Healing Responses of Human Intraosseous Lesions Following the Use of Debridement, Grafting and Citric Acid Root Treatment*

I. Clinical and Histologic Observations Six Months Postsurgery

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Three block sections of treated human intraosseous lesions within one individual are presented. These lesions were debrided, filled with autogenous grafts and at two sites the root was treated with citric acid. The treated sites were lightly root planed once a month and the blocks were removed 6 months after surgery. In addition, the root accretions within two lesions were notched with a bur prior to root planing in order to positively identify the position of these root accretions in the histologic sections. Clinically, the lesions closed by marginal shrinkage and limited pocket closure. Histologically, regeneration of new cementum, osteogenesis at bone and graft spicule seams and reformation of functionally oriented ligament fibers were present at sites within lesions where accretions had covered the root. Such a healing phenomenon was observed close to the base of the lesions and seemed to be related to this spatial configuration rather than to the notching of the root itself. No specific increased healing responses could be attributed to citric acid root treatment. Thus, "regeneration" of new attachment is possible within human intraosseous lesions even at root sites previously covered by accretions. However, such responses seem to be limited to areas near the base of the intraosseous lesion.

Previous publications have presented clinical and histological evidence that the use of osseous autografts enhances the repair response of human intrabony osseous defects. Animal and human histological data have presented conflicting results concerning the potential for new attachment to previously denuded root surfaces following demineralization with citric acid. The purpose of the present report was to compare the healing periodontal response when combinations of debridement, citric acid root treatment and osseous grafts were utilized in the treatment of human intraosseous lesions. These treatment variations were performed at three sites in one individual. Since human histologic material, for obvious reasons, will always be limited, the responses to treatment will be described in detail.

MATERIALS AND METHODS

A 24-year-old male patient presented for periodontal examination and treatment at the dental service of the New York Veterans Administration Medical Center, New York City. His medical history was unremarkable except for an allergy to penicillin. His chief complaint was bleeding gums and poor esthetics due to gingival recession. A clinical and radiographic examination revealed advanced periodontal disease (Class IV) around all of the maxillary teeth (Fig. 1). These teeth had 50 to 70% loss of osseous support. All of the maxillary teeth, for both periodontal and prosthetic reasons, were diagnosed as hopeless and full arch extractions were indicated. The patient agreed to participate in a study which included various surgical procedures prior to extraction. The nature of the surgical procedures and the selective block section extractions were explained in detail to the patient. Written consent following a repeat of the explanation was obtained prior to each surgical procedure.

Description and Measurements

An Omnivac acrylic stent was fabricated from 0.1 mm thickness surgical tray material to serve as a fixed reference point for all clinical measurements. These measurements were recorded to the nearest 0.1 mm using an endodontic silver point, locking pliers and a boley gauge.
The stent was grooved in an occlusal apical direction to allow repeated placement of the silver point when taking measurements at different times.

All measurements were performed by the same operator to eliminate interexaminer discrepancies. Measurements of the same distances were repeated on several occasions to test for intraexaminer variability over different time periods. The calculated differences were not statistically significant.

The following measurements were recorded prior to initial surgery and again 2 weeks prior to block section:

(a) stent to gingival margin
(b) stent to pocket depth
(c) stent to cementoenamel junction to test for the complete seating of the stent.

During surgery the following measurements were recorded:

(a) stent to crest of the defect
(b) stent to deepest part of the defect
(c) stent to cementoenamel junction

Table I summarizes the measurements obtained at the times described above.

**General Description of Treatment Procedures**

Presurgical treatment of the maxillary teeth consisted of oral hygiene instruction and supragingival scaling. Removal of subgingival calculus during scaling was avoided. Occlusal adjustment was performed to remove gross occlusal discrepancies. Prior to surgery, clinical measurements, radiographs and photographs were taken.

The surgical procedure on each tooth consisted of an inverse bevel incision and reflection of a full thickness mucoperiosteal flap. An attempt was made to retain as much of the marginal gingiva as possible. The surgical procedures were performed at the same time on all three teeth. Upon exposure of the root and defect, prior to debridement, two teeth were notched through subgingival calculus into dentin (see description below). The calculus and deposits were then removed from all three teeth by root planing. The osseous defects were debrided, irrigated with isotonic saline, measured and photographed.

The exposed roots of two of the three teeth were treated with citric acid (pH = 1) for 5 minutes with repeated 30 second cotton pellet application. These roots were then dried and irrigated with isotonic saline.

Subsequently, all three defects were filled with an osseous coagulum-bone blend graft obtained from the edentulous area of the first molar and the tuberosity distal to the second molar. The cancellous and cortical bone chips obtained with rongeur forceps were triturated for 10 seconds in a sterile capsule and amalgamator, and the defects were overfilled with the bone blend.

Table I

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Preop. probing depth (mm)</th>
<th>Preop. osseous defect depth (mm)</th>
<th>Type of osseous defect</th>
<th>Treatment procedure</th>
<th>Postop. probing depth (mm)</th>
<th>Recession (mm)</th>
<th>New attachment (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 15, mesial</td>
<td>9.5</td>
<td>5.0</td>
<td>2.3 Wall</td>
<td>Osseous coag-bb*, no citric acid</td>
<td>6.5</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>No. 13, distal</td>
<td>8.3</td>
<td>3.5</td>
<td>3 Wall wide</td>
<td>Osseous coag-bb*, citric acid</td>
<td>2.1</td>
<td>0.3</td>
<td>5.9</td>
</tr>
<tr>
<td>No. 12, mesial</td>
<td>5.5</td>
<td>2.3</td>
<td>3 Wall wide</td>
<td>Osseous coag-bb*, citric acid</td>
<td>2.5</td>
<td>1.9</td>
<td>1.1</td>
</tr>
</tbody>
</table>

* Coag-bb = coagulum (bone blend).
osseous coagulum-bone blend placed into the defect. Twenty-four weeks postsurgery a radiograph was taken (Fig. 6). Probing revealed a pocket depth of 6.5 mm. The tooth was extracted in block section.

HISTOLOGIC OBSERVATIONS

Site Tooth No. 15 Mesial. Histologically, the notch was now part of the root surface in a recurring pocket. Crevicular epithelium lined the incisal portion of the notch; however, junctional epithelium was present at the apical portion. This junctional epithelium had migrated to about the level of the existing crest. No evidence of cementogenesis or osteogenesis were seen in this level of the block (Fig. 7). Yet, in sections more palatal to the above described section and beyond the confines of the notch, a long junctional epithelium was present supra-
Figure 7. Area of notch mesial No. 15 (H & E stain, magnification × 10). Block obtained 24 weeks postsurgery. Note epithelial closure in area of notch (Top arrow, height of crest; bottom arrow, base of vertical defect).

crestally. In this area, graft spicules were evident (Fig. 8). Apical to the epithelium (in the region of the crest), osseous wall remodeling and evidence of "new cementum/connective tissue insertion" were observed, as were graft spicules (Fig. 9). The graft spicules showed osteogenesis around portions of their seams in close relation to limited osteogenesis of the crestal wall (Fig. 10).

Tooth No. 13 Distal—Osseous Coagulum—Bone Blend and Citric Acid. The preoperative pocket depth measured 8.3 mm (Fig. 11). Prior to surgery, a notch was made at or slightly apical to the level of the gingival margin with a No. ½ round bur using a high speed handpiece. Full thickness flap reflection revealed a 3-wall defect measuring 3.5 mm in depth (Fig. 12). At this time, another notch was made into the root, through calculus, at or near the apical extent of the accretion within the osseous lesion. After notching, the root and defect were debrided. Citric acid (pH 1) was applied for 5 minutes with cotton pellets changed at 30-second intervals. The root was then dried and irrigated with sterile saline. An osseous coagulum bone blend graft was prepared and placed in the defect.

At 24 weeks postsurgery a radiograph was taken (Fig. 13). Probing revealed a decrease in pocket depth to 2.1 mm (Fig. 14). The tooth was extracted in block section.

Site Tooth No. 13 Distal. Histologically, the block demonstrated two notches. The more incisal notch was lined by pocket epithelium at its more incisal portion, while more apically, junctional epithelium was present. This had migrated apically into the root planed dentition (Fig. 15). In the lower notch area, which had been drilled through calculus and then root planed, graft spicules were present (Fig. 16). A higher magnification of this
area showed evidence of cementogenesis at the most apical portion of the notch with the formation of new connective tissue insertion into this cementum (Fig. 17). The nature of this cementum was somewhat cellular and similar to "repair cementum" (Fig. 18). It should be noted that this "new attachment" was incisal to the crest of bone (Fig. 19). Serial sections of the block presented evidence of graft particles adjacent to a long, supracrestal epithelial adhesion, while at the base of the second notch, marked osteogenesis and cementogenesis was noted around graft spicules (Fig. 20). A higher magnification of the more incisal region within the section showed
Figure 15. Low magnification of distal No. 13 (H & E stain). Block obtained 24 weeks post-surgery. Note that the incisal notch shows epithelial adhesion, while the more apical notch shows connective tissue fill adjacent to which graft spicules are present (arrows).

Figure 16. A more apical area of section shown in Figure 15 demonstrating cementogenesis within the notched root surface into which fibers appear inserted. Within this area, note presence of graft spicules. The notch site is incisal to the alveolar crest.

Figure 17. A higher magnification (× 25) of area shown in Figure 16. Note cementogenesis at notched surface and connective tissue fiber insertion.

Figure 18. A higher magnification of notched site (× 50) showing morphologic character of "repair cementum."

evidence of osteogenesis at some of the seams of graft spicules adjacent to the junctional epithelium (Figs. 21 and 22). At the more apical area of this site, significant
Figure 19. This photomicrograph shows in greater detail (magnification X 25) the spatial relation between the apical portion of the "repair cementum," below which functionally oriented transseptal fibers are present. The alveolar crest of course is apical to the transseptal fibers. An overview of this area is shown in Figure 16.

Figure 20. Serial section of block shown in Figure 15 (magnification X 10). Area of apical notch. Note apical migration of the junctional epithelium into the incisal portions of the notch, while in the apical area, cementogenesis is present at the tooth wall. The presence of graft spicules is evident in this area.

Figure 21. A higher magnification (X 25) of area shown in Figure 20. Note presence of graft spicules.

new cementum and new bone was seen at the root surface and the adjacent osseous wall. The spicules to the graft, while small in size, demonstrated marked osteogenesis and were surrounded by active connective tissue formation (Fig. 23). In this regard, it should be underscored that this block demonstrates specific evidence of periodontal repair (regeneration?) at a root surface previously covered by plaque and calculus.

Tooth No. 12 Mesial—Osseous Coagulum—Bone Blend and Citric Acid. The preoperative pocket depth measured 5.5 mm (Fig. 24). A full thickness flap revealed a 2.3 mm wide 3-wall defect (Fig. 25). Following debridement of the root and defect, the area was treated with citric acid (pH 1) for 5 minutes with cotton pellets applied at 30 second intervals. An osseous coagulum-bone blend graft, was placed into the defect.

At 24 weeks postsurgery, a radiograph was taken. Probing revealed a decrease in pocket depth to 2.5 mm (Fig. 26). The tooth was extracted in block section.

Site Tooth No. 12 Mesial. Histologically, this specimen showed recurring pocketing with limited junctional epithelial adhesion. Very limited (questionable) evidence of new bone or cementum was seen (Fig. 27). This in part may have been due to the presence of root accretions within the pocket. The graft spicules were in the process of exfoliation or appeared inert within the gingival connective tissue (Fig. 28).

DISCUSSION

Clinical Findings. Since we were dealing with only three lesions, no significant clinical conclusion could be
Figure 22. A more detailed view of the graft spicules shown in Figure 21 demonstrating osteogenesis at the seams of the graft spicules (magnification \( \times 50 \)).

Figure 23. Photomicrograph of graft spicules (magnification \( \times 50 \)) shown in Figure 20 at the more apical area of notch. Note the intense osteogenic and connective tissue activity around the small spicules located in this area.

Figure 24. Preoperative photograph of No. 12 mesial with probe in lesion.

Figure 25. Preoperative infrabony lesion in No. 13.

raised. However, it should be noted that on probing, all clinical pockets showed a reduction in depth. The most striking reduction was seen at the distal site of tooth No. 13 which also showed the most notable repair/regeneration response histologically. With regard to the overall clinical responses, the partial closure of periodontal lesions by a combination of reduction in inflammation (shrinkage) and apical closure have been reported extensively\(^2^,^8\) and our limited samples followed published sequences.

Histologic Observations. Again, before discussing the histologic observations, we must underscore the limited sample size. With this caution in mind, our samples have demonstrated responses unusual in human periodontal repair research; namely the repair/regeneration of a site within an intraosseous lesion where calculus was defi-
Figure 26. m No. 12 24 weeks postsurgery.

Figure 27. Photomicrograph of m No. 13 24 weeks postsurgery (H & E stain, magnification × 25). Note limited adhesion of junctional epithelium.

Figure 28. Serial section of block shown in Figure 27 (magnification × 25). Note presence of root accretions and exfoliation of graft spicules.

The base of the lesion showed repair cementum into which fibers were inserted. These connective tissues in turn encapsulated and/or inserted into graft spicules. Soft tissue insertion was obviously only observed at graft seams which showed osteogenesis. These responses, it should be emphasized, took place incisal to the crest of bone and thereby represent "regeneration." In fact, supracrestal fibers separated the notched area from the crest of the alveolar housing at this site. The notch placed at the gingival margin area showed no such evidence of periodontal repair/regeneration (nor did the notch site on tooth No. 15). We therefore suggest that repair/regeneration responses may be related more to their spatial closeness to the periodontal ligament than to the notched configuration of a root. On the other hand, such configurations may add to the regeneration potential.

Increased repair close to the base of an intraosseous lesion has been commonly observed in clinical practice and has been shown, histologically, in human sections with infrabony lesions. What was especially surprising in this block was the magnitude of repair/regeneration taking place 6 months after the procedure, albeit at this time, the response appeared to be essentially remodelling in nature rather than regenerative. In other words, no further incisal periodontal regeneration seemed possible due to the apical level reached by the junctional epithelium.

By contrast, the notch placed into tooth No. 15 was at about crestal level which, in turn, was about 5 mm incisal
to the base of the lesion. Here we observed the notching showing an epithelial/tooth interface, again demonstrating graft particles in the gingival marginal area. Much of the crest appeared to have resorbed in this lesion. However, at the base of the lesion, attempts at repair/regeneration could be seen, as demonstrated by osteogenesis at the graft seams, repair cementum at the root, connective tissue realignment into this repairing site and limited crestal osteogenesis. These observations again indicate that intraosseous lesions repair at their base with an attempt at “regeneration” of the periodontal attachment apparatus, namely new cementum and bone into which functioning fiber bundles insert. However, the level of repair is not necessarily of the same intensity throughout an entire lesion. In a recent paper we observed that clinical pocket closure after debridement occurred within similar probing levels especially when frequent maintenance levels were used. Yet, when these sites were reopened, we noted that the level of intraosseous fill varied considerably within the same lesions. Since these lesions had close to similar clinical probing levels, we can only surmise that within the same lesion, the depth (apically) and width (facially-lingually) of the junctional epithelium varied inversely with the amount of regeneration of periodontal attachment tissue. (Parenthetically, it should be noted that the naturally occurring intraosseous human lesion shows a similar configuration of junctional epithelium, i.e. epithelial adhesion both facially-lingually as well as incisally-apically at varying levels throughout a human block section.) Thus, it is not too surprising that block sections show graft particles adjacent to a long junctional epithelium while at other sites within the same block “regeneration” may also be seen. It has long been understood that successful “fill” procedures heal by: (a) supracrestal epithelial adhesion and (b) “regeneration” at the base of a lesion, and while the use of graft particles may enhance this response, it does not initiate it.

Recognizing this repair potential, our specimens also show the converse, namely: the presence of root accretions effectively limit any kind of soft tissue/tooth closure and/or repair or regeneration at the treated site.

With regard to citric acid root treatment, our samples were too limited to make meaningful judgments. However, no significant variation of the healing process was observed when citric acid root treatment was performed during initial treatment.

Finally, as has been observed repeatedly, smaller graft particles appeared to be associated with more active osteogenesis at their seams than larger particles. This may be of clinical consequence and should be taken into consideration when grafts are placed.

REFERENCES


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