Reentry Evaluation Following Treatment of Peri-implantitis with a Regenerative Approach

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Twelve implants with peri-implantitis underwent reentry flap surgery in five patients 6 to 96 months postregenerative surgery. This was necessary for additional treatment or new treatment of adjacent or other implants in close proximity to the original implant. Clinical measurements of the original depth of bone lesions ranged from 3 to 12 mm. Bone fill occurred around all implants and ranged from 2 to 9 mm, representing 40% to 100% of the original defect depth. These direct bony measurements support radiographic and sounding data in a previous report that recorded a mean of over 3 mm of bone fill in the defects treated with the specific regenerative approach used in this study. The results of this clinical series are encouraging; however, histologic research is necessary to determine if reosseointegration occurred, with direct visual evidence suggesting new bone formation, and more multicenter studies are needed to verify the results. (Int J Periodontics Restorative Dent 2014;34:47–59. doi: 10.11607/prd.1904)

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Peri-implantitis is a biologic complication of implant therapy. It has been defined as an inflammatory process affecting the soft tissue around an osseointegrated implant, resulting in the loss of the surrounding bone.[1,2] The etiology of peri-implantitis has been related to biome forming on the implant surface following its exposure to the oral environment.[3–6] Recently, a publication proposed several factors, including occlusal forces, damage to the implant surface, and corrosion, that could work synergistically with bacteria to progressively increase the loss of supporting bone.[7] A number of risk factors have also been identified that may lead to the establishment and progression of peri-implantitis bone loss.[1,8,9] While parameters have been identified to diagnose peri-implantitis, to date, predictable treatment strategies have yet to be established.[10] What is clear is that nonsurgical therapy has been uneqivocally shown to be ineffective in the treatment of peri-implantitis.[11] Six systematic reviews of the literature concluded that a variety of surgical approaches result in limited success.[12–17] The

use of access flaps combined with and without antimicrobial therapy have demonstrated success rates of less than 60%.[18] Simultaneously, access flaps including recontouring of the bony defects have also achieved limited success.[19–21] Several regenerative approaches have been reported to improve clinical outcomes with limited long-term follow-up.[22–26] More recently, however, a case series of 51 peri-implantitis implants treated using a unique regenerative approach reported successful results with 3- to 7.5-years of follow-up.[27] This study reported bone-level changes of 3.75 mm (measured radiographically) and 3.00 mm (measured by bone sounding) with probing depth (PD) reductions of 5.4 mm and 5.1 mm, respectively, in the same two groups of the 51 treated implants. These PD reductions were obtained without the adverse consequence of gingival recession. In fact, both groups achieved a mean gain in soft tissue coverage of the exposed implant surface of 1.3 mm and 1.0 mm, respectively.[27] Although these clinical results are extremely positive, the question of whether reosseointegration was obtained cannot be answered without performing block sections and histology of the healed tissues together with the previously exposed implant surfaces. This, of course, is impossible to obtain from patients seeking care in clinical private dental practices. However, reentry flap procedures around implants can provide further evidence supporting radiographic evidence of bone gain, similar to the assessment of

the clinical healing response of bone around natural teeth treated with regenerative efforts for periodontal disease.[28–30] The purpose of the current study is to report the clinical results, which include both soft tissue and reentry hard tissue measurements, from five patients treated with a regenerative approach for peri-implantitis. Three of the patients are presented as illustrative of the results.

Method and materials

Twelve moderate to advanced peri-implantitis–affected implants, as defined by a previously published classification, in five patients were treated with a regenerative approach.[31] All patients included in this report were subjected to reentry procedures that allowed direct visualization and quantitative measurement of the healed bone fill around the implants. These reentry procedures were necessary to either further treat the affected implant or to extend the flap to manage adjacent areas where teeth or implants had developed pathology or where a sinus elevation was to be performed.

The surgical techniques used in these cases were, with minor changes, described in a recent paper.[27] To briefly review, the protocol consisted of the following steps. *(1)* Reflection of full-thickness flaps to gain access to the peri-implantitis–affected implant surface and surrounding bone defect and the removal of retained cement when present with either titanium curettes

(Hu-Friedy) or TiBrush (Straumann). *(2)* Defect debridement and surface decontamination using a combination of air abrasion with powder (prophyjet, Dentsply) followed by saline spray alone; tetracycline 50 mg/mL and/or citric acid pH = 1 (applied for 30 seconds); saline spray irrigation alone applied with the air powered device (60 seconds); application of povidone-iodine or chlorhexidine; or a 60- to 90-second spray of saline alone using the air-powered device. *(3)* Application of a biologic (enamel matrix derivative [EMD], Emdogain, Straumann) or recombinant platelet-derived growth factor BB [rhPDGF-BB], Gem 21, Osteohealth) on the dried decontaminated implant surface. *(4)* Placement of a combination of PDGF and/or EMD combined with either mineralized freeze-dried bone allograft (FDBA) and/or anorganic bovine bone. *(5)* Coverage of the graft/implant surface with a collagen barrier membrane, a barrier gel (MembraGel, Straumann), or a subepithelial connective tissue graft when there was a deficiency of keratinized tissue. *(6)* Coronal flap positioning (or complete flap coverage of the implants that were submerged) with tension-free closure of the flap. The time of reentry and measurement of bone fill of the defect for the twelve implants are documented in Table 1. In all cases, by using the surgical photographs and provisional restoration as a guide, bone measurements were recorded at the same location at the time of reentry surgery as those made at time of the initial surgery.

Table 1	Bone changes and reentry times following regenerative surgery around peri-implantitis–affected implants					
Patient no.	Implant position*	Posttreatment time of reentry (mo)	Pretreatment defect depth (mm)	Posttreatment defect depth (mm)	Bone gain (mm)	Fill (%)
1	15	18	5	0	5	100
	14	96	10	0	8	80.0
2	16	14	5	1	4	80.0
	14	14	10	5	5	50.0
	12	14	9	3	6	66.7
	22	14	10	2	8	80.0
	24	14	4	0	4	100
	26	14	12	3	9	75.0
3	25	12	4	0	4	100
4	36	6	3	1	2	60.0
	35	6	5	3	2	40.0
5	12	14	10	5	5	50.0

*FDI tooth-numbering system.

Results

The following three cases are representative of the results observed in this case series.

Patient no. 1

The patient was a 67-year-old woman who had a number of titanium plasma-sprayed (TPS) implants placed in the rehabilitation of her maxilla approximately 17 years ago. Teeth had been lost due to caries and periodontal disease. Her medical history was unremarkable other than a light smoking habit of five cigarettes per day in the past, which stopped around the time of implant placement. She had complied with maintenance care, returning every 3 months alternating this service between the general clinician and a periodontist. The implant at the maxillary right first premolar site had developed severe bone loss 8.5 years after its placement despite compliance with her maintenance care. Probing depths ranged from 6 to 10 mm from the mesiofacial to distofacial aspects with purulence expressed on probing and bone loss of > 50% of implant length. Following a discussion of benefits, risks, and options, it was decided to treat the area with a surgical regenerative approach because there was serious concern that this implant could be lost and was critical to the support of the prosthesis. After prerinsing with 0.12% chlorhexidine and obtaining adequate local anesthesia, sulcular full-thickness flaps were elevated from the distal aspect of the implant at the maxillary right second premolar to the mesial aspect of the maxillary right canine, where a vertical incision was made. Elevation of the flap with removal of granulomatous tissue revealed an advanced facial dehiscence lesion that approached the apex of the implant with a two-wall component at the mesial aspect (Fig 1). Surface decontamination (SD) was performed as previously described. Following SD, EMD was applied to the implant surface followed by FDBA hydrated with EMD (Fig 2). A 6-month bioabsorbable collagen membrane was placed over the graft to aid in graft containment (Fig 3), and the flaps were secured with expanded polytetrafluoroethylene (e-PTFE) (Goretex, WL Gore & Associates) sutures using

Fig 1 *Elevation of the flap with removal of granulomatous tissue revealed an advanced facial dehiscence lesion that approached the apex of the maxillary right first premolar implant with a two-wall component at the mesial aspect.*

Fig 2 *A regenerative approach was used with surface decontamination with citric acid followed by the application of a saline spray. Mineralized FDBA hydrated with EMD was placed over this decontaminated implant.*

Fig 3 *A 6-month resorbable bovine collagen membrane covers the allograft/biologic combination.*

Fig 4 *A radiograph 7 years following the treatment of the maxillary right premolar area suggested stability of the regenerative outcome for the first premolar implant, while the second premolar had severe bone loss, suggesting a circumferential lesion.*

an interrupted suturing technique. The postsurgical antibiotic prescribed was amoxicillin and clavulanic acid along with topical application of chlorhexidine 0.12% rinses twice a day for 2 weeks. The patient was seen on regular intervals, and the implant reached a steady state of health that has been maintained since the surgery. Probing depths were reduced to 3 to 4 mm on the mesial and buccal aspects, and postsurgical radiographs suggested complete eradication of the lesion. However, when the patient presented for a periodic maintenance visit 7 years following the surgery, purulence was expressed upon probing of the second premolar implant site, with probing depths ranging from 7 to 9 mm with no implant mobility. A radiograph of this area (Fig 4) suggested stability of the regenerative outcome for the first premolar site implant, while the second premolar implant had severe bone loss with clinical probing suggesting a possible circumferential defect. A regenerative surgical approach was performed to treat this peri-implantitis lesion. Exposure of this area revealed that the regenerative outcome for the first premolar site implant had bonelike tissue extending to the polished
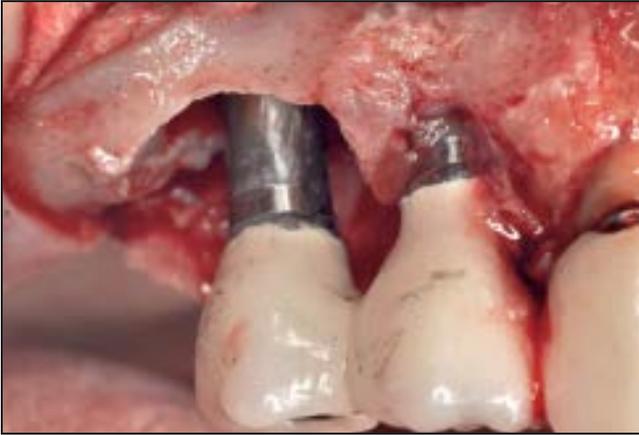
Fig 5 Exposure of the second premolar area 7 years following treatment of the first premolar implant revealed bonelike tissue extending to the polished collar on the first premolar implant.

Fig 6 Citric acid pH = 1 being applied to the implant surface for detoxification.

Fig 7 rhPDGF-BB has been applied to the implant's surface, and a mineralized allograft hydrated with rhPDGF-BB and EMD was used to completely fill the lesion.
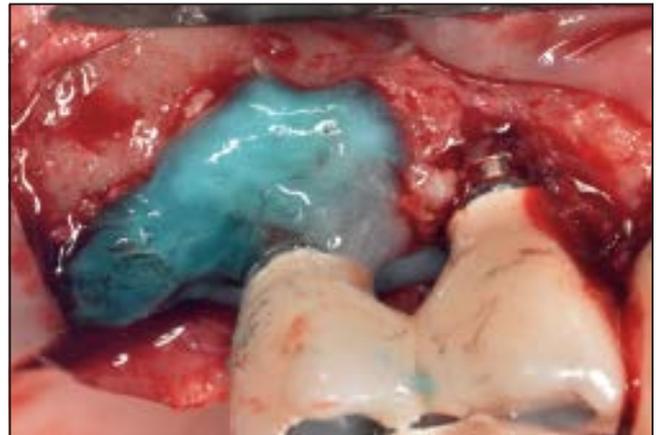
Fig 8 A hydrogel barrier is applied to contain the graft.

collar while the second premolar implant, which had no prior bone loss 7 years earlier, now had an advanced circumferential lesion that measured 5 mm in depth approaching the implant's apex. A combination approach was performed for this implant where the TPS surface located coronal to the lesion was removed with rotary high-speed instrumentation using a finishing bur since there was concern that postsurgical recession could directly expose this surface to the oral environment (Fig 5). The apical portion of the implant was decontaminated with citric acid pH = 1 (Fig 6). The surface of the implant had rhPDGF-BB applied followed by a composite graft of FDBA hydrated with rhPDGF-BB and EMD used to fill the defect (Fig 7). The biologic graft was covered by a flowable hydrogel barrier to facilitate its containment (Fig 8), and the flaps were coronally advanced and secured with e-PTFE sutures. The patient was placed on amoxicillin and antimicrobial rinses for 2 weeks postsurgery. This area has remained stable since the second regenerative procedure as determined by probing depths of 3 to 4 mm and bone fill suggested on a periapical radiograph exposed at 1 year following the procedure

Fig 9 *Radiograph 1 year following the regenerative surgery on the second premolar suggests good fill of the circumferential lesion and good stability of the outcome at the first premolar implant.*

Fig 10 *Reentry performed at 8.5 years following the first premolar surgery and 1.5 years following the second premolar treatment suggests regeneration by bone fill of these two peri-implantitis lesions.*

(Fig 9). Unfortunately, this patient developed an abscess of the implants at the maxillary right lateral incisor and canine at 1.5 years after the second surgery and 8.5 years after the first surgery. As part of the procedure to treat this anterior area, the flap was extended to these two premolar implants to see if any revision was required. Elevation of the flap in this area revealed complete elimination of the intrabony circumferential lesion around the second premolar implant, which approximated 5 mm of fill. The bone height of the implant at the first premolar site was slightly apical to the level measured at the previous reentry but measured 8 mm of fill with 2 mm of resorption, thus eliminating the original 10-mm defect. This resorption may have been related to exposure of the area a second time following the regenerative procedure on the second premolar implant. However, the bone around both of these implants was virtually indistinguishable from the host bone and the defects completely resolved, suggesting that the composite graft had been completely remodeled (Fig 10).

Patient no. 2

A 45-year-old man in good physical health was referred for the treatment of his six maxillary implants, all having peri-implantitis. The only medication that the patient was taking was 81 mg of aspirin per day on his own volition. He presented with six implants in the 16, 14, 12, 22, 24, and 26 positions. The implants were all 4.3 mm in diameter except for no. 16, which had a diameter of 5 mm. The implant lengths varied from 10 to 16 mm. They were placed in November 2010 in a one-stage guided flapless procedure with healing abutments placed at the same surgery. The maxillary complete denture that the patient was wearing was relieved and the patient returned 2 weeks later followed by a 3- to 4-week interval up to 3 months postsurgery. At that time, torque testing suggested that all implants had integrated. However, radiographs suggested extensive bone loss. Four months later, the bone loss continued and the patient was referred for examination and treatment. Light probing revealed bleeding on all implants with exudate on implants 14, 12, 22, and 26. Probing depths ranged from 7 to 15 mm with evidence of moderate to advanced peri-implantitis

Fig 11 *Panoramic radiograph revealing bone loss around all six maxillary implants.*
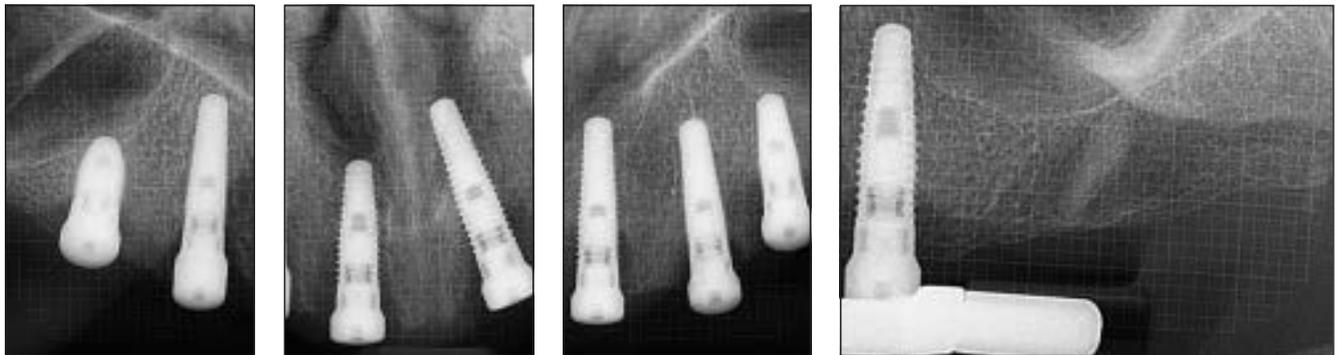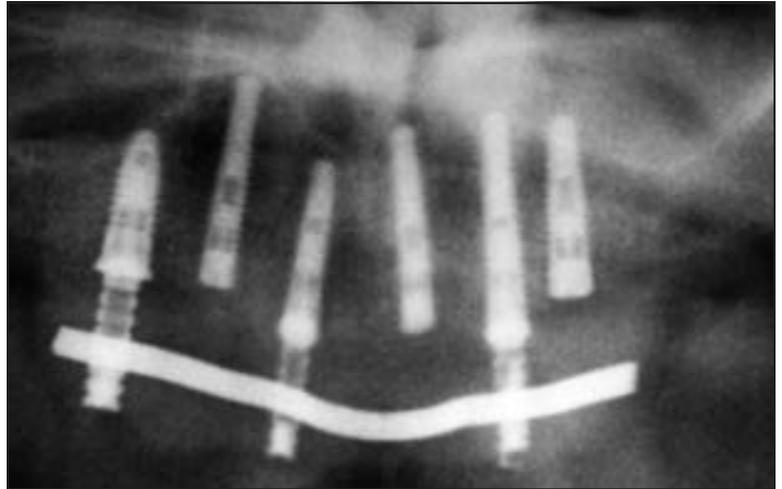

Fig 12 *Periapical radiographs of all six maxillary implants revealing bone loss.*

according to the peri-implantitis classification.[31] The patient was referred back to his restorative clinician for a metal-reinforced provisional screw-retained restoration extending from implant 16 to 26 using implants 16, 12, and 24 as abutments (Figs 11 and 12). The patient presented 2 months later for surgery. The provisional restoration was removed following the administration of local anesthesia. Full-thickness flaps were reflected from implants 16 to 26, and the bony defects around each implant were debrided and probed. The probing revealed circumferential defects around all implants. Osseous defect depths were as follows: 16, 5 mm; 14, 10 mm; 12, 9 mm; 22, 10 mm; 24, 4 mm; and 26, 12 mm (Fig 13). Each implant received surface decontamination and the treatment protocol previously described. Implants that were submerged had the bone grafts covered with resorbable collagen membranes. Those that remained exposed as abutments were treated in the same manner except that an absorbable gel was selected for barrier use. The patient returned to his clinician and periodontist following suture removal for maintenance and monitoring. Fourteen months later, the patient returned, flaps were reflected, and the submerged cover screws on implants 14, 22, and 26 were removed. Any soft tissue around the implants was removed and clinical bone measurements were performed. Bone gain was evident on all implants with the following bone gain measured: 16, 4-mm fill; 14, 5 mm-fill; 12, 6-mm
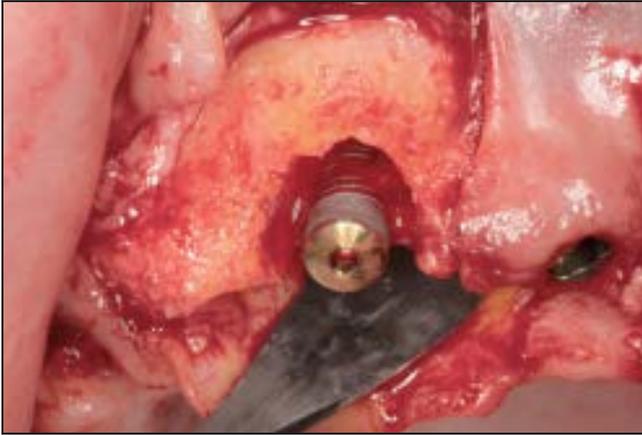
Fig 13a   *Circumferential defect around implant 22 measuring 10 mm in depth.*

Fig 13b   *Treatment of the defect with surface decontamination, biologic grafts, allografts, and a resorbable collagen membrane.*

Fig 13c   *All implants were treated using the same regime as in 13b.*

Fig 13d   *Complete closure and submerging of all implants except implants 16, 12, and 24, which served as abutments for the fixed provisional.*

fill; 22, 8-mm fill; 24, 4-mm fill; and 26, 9-mm fill (Fig 14). All surfaces and defects were again treated as before, with 16, 22, and 24 serving as loaded abutments of the new provisional restoration. Defects on these implants were treated with bone grafts and covered with the absorbable gel membrane. Residual defects on implants 14, 12, and 26 were grafted, covered with ab-

sorbable collagen membranes, and submerged. Two weeks later, the patient returned for suture removal and oral hygiene instruction.

Patient no. 3

A 65-year-old man presented for evaluation who had an implant placed approximately 4 years

prior into a healed grafted site at the maxillary left second premolar (Fig 15). The patient regularly attended an alternating 3- to 4-month periodontal maintenance program between his general clinician and periodontist. Concerns about this patient included a history of periodontitis, which had been treated surgically, smoking 1/2 pack cigarettes per day,
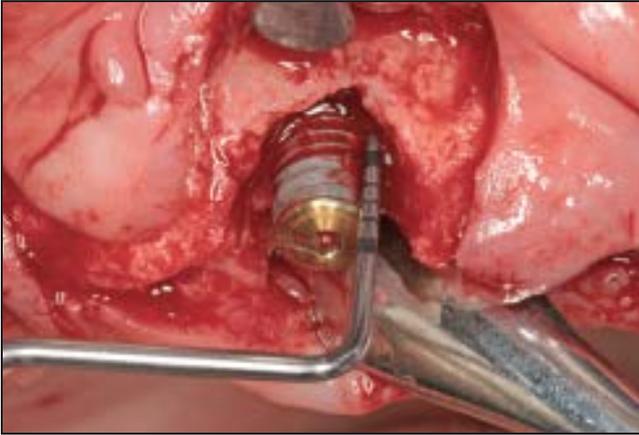
Fig 14a *Twelve-mm bony defect around implant 26 prior to treatment and submerging.*
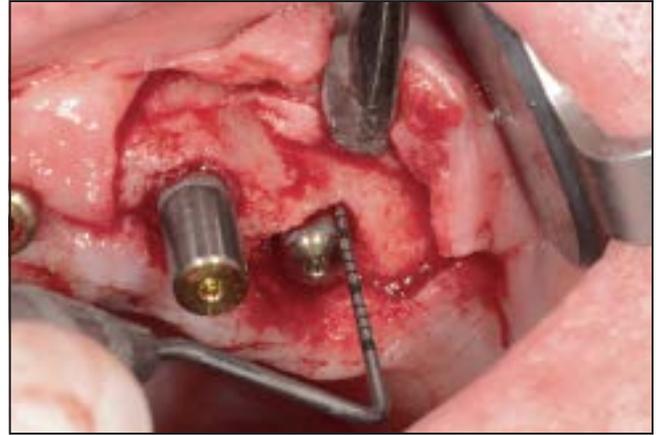
Fig 14b *Residual defect on implant 26, 14 months following treatment at time of reentry, measuring 3 mm and representing 9 mm of fill.*

Fig 15 *Radiographic image of the maxillary left second premolar implant at the time of restoration.*

Fig 16 *Digital radiograph 4 years after the maxillary second premolar implant was restored suggests bone loss at the mesial and distal aspects extending halfway up the implant body.*

and parafunctional habits of both clenching and bruxing. Probings around this implant had increased to 7 to 8 mm with purulence. Radiographs suggested bone loss measuring 50% of the implant length (Fig 16). Additionally, there was 7 mm of pocketing around the first molar with a Class III furcation from the mesiopalatal to the distal aspect. Nonsurgical treatment to eliminate this problem had been performed using a local-delivery controlled release antibiotic in conjunction with scaling under local anesthesia. As this proved unsuccessful, a regenerative surgical approach was planned. After obtaining local anesthesia, sulcular full-thickness flaps were extended from the distal aspect of the first molar to the mesial aspect of the canine at both the facial and palatal aspects to access the implant and the surrounding bony lesion. The defect around the implant had a circumferential configuration that extended around the palatal aspect of the implant with a facial dehiscence that extended 4 mm coronally along the implant body (Fig 17). The surface of the implant was decontaminated using

Fig 17 *Exposure and degranulation of the lesion.*

Fig 18 *Following surface decontamination with citric acid and application of rhPDGF-BB, mineralized FDBA hydrated with rhPDGF-BB and EMD was placed to fill the lesion.*

the method previously described. After rinsing the area thoroughly, rhPDGF-BB was applied to the surface of the implant and the surrounding bony walls were decorticated with a piezoelectric handpiece. The defect was filled with FDBA hydrated with both rhPDGF-BB and EMD 15 minutes prior to the graft placement (Fig 18). The biologic graft was covered by a barrier derived from human amnion-chorion (BioXclude, Snoasis Medical) to facilitate its containment and prevent gingival connective tissue and epithelium from gaining access to the site (Fig 19). The crown was recemented as it came off during the surgery and the flaps were coronally advanced and secured with e-PTFE sutures. The patient was prescribed amoxicillin and an oral rinse of 0.12% for 2 weeks postsurgery. He was seen every 2 weeks for the first 3 months, at which time

light debridement of the site was performed and oral hygiene reinforced. Sutures were removed at 2 weeks. The patient was then seen every 2 to 3 months thereafter. At approximately 4 months postsurgery, an abscess occurred around the first molar and the patient elected to have the tooth extracted and subsequently replaced with a dental implant. One year following the regenerative procedure, sinus elevation and simultaneous implant placement was planned, which also provided an opportunity to assess the results of the peri-implantitis treatment. Probings were now 3 mm and healing had progressed uneventfully. Upon full-thickness flap reflection, the bone healing demonstrated complete resolution of the lesion with 4 mm of bone fill (Fig 20). An implant was successfully placed and subsequently restored at the molar site.

Discussion

Evaluation of hard and soft tissue responses to periodontal regenerative procedures has traditionally been performed using clinical parameters including probing depth reduction, clinical attachment level gain, changes in gingival levels, and bone gain as ascertained on standardized radiographs. Surgical reentry procedures allow direct visualization of bone morphology and a more accurate assessment of the defect fill, which can be directly viewed circumferentially around the tooth whereas conventional radiographs only reflect (at best) changes in interproximal bone levels.[28–30]

Similar clinical parameters have been used to evaluate healing around peri-implantitis–affected implants. However, the additional ability to view and measure bone fill becomes more important when

Fig 19 *The biologic graft was covered by an amnion-chorion barrier to aid in its containment.*

Fig 20 *Exposure of the second premolar implant 1 year following treatment revealed complete hard tissue fill (4 mm) extending to the metal collar.*

comparing healing around implants versus teeth because, as the literature has shown, the majority of peri-implantitis defects occur circumferentially around the implant.[32] Only with reentry or bone sounding procedures can the bone response on the lingual and buccal aspects of the implant be qualitatively measured with similar accuracy as that on the mesial and distal aspects.[27]

The present reentry case series following regenerative surgery around peri-implantitis–treated implants allowed direct pre- and posttreatment assessment of the bony lesions. A previous paper measured bone gain by changes in bone level on standardized radiographs or by bone sounding.[27] Results reported a mean bone gain of 3.75 mm (on radiographs) and 3.00 mm (by sounding). These measurements were means of the 51 treated implants.

In the current series, albeit limited to 12 implants in five patients, the range of bone fill was 2 to 9 mm, with initial defect depths varying from 3 to 12 mm. This represents a range in bone fill of 40% to 100% of the depth of the original defects. No lesion in this reentry series had either lost bone or recorded no fill after treatment. The variation observed in percent fill demonstrated in this series may have been influenced by initial defect depth or width, healing potential of different implant surfaces, differences in healing between patients or sites, or the use of different materials (grafts or graft replacement materials, barriers, volume of biologics used, etc).

The reentry procedures provided the ability to visualize both the fill of the lesion and the residual exposed implant surface for further treatment. Reentry evidence cannot determine if reosseointegration had

occurred between the regenerated bone and the diseased implant surface. This can only be determined by histology. However, the consistent bone formation for all implants in all subjects using a specific regenerative surgical approach is encouraging for clinicians attempting to treat implants with moderate to advanced peri-implantitis. Moreover, the four patients for whom treatment did not include submerging the grafted sites showed similar positive results to the 51 implants all treated and not submerged in the previous study.[27]

The maintenance of positive stable results is the key to success of this treatment approach. Studies with long-term postsurgical observation (ie, > 3 years) are necessary to demonstrate continued success. The 8.5-year reentry in the present study supports these findings with the specific regenerative protocol used in this study.

It is also interesting to note that all patients in this and the previous study had undergone similar methods of implant surface detoxification prior to the topical application of biologics and to the placement of a composite graft-membrane approach. In the current study, a combination of biologics was used as there has been some suggestion in translational research of a synergy to these products when used together.[33] This surface decontamination relied heavily on both the use of known decontamination agents like citric acid and tetracycline along with air abrasion both with particles and with sterile saline alone in the debridement cycle. This ability to detoxify the implant surface using air abrasion follows successful reosseointegration achieved in a previous animal study.[34]

Lastly, the reentry measurements made in the current case series support the clinical parameters of radiographic analysis and bone sounding used in previous studies. Less invasive methods of ascertaining bone fill (eg, cone beam or computed tomography scan) circumferentially around an implant would require at least two exposures (pre and post) to measure new bone and would still not determine whether reosseointegration had occurred. However, the results in this and other studies should encourage additional research to treat peri-implantitis–affected implants and avoid the additional surgeries, cost, and time required by explantation, bone rebuilding, and attempts to replace failed implants.

Conclusions

Reentry flaps performed on 12 implants with moderate to advanced peri-implantitis in five patients revealed bone fill in all lesions ranging from 40% to 100% of the depth of the presurgical defect. No implant was lost, nor did any fail to gain some level of improvement as measured by bone fill from pretreatment. The surgical approach in all cases was similar and included strict methods for surface decontamination. While the results appear quite promising, as the hard tissue gains have been stable up to 8.5 years, caution must be taken when interpreting whether reosseointegration has been achieved. The clinical results should also be confirmed by multicenter studies in larger patient populations. Nevertheless, the results are encouraging since the bone gains have demonstrated long-term stability.

Acknowledgment

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