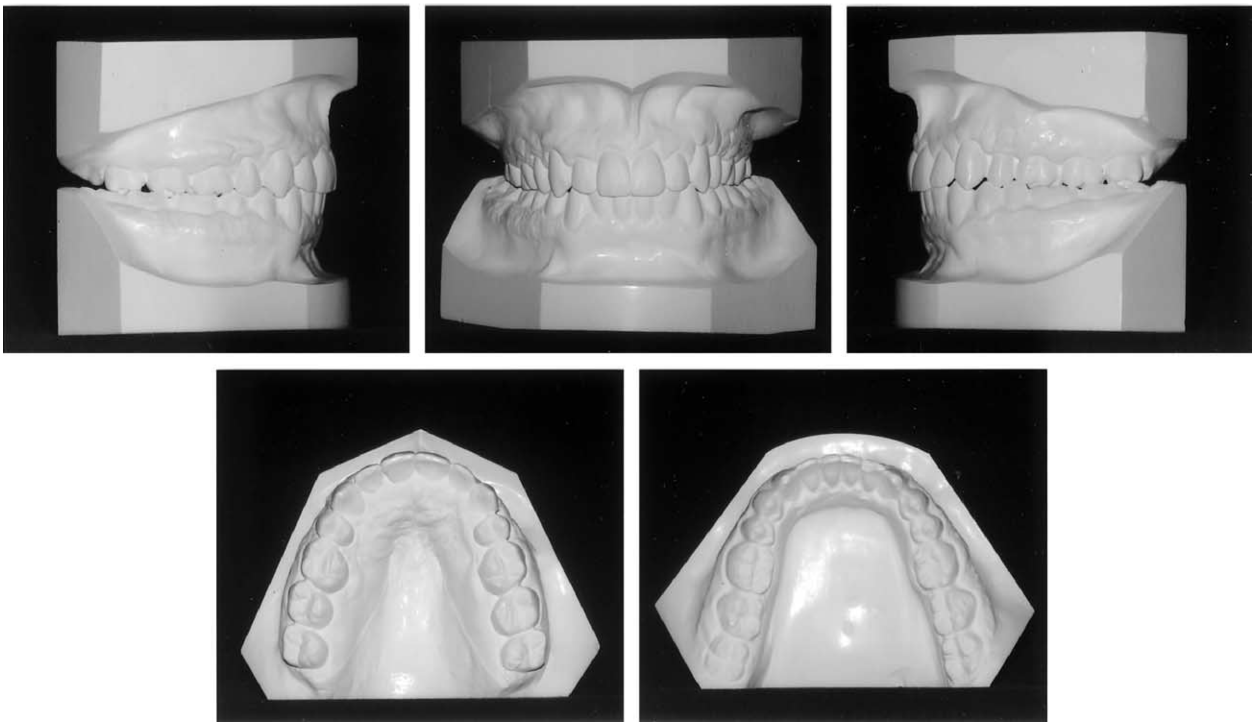

Fig 11. Posttreatment dental casts.

occurred in the lower face. This case became more interesting and complicated because of the periodontal changes after a traumatic injury while extracting the maxillary right first premolar. Thus, we attempt to illustrate the use of the GBR method and speculate on the usefulness of these procedures to assist in orthodontic treatment in selected cases.

Periodontal regeneration can be described as de novo cementogenesis, osteogenesis, and regeneration of newly formed fibers inserting into both newly formed cementum and alveolar bone (described by Melcher[5]). According to the American Academy of Periodontology,[7] regeneration is defined as the "reproduction or reconstitution of a lost or injured part." However, if the healing outcome of periodontal treatment is via repair mechanisms, and not regenerative

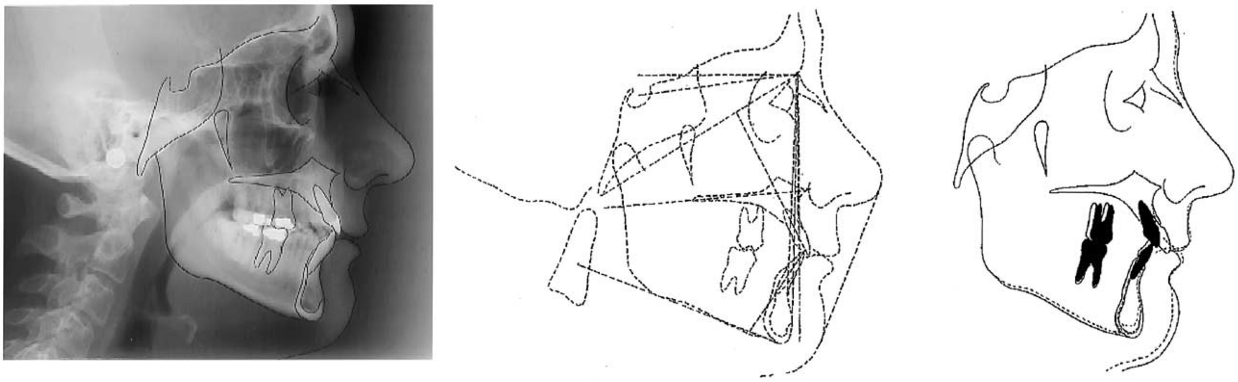

Fig 12. A, Posttreatment cephalometric x-ray; **B**, posttreatment cephalometric tracing; **C**, cranial base superimpositions.

Fig 13. Posttreatment panoramic radiograph.

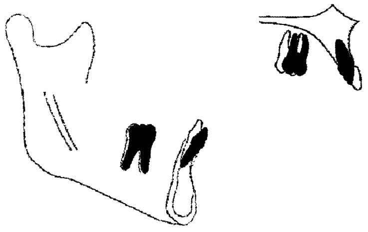

Fig 14. Posttreatment dental superimpositions (*white*, before treatment; *black*, after treatment).

ones as described above,[27,28] the newly formed tissue does not restore the architecture of the lost tissue.[5] Even though new cementum and a PDL might be obtainable with techniques such as GTR, new bone growth might not always occur.[29]

In an attempt to reproduce or improve regeneration, bone grafts (autogenous, allografts, and alloplasts) have been suggested.[30] Brushvold and Mellonig[31] have reported that the mean attachment gain with bone grafts is 2.68 mm with a 60% mean fill of the defect. Harris[32] has shown a 5.2-mm mean attachment gain produced by surgical GBR and bone allograft with combined biomodification of root surfaces with tetracycline. Bowers et al[10] have shown that bone allografts appear to produce regeneration histologically. These procedures are especially indicated for vertical bony defects.[30] Biomodification of root surfaces has also been suggested as an adjunct in regenerative PDL techniques. Citric acid[1,30] and tetracycline[32-34] have been used to promote greater connective tissue attachment both in vitro and in vivo.

According to Polson et al[35] and Wennstrom et al,[36] orthodontic tooth movement into existing infrabony periodontal defects has no favorable effect on the level of connective tissue attachment.[1] However, the loss of periodontal attachment produced before orthodontic treatment, seen in those studies,[35,36] took place in part because a diseased root was moved through a bony defect. In contrast, our patient began with a normal bone level and an intact periodontal apparatus (Fig 2). Consequently, the purpose of the preorthodontic ridge augmentation was to minimize or prevent further attachment loss in an otherwise healthy periodontium after orthodontic tooth movement into an isolated buccal ridge defect. This agrees with the concept of GBR, defined as the formation of new bone either to reconstruct a deficient alveolar ridge before or in conjunction with implant placement.[24] In this patient, instead of implant placement, the reconstructed ridge was needed to allow for the retraction of the canine through orthodontic mechanotherapy. As a result, only 1 mm of bone loss was detected from the CEJ to the osseous crest (Fig 8, *B*), from beginning to end of the treatment. The untreated (periodontally) contralateral left side also had a bone height of 2 mm from the CEJ to the osseous crest (Fig 8, *C*).

Studies have shown that orthodontic treatment after guided regenerative procedures resulted in significant attachment gain in spite of periodontal disease.[20,22,23]

The use of a nonresorbable polytetrafluoroethylene membrane in this study had the disadvantage of the need of a further surgical intervention for its removal (Fig 6). Currently, the use of polymer-based biodegradable membranes (Vicryl, Guidor, PLACA) has eliminated multiple intervention procedures.[1,24,32] Although multiple flap procedures in the grafted area (total of 3) were extremely useful to monitor probing depth and bone level, more invasive surgical procedures could have certainly contributed to decreased buccal bone height in the grafted area. However, careful monitoring of surgical procedures into the grafted and the contralateral control areas (with the patient's consent and full support) were invaluable in tracking the progress and the efficacy of GBR procedures as an adjunct to orthodontic therapy without radiographic distortions.

As described above, regeneration is difficult to attain. It is made more elusive by the difficulty in documenting the clinical environment, because conclusive proof would come only from human histology.[32] In this clinical case, short of notching teeth and other markings, we could document overall attachment level both before and shortly after tooth movement by flap periodontal surgery and direct visualization of the treated periodontium (Figs 6 and 8). During the active phase of tooth movement, the status of bone height, attachment levels, and probing depths was assessed every 2 months during periodic periodontal visits. Because no histology was performed, it was not possible to determine whether true regeneration or repair healing occurred in this patient. Nonetheless, favorable clinical results were achieved by reestablishing periodontal health in the affected area.

Experimental evidence suggests that the crucial factor in periodontium regeneration lies in the early induction of cementogenesis and the assembly of newly formed PDL fibers onto the highly mineralized and avascular root surface.[5,10,39] According to Bowers,[40] the combination of highly osteogenic materials and epithelial exclusion techniques is promising for enhancing the amount, frequency, and predictability of periodontal regeneration. Modern regenerative procedures have allowed for the enhancement of these phenomena, as this clinical case and others[41] exemplify.

The mode of action of bone grafts with Gore-Tex or other types of membrane can be classified as osteoconductive.[42] Osteoconduction occurs when a physical matrix or scaffolding is present, allowing for bone apposition, if this takes place over existing bone or differentiated mesenchymal cells.[43] The result described here was made possible by the formation of a matrix (in which new bone grew) through the placement of DFDBA. Based on our results, it can be assumed that osteoconduction or possibly osteoinduction took place, ultimately resulting in osteogenesis. By constrast, only autogeneous bone grafts (typically harvested from the iliac crest or another intraoral site) have the necessary combination of inductive bioactive molecules responsible for new bone formation. Such de novo induction and morphogenesis of periodontal tissue can enhance the use of gene-related products with inductive and morphogenetic properties that have been termed bone morphogenetic proteins (BMPs).[28,44-47] BMPs, particularly rhBMP-2, can bring about bone induction by stimulating the pluripotential or precursor cells of the host wall or from the cancellous portion of any bone graft placed in conjunction with the inductor material.[44,47] Once undifferentiated cells are stimulated into the endochondral pathway, they will regulate osteogenic cells that are already committed to osteogenesis.[48] The combination of BMPs and DFDBA helps expose the underlying bone collagen and BMP-type growth factors[43] from the DFDBA, enhancing the purported osteoinductive ability of these preparations.[43] This is important because it is believed that DFDBA alone cannot induce new bone formation at sites not normally considered capable of de novo osteoactivity.[49] It has also been shown that, in the presence of BMPs, bone formation occurs heterotopically.[48] Although it is still difficult to speculate into the clinical applications of these proteins, their induction of tissue morphogenesis through cementogenesis and periodontal regeneration is an essential ingredient of periodontal regeneration.[28]

We have demonstrated that, with GBR and DFDBA after the traumatic extraction of the maxillary right premolar in this patient, it was possible to move a tooth bodily into and through a ridge defect. This procedure reestablished a favorable alveolar ridge so that orthodontic treatment could ensue. Without such intervention, the remaining adjacent teeth might have been subjected to dehiscences and other sequelae provoked by tooth movement into an area of reduced bone width. Wennstrom et al[50] showed lessened bone height and possible loss of connective tissue attachment in incisors that were moved labially outside the existing alveolar bone. Figure 15 is a diagrammatic view of at least 2 alternatives after the accidental fracture of the buccal bone in the maxillary first premolar area. If nothing was done to repair this area after extraction, tooth movement would likely still be possible, but the periodontal consequences could be severe (Fig 15, *A* and *B*). Figure 15, *C* and *D*, shows a favorable result after bone regeneration procedures. Overall, the orthodontic correction of a full-cusp distocclusion was achieved with a

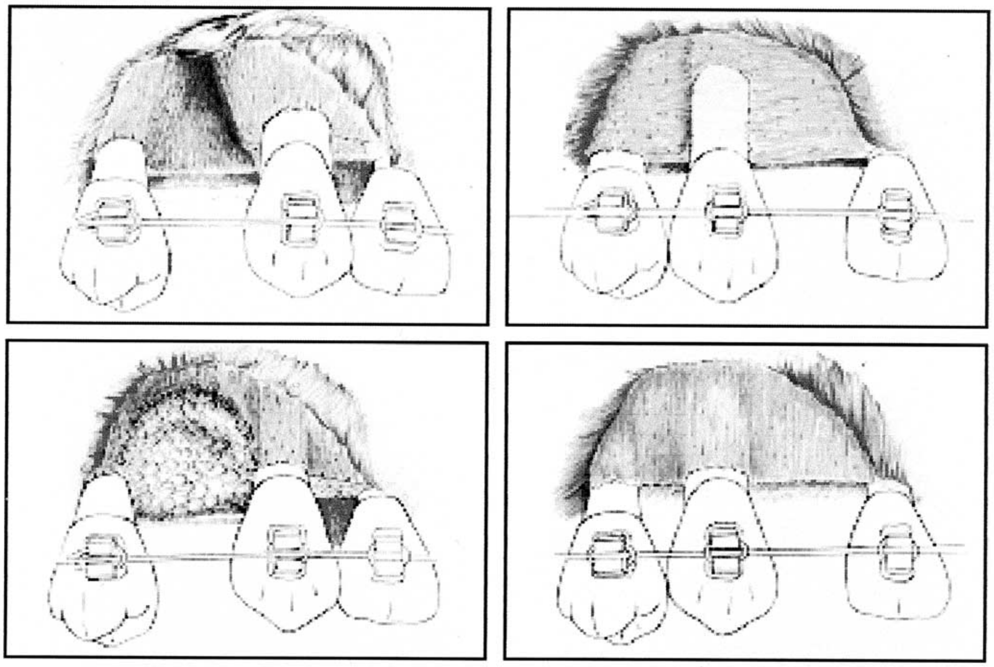

Fig 15. A, Diagrammatic view of ridge defect due to loss of alveolar bone from traumatic removal of maxillary first premolar. **B,** Possible dehiscence resulting from distal movement of maxillary right canine into defect area. **C,** Diagrammatic view of ridge defect due to loss of alveolar bone from traumatic removal of maxillary first premolar after placing DCBDA and GBR to obliterate defect. **D**, Preservation of buccal bone on maxillary right canine moved into defect area.

good dental change. Functionally, we finished this case in a good occlusion with improved dental esthetics; this was very important in view of the patient's chief concern. This combination of regenerative and orthodontic procedures has contributed to the reestablishment of function with good long-term prognosis. Previously reported cases have also had good long-term prognoses.[22,23] However, in our case, one might speculate that, at 2 months after grafting, the regenerate was encouraged via the distal movement of the canine to proliferate coronally or bucally. One can also only conjecture whether there might have been a much less favorable osteogenic response if the distal movement of the canine had begun into the healing extraction site with an accompanying alveolar defect from the traumatic removal of the first premolar without having first performed the GBR procedure (Fig 15).

CONCLUSIONS

This case report shows the advantage of using regenerative therapy to regain alveolar bone in a traumatic extraction site to prevent additional attachment loss due to orthodontic movement into the defect. We speculate that defects in similar cases (ie, with long-term extraction of permanent teeth in the mandibular arch resulting in atrophy of the alveolar ridge buccolingual dimension) can be treated similarly. However, in any of these circumstances, type and magnitude of the lesion as well as clinical variability will highly influence the success rate of regenerative procedures. Thus, it is important to report both clinical successes and failures to determine which defects respond most favorably to regeneration combined with orthodontic therapy. We hope that similar case reports will continue to define the interrelationship between orthodontic treatment and GTR principles.

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