Human Intraosseous Healing Responses to the Placement of Tricalcium Phosphate Ceramic Implants*

II. 13 to 18 Months

S. Froum and S. S. Stahl

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FIVE INTRABONY LESIONS IN A 40-year-old healthy, white female patient suffering with severe periodontitis were removed *en bloc*, 13 to 18 months after flap debridement and graft placement. At the time of debridement, the position of the gingival margin and the most apically located calculus were notched in the root to serve as reference points. All lesions received tricalcium phosphate ceramic implants, and the lesions healed uneventfully. The sites were professionally cleaned frequently during the experimental period. At the time of block removal, clinical measurements demonstrated gingival recession (average = 2.6 mm) and a gain in clinical closure (average = 2.3 mm).

Histologic evaluation of step serial sections of these blocks showed limited presence of graft particles. The particles were surrounded by dense connective tissue. They did not induce inflammation, nor did they appear to enhance osteogenesis or cementogenesis. Closure of lesions was essentially done by a long junctional epithelium adhesion and limited evidence of new connective tissue—root attachment. In the 18-month specimen, active root resorption was seen immediately apical to the junctional epithelium at a site demonstrating significant inflammation in some sections. Fibrils apparently arising from the resorbing dentinal wall were seen in these sections. Serial sections of this site showed cellular cementum and functional fiber attachment at the resorption sites. These variations in resorption/repair/regeneration within the same surgical site were seen 18 months postsurgery and thus may reflect local tissue responses to inflammatory fluctuations rather than surgical sequellae.

In a recent report, we reviewed the pertinent literature and described human intraosseous healing responses to tricalcium phosphate ceramic implants over an 8-month period.[1] We now wish to briefly extend these observations to 13 to 18 months after graft placement, again using clinical and histologic parameters for our evaluation.

MATERIALS AND METHODS

Five periodontal lesions in a healthy 40-year-old female volunteer patient were selected for histologic study of the effects of tricalcium phosphate, ceramic† implants in the repair of intraosseous lesions.

These sites were diagnosed as having a hopeless periodontal prognosis by the dental treatment team, and the patient signed an informed consent as part of the protocol requirements.

Roots at the involved sites received a notch at the gingival margin which served as a reference for pocket measurements to within 0.1 mm. The notch was created using a half-round bur. After obtaining local anaesthesia, a full-thickness mucoperiosteal flap was elevated. Prior to debridement, and again using a half-round bur, the root was notched through the most apical extension of calculus. The lesion was then thoroughly debrided and appropriate measurements taken. Following intramarrow penetration, the site was overfilled with the ceramic graft material. The flap wall was then positioned as incisally as possible and complete closure was attempted. Interrupted sutures (4.0) were used and a periodontal dressing was applied over the sutured site. All presurgical and immediate postsurgical measurements and photographs were taken during this time. Ten days after graft placement, dressings and sutures were removed and the site cleansed. Then, the

* Department of Periodontics, New York University College of Dentistry, New York, NY. This study was supported in part by a Grant-in-Aid from the Johnson and Johnson Dental Products Co., East Windsor, NJ 08520.

† The graft material is marketed as "Synthograft" by Johnson and Johnson Dental Products Co., East Windsor, NJ 08520.

Table 1
Presurgical and Postsurgical Clinical Findings at Implant Sites

Patient	Age (Yrs)	Site	Initial pocket depth (mm)	Mobility	Initial osseous depth (mm)	Observation period (mo)	P.O. pocket depth (mm)	P.O. gingival recession (mm)	Gain in closure (mm)
K	40	# 3 m	13.2	II	8.7	18	7.2	3.0	3.0
		#12 m	8.5	II+	3.2	13	4.9	1.9	1.7
		#12 d	9.9	II+	6.8	13	4.9	2.3	2.7
		#13 m	10.5	III	7.3	13	5.0	3.0	2.5
		#13 d	8.8	III	5.6	13	4.3	2.7	1.8

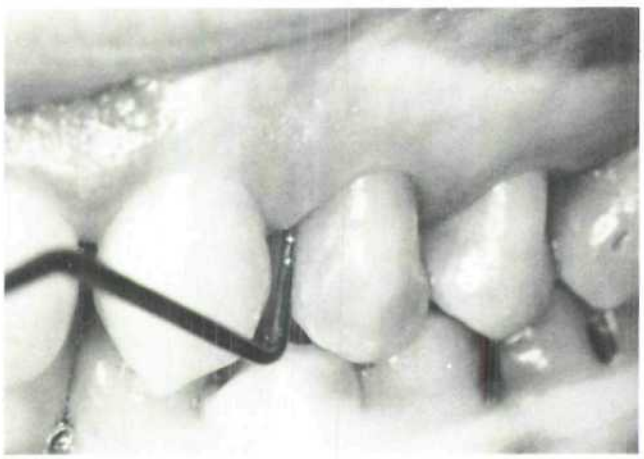

Figure 1. *Preoperative appearance of implant sites, teeth #12 and 13.*

Figure 2. *Preoperative radiogram of sites, teeth #12 and 13.*

patient received weekly professional plaque removal at the surgical site for the first 6 weeks and then once every 2 to 4 weeks until the block was removed. At time of block removal, appropriate clinical records, photographs and radiograms were taken, and pocket depth, recession and the amount of clinical closure were recorded, again using the gingival marginal notch as the fixed point of reference. Blocks were removed 13 to 18 months after graft placement.[2,3] No adverse reactions were noted during the observation time.

Upon removal, all specimens were decalcified and prepared for histologic study. Step-serial, mesiodistally

Figure 3. *Sites debrided, teeth #12 and 13.*

cut sections were prepared and selectively stained with hematoxylin-eosin, Mallory-Trichrome and Van Kossa stains.

Clinical Observations (Table 1)

Preoperative pocket depth at the five sites ranged from 8.5 mm to 13.2 mm and intraosseous depth ranged from 3.2 mm to 8.7 mm. The osseous configurations were essentially one- to two-wall lesions. Following treatment, the sites showed pocket depth ranging from 4.3 mm to 7.2 mm. Gingival recession was present at all sites and ranged from 1.9 mm to 3.0 mm. Clinical gain in closure ranged from 1.7 mm to 3.0 mm (Figs. 1–9). All measurements were made from a fixed point (marginal notch) using an endodontic silver point and Boley gauge to measure distances to the nearest 0.1 mm.[4]

Histologic Observations

In the five sites available for histologic evaluation, the gingival margin had receded apical to the marginal notch. Closure was by adhesion of the junctional epithelium (JE) to the level of the most coronal fiber/cementum insertion sites. Inflammation at these pocket sites varied from minimal to severe in both inter- and intraspecimen comparisons but did not seem to be related to the presence or absence of graft particles. Our

Figure 4. *Ceramic implants in place at sites, teeth #13 and 14.*

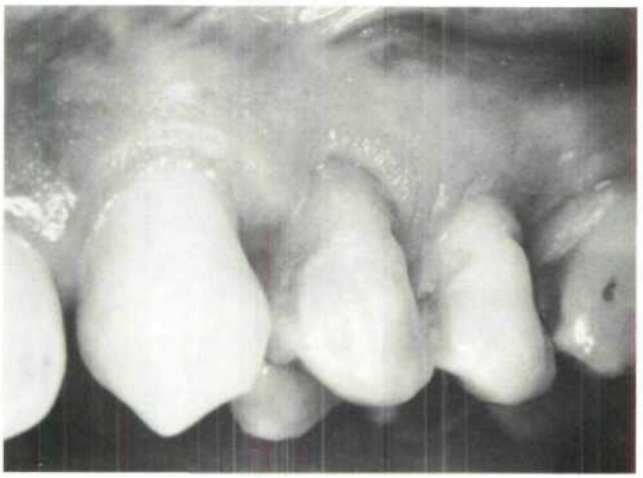

Figure 5. *Postoperative appearance of implants sites, 13 m, postsurgery.*

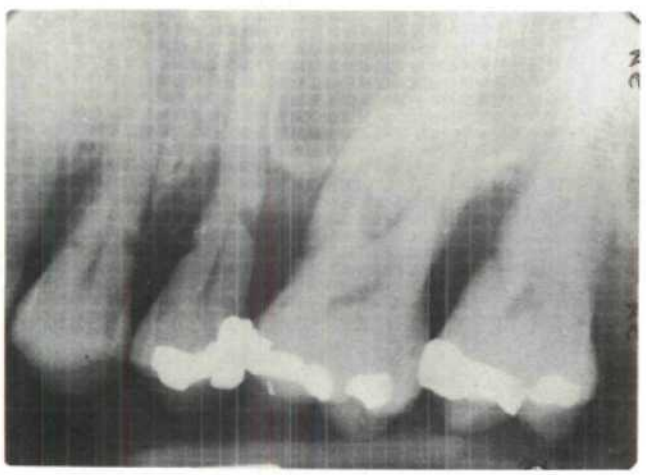

Figure 6. *Postoperative radiogram of implant sites, teeth #13 and 14, 13 m, postsurgery. Note notches in root placed at time of surgery.*

specimens showed minimal presence of graft particles at the operative sites. However, around the still remaining particles, inflammation was minimal or absent and dense connective tissue bundles surrounded the implants. Our specimens showed no evidence of osteogenesis at particle seams and the alveolar crest was remodeling (Figs. 10 and 11).

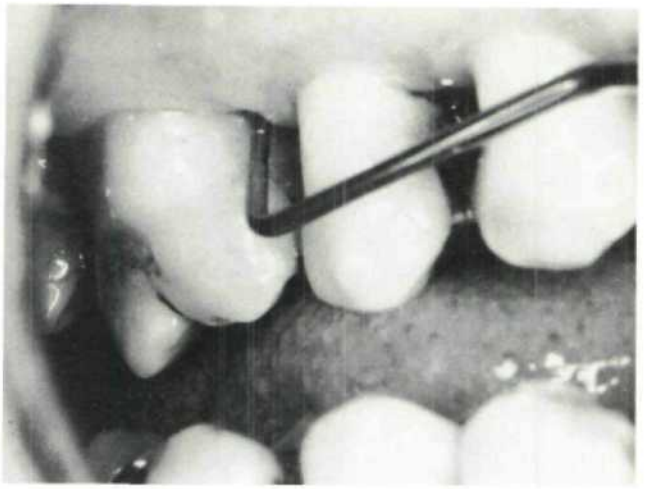

Figure 7. *Preoperative appearance of implant site, tooth #3.*

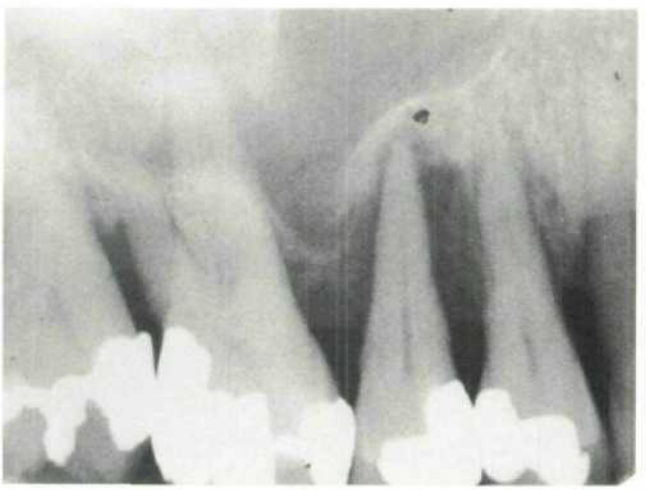

Figure 8. *Preoperative radiograms implant site, tooth #3.*

Cemento-dentoclastic activity was seen at the root surface below the most apical position of the JE in one specimen (mesial, tooth #3). The resorbing site demonstrated odontoclasts, and the connective tissue at this site was highly cellular (Figs. 12–14). Fibrils appeared to project from the dentin border and were at right angle orientation to the dentinal wall. These fibrils stained as collagen (Fig. 15).

In step serial sections of this site, areas of surface root resorption were seen at the level of the JE (Fig. 16). Here, the coronal cemental resorption area was covered by the migrating junctional epithelium. Immediately apical to this epithelial adhesion, cementogenesis had taken place at the resorption site and functionally attached fibers inserted into this cellular (repair) cementum (Figs. 17–18). The epithelial migration appeared to be limited by the fiber insertion. Obviously, we have no information when the cemental/dentin root resorp-

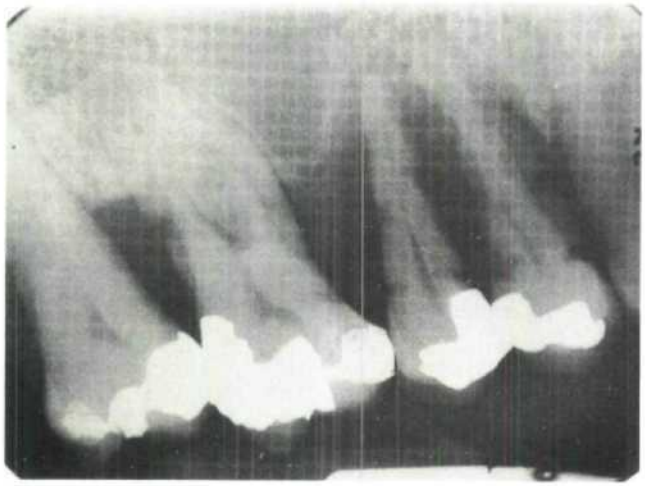

Figure 9. *Postoperative radiogram of implant site, tooth #3, 18 months postsurgery. Note notches in root placed at time of surgery.*

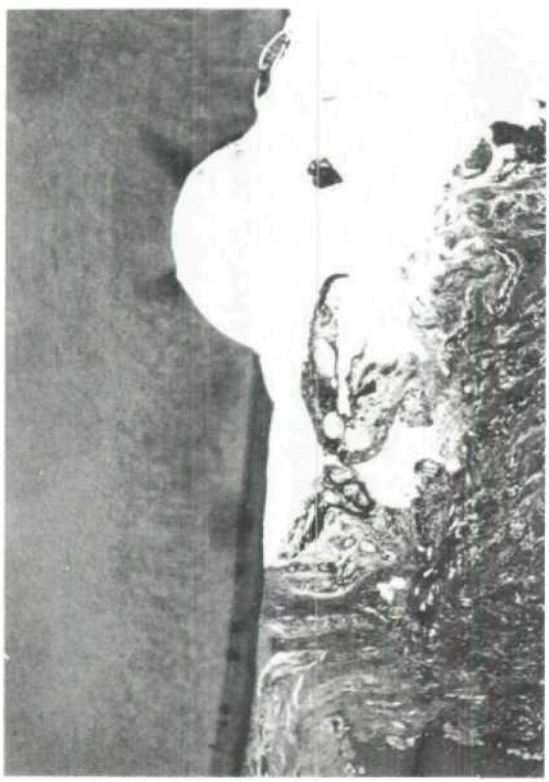

Figure 10. *Histologic overview of implant site, tooth #13 (magnification × 10).*

tion and epithelial adhesion/cementogenesis occurred. However, the process took place apical to the most apical position of calculus (notch) and within the surgical site.

Comment

As in the earlier report, the present data do not indicate significant (1) new attachment, (2) cementogenesis or (3) osteogenesis in healing periodontal lesions in the presence of ceramic implants harvested 13 to 18 months after placement. Of interest in our blocks was

Figure 11. *Higher magnification of implant site shown in Figure 10. Note connective tissue surrounding implant particle site (arrow) (magnification × 64).*

Figure 12. *Histologic overview of root resorption site, tooth #3, mesial (magnification × 10).*

the paucity of graft particles remaining at the operative sites. While the specific reason for the limited presence of particles could not be determined, it may reflect resorption or exfoliation of these particles with subse-

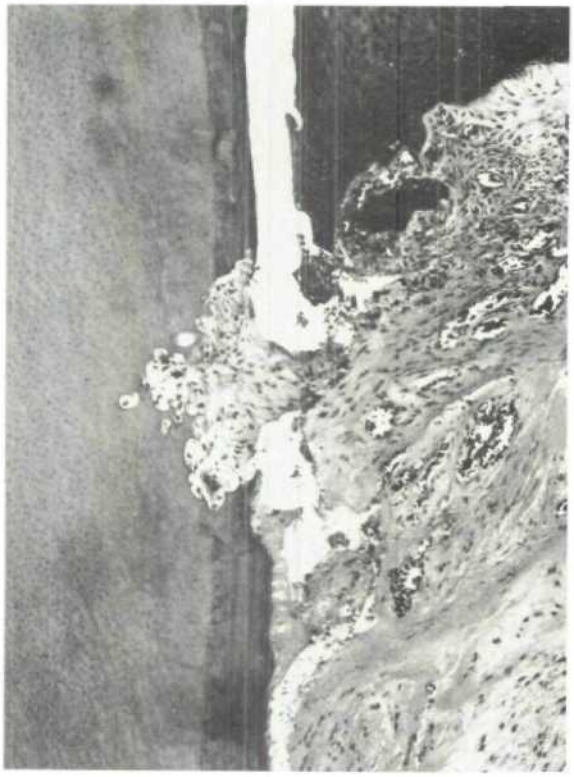

Figure 13. *Serial section of resorption site shown in Figure 11 (magnification × 25).*

Figure 14. *Higher magnification of root resorption site shown in Figure 13. Note odontoclastic activity (magnification × 160).*

quent replacement by dense connective tissue at this time interval.

Of particular interest was the presence of root resorption about the most apical positions of the junctional

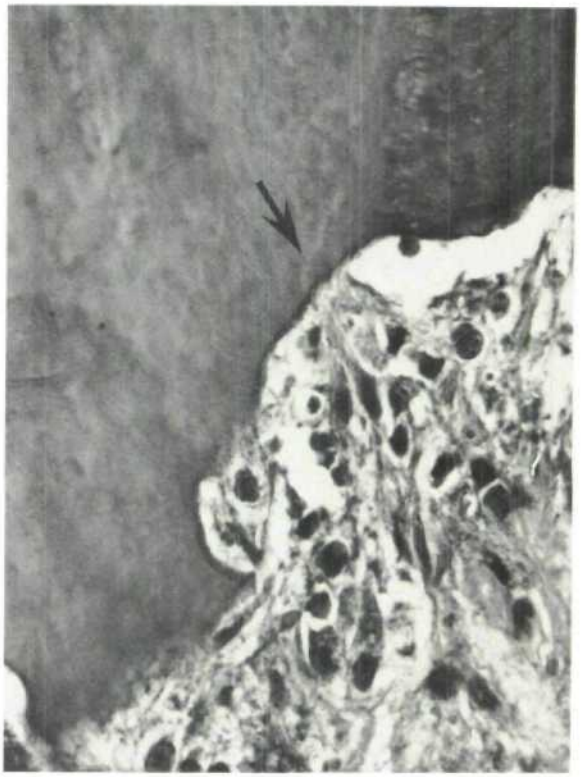

Figure 15. *Higher magnification of root resorption site in tooth #3. Note fibrils at dentin border (arrow) (magnification × 160).*

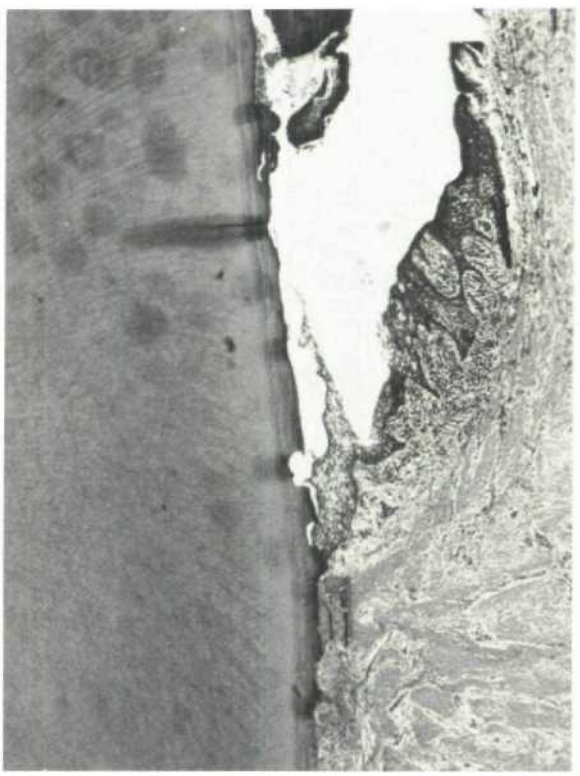

Figure 16. *Serial section of root resorption site shown in Figure 12, tooth #3. Note root resorption limited to cementum and JE migration into these resorption bays. The migration appears to be limited by cementogenesis immediately apical to the JE (magnification × 10).*

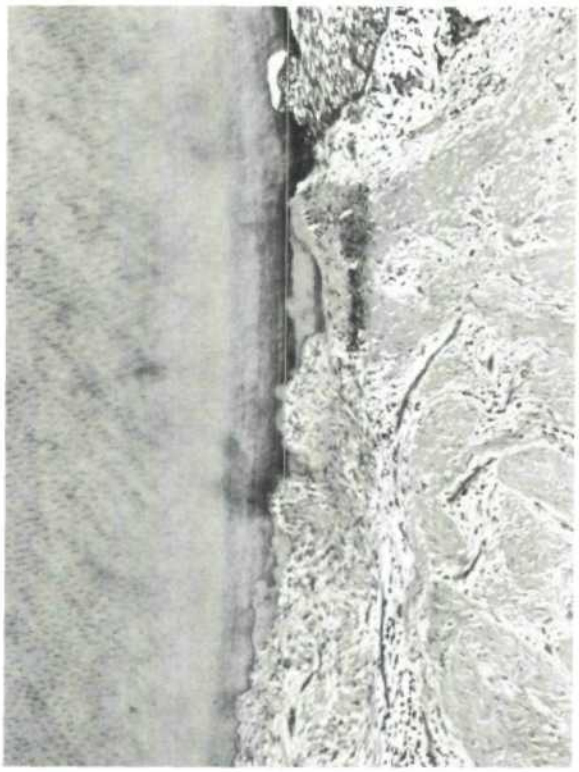

Figure 17. *Higher magnification of Figure 16. Note interface between JE and new cementum (magnification × 25).*

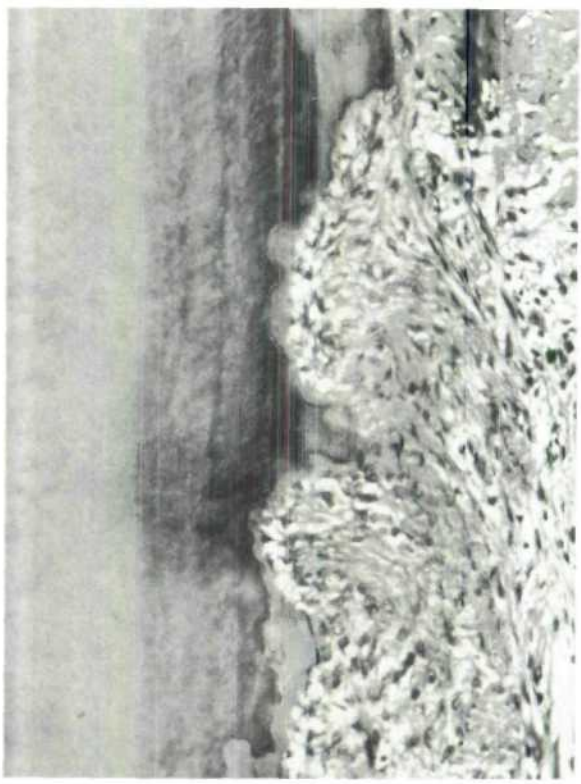

Figure 18. *Higher magnification of Figure 16. Note functional attachment of fibers into areas of "new cementum" (magnification × 64).*

epithelium. Since such cemental/dentinal resorption patterns have been observed following ceramic graft placements,[1] subgingival placements of crowns[5] and experimental periodontal flaps in cats,[6] the observed root resorption cannot be solely the result of placement of ceramic grafts. Rather, it may reflect root responses to inflammation at sites of local injury.[7-9] The sequellae to cemental resorption is loss of fiber attachment, thereby allowing migration of epithelium onto this fiber-denuded root. Or, if resorption extends into surface portions of dentin, it may unmask dentinal collagen which in turn may link with gingival fibers to create attachment at this site with subsequent mineralization of the resorption site.[10-12] On the other hand, the severity of inflammation may lyse all fibrils, thereby allowing for epithelial migration onto this root site.[13,14] In this connection, a recent report of healing responses following flap surgery in dogs described resorption lacunae at the dentin surface two weeks after surgery. Electron microscopic studies of the resorption sites noted that "in these sites, interdigitation of newly formed collagen fibrils with denuded ones on the resorbed dentin surface was observed."[15] Finally, root resorption has also been related to early postsurgery sequellae when gingival connective tissue contacted denuded dentin.[16] On the other hand, periodontal ligament cells coming in contact with the root surface, possessed the ability to "re-establish connective tissue attachment."[17] Our specimen showed active root resorption taking place 18 months after surgery. Thus, as pointed out previously, root resorption may not be limited to early postsurgical sequella but may also reflect cementum-dentin responses to on-going inflammatory shifts within periodontal lesions. When such resorption sites become exposed to the oral environment, they may predispose to plaque and calculus retention and possibly relate to increased root caries seen in patients with higher periodontal disease scores.[18]

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Send reprint requests to: S. Froum, Department of Periodontics, New York University College of Dentistry, New York, NY 10003.