Alveolar Bone Remodeling Following Osseous Surgery
A Clinical Study

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REMODELING of the alveolar bone crest was monitored following periodontal surgery including osseous recontouring at 26 sites in 17 patients, aged 23 to 60 years, with advanced periodontitis. Comparison of measurements obtained at initial surgery with those noted at re-entry showed a reduction in crest height 3 months postsurgery at all sites tested: A) At the intraradicular sites a mean reduction of 0.38 mm; B) at the radicular sites a mean reduction of 0.84 mm; and C) at the furcation sites a mean reduction of 0.79 mm. A reduction in crest height was also noted 6 months postsurgery at all sites tested: A) At the intraradicular sites a mean reduction of 0.23 mm; B) at the radicular sites a mean reduction of 0.55 mm; and C) at the furcation sites a mean reduction of 0.88 mm. The mean bone loss at different surfaces in both 3-month and 6-month groups was statistically significant when compared with zero loss, using the t test. Within the limits of this clinical study, it can be concluded that crestal resorption, albeit limited in extent, was the usual remodeling response following osseous recontouring.

Periodontal disease associated with crestal resorption alters the morphology of the alveolar process. At times, it produces reverse osseous architecture.1-2 Osseous surgery has been utilized to recontour reverse osseous architecture so that pocket recurrence may be reduced.3 However, some studies have questioned the validity of this concept.4-11 For example, does the recontoured crest maintain the shape created by surgical intervention? And if so, for how long? With specific reference to human experience, the clinical data are obviously limited.

Friedman and Levine,6 in a limited histologic study performed apically positioned gingival mucoperiosteal flap procedures on three teeth of two patients. Osseous recontouring was done in only two of the three specimens. They found 0.25 to 0.3 mm of crestal bone resorption following osseous recontouring in a period of 70 to 84 days. The authors considered this amount of bone loss an insignificant clinical event. Pennel et al.3 reported an average reduction of 0.54 mm in the height of the crest of the alveolar bone when 1.0 mm of crestal bone was removed during gingival mucoperiosteal flap operations with osseous resection in 20 patients. Closure was accomplished by coronal flap repositioning. In three periodontal patients, Donnenfeld et al.10 compared the extent of alveolar bone remodeling following coronally replaced mucoperiosteal flap procedures, with or without osteoplasty. Six months after initial surgery similar osseous remodeling was noted in both procedures. However, more loss was observed in the radicular and interradicular bone (1.0 mm vs. 0.6 mm) following osteoplasty than after flap elevation alone (0.8 mm and 0.4 mm). Wilderman et al.11 elevated gingival mucoperiosteal flaps in 23 patients. They then performed osteoplasty and osteoectomy procedures to reduce thickness and height of the buccal alveolar bone and positioned the flap 1 to 2 mm coronal to the reduced alveolar bone crest. The results of their study revealed an average of 0.8 mm resorption of crestal bone 3 weeks to 18 months after surgery. Thickness of the crestal bone was felt to be a factor in the pattern and amount of alveolar bone resorption.

The present study was undertaken to further examine human osseous remodeling following periodontal surgery, including osseous recontouring, and thus to provide additional human data.

MATERIALS AND METHODS

Seventeen patients, eight men and nine women, were selected from among clinical patients requiring periodontal therapy at the New York University College of Dentistry. They ranged in age from 23 to 60 years, and all had a normal medical history. A consent form was required from each patient. All patients received, as part of their periodontal therapy, an apically positioned flap procedure consisting of the reflection of both buccal and lingual gingival tissues (Fig. 1A). In addition, osteoplasty and/or osteoectomy procedures were performed when eradicated the interproximal bony craters and developed a normal scalloped contour in the bone (Fig. 1B). Implant pocket depth varied from 4 to 7 mm, and only posterior segments were used.

At the initial visit, a complete diagnostic examination

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was performed consisting of case history, clinical examination and preoperative photographs and radiographs. Surgery was performed only on patients who were able to maintain satisfactory oral hygiene, i.e., a low Green-Vermillion index.

All patients received a series of presurgical treatments which included cavitrion scaling, root planing, and soft tissue curettage. The occlusion was adjusted if any traumatic occlusion was present, and oral hygiene instructions were given to all patients.

Surgical procedures were performed on a total of 26 sites. Each site consisted of three teeth (1st bicuspid, 2nd bicuspid, and 1st molar). Thus, the total number of tooth sites was 78 and of surfaces 182.

Technique of Measurements

The method of measuring crestal height was as follows: A polyvinyl stent was fabricated on study casts obtained from each patient. The stent was then checked for proper insertion and the base of the stent was used as a fixed reference point. A guideline for measurements was obtained by gloving the stent coronally in line with the mesio-facial, mid-facial, and disto-facial surfaces of each tooth utilized in the study. This insured accurate placement of the measuring instrument, a No. 0.02 endodontic silver point. Measurements were expanded in increments of 0.1 mm using a holey gauge.

The base of the stent serving as a fixed point of reference, the following measurements were recorded:

1. From the base of the stent to the crest of the alveolar bone at the mesio-facial, mid-facial, and disto-facial site of each tooth before and immediately after osteoplasty and/or osteotomy. (2) The identical measurements outlined in (1) but at 3 and 6 months post surgery using a flap (re-entry) procedure.

Comparison of postsurgical and re-entry measurements served as an index of osseous remodeling (Figs. 1C and 1D).

For additional documentation of remodeling, alginate impression was taken immediately after osseous recontouring and again at the time of the re-entry procedure. Changes in the osseous contours at the operated sites were used to evaluate postsurgical response.

Surgical Procedures

Following local anesthesia at the operative sites, a standard flap and debridement procedure was performed. This procedure consisted of a buccal and lingual inverse bevel incision. A vertical releasing incision was utilized distal to the area of the canine, extending from the gingival margin into the mucosa. A gingivo-mucoperiosteal flap was then reflected on the buccal as well as lingual surfaces. These areas were completely debrided. After exposing the alveolar bone and planing the root surfaces, a No. 4 tungsten carbide round bur and/or a hand chisel was used for the osteoplasty and/or osteotomy procedure in order to create a normal scalloped contour in the bone (Figs. 2A, 2B).

At this time, the stent was inserted on the teeth and measurements and photographs were taken. The stent
was then removed and an alginate impression obtained.

Following the measurements, the flap was positioned at the crest of the alveolar bone, sutured and the stent was removed. Commercially available periodontal dressings were used. After 1 week, the dressing and sutures were removed and the area was repacked for an additional week. At the end of the second postoperative week, the pack was removed and the patient retrained in oral physiotherapy. All patients were evaluated for oral hygiene maintenance every 2 weeks until completion of the study.

Patients were divided into two groups prior to the re-entry procedure. In the first group (eight patients), the operative sites were re-entered 3 months postoperatively, and in the second group (nine patients) 6 months after initial surgery.

Re-entry Procedure

Re-entry consisted of a standard mucoperiosteal flap elevation. After reflecting the mucoperiosteal flap, measurements, photographs, and an alginate impression were taken. These recordings followed the same guidelines described previously. After measurements, the flaps were repositioned, sutured, dressed, and all necessary follow-up care rendered (Fig. 2C).

All measurements were analyzed statistically, using the t test.

RESULTS

Healing appeared uneventful following surgical procedures in all patients studied.

Clinical Measurements

A. Mean amount of bone resected at osseous recontouring. The mean amount of interradicular crestal bone resected was 0.09 mm for the 3-month group and 0.12 mm for the 6-month group, while the mean amount of radicular crestal bone resected was 0.37 mm and 0.31 mm for the 3-month and 6-month groups, respectively. The mean amount of crestal bone resected at the fusion sites was 0.06 mm for the 3-month group and 0.22 mm for the 6-month group (Table I).

The differences in mean amount of crest resected between the two groups were not statistically significant.

B. Mean amount of alveolar crestal loss 3 to 6 months after surgery. The mean interradicular crestal bone loss was 0.38 mm for the 3-month group and 0.23 mm for the 6-month group, while the mean radicular crestal bone loss was 0.84 mm for the 3-month group and 0.55 mm for the 6-month group. The mean crestal loss on the fusion sites was 0.79 mm for the 3-month group and 0.88 mm for the 6-month group (Table II). The differences between 3 and 6-month values within specific sites were not statistically significant.

Ideally a zero amount of crestal resorption should follow osseous recontouring. Since our data showed that crestal resorption followed recontouring, a t test was utilized to study differences between the level of observed resorption values and the null hypothesis of no loss. In each of six comparisons between mean bone loss and zero bone loss at the interradicular, radicular, and fusion sites, the differences were statistically significant (P < 0.01 for five of the six comparisons; P < 0.02 for

Figure 2A. Patient S.K., 49-year-old white female. Flap reflected prior to recontouring. Note existing ledge at the radicular and interradicular surfaces of bicuspid and molar. B. Patient shown in A immediately after recontouring. Note removal of bony ledge and interproximal plakeway at interradicular surface between bicuspid and molar area. C. Patient shown in A 3 months after surgery. Buxtryse bone has formed on radicular and interradicular surfaces.
Table I
Mean Amount of Bone Resected at Initial Surgery

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
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<tbody>
<tr>
<td></td>
<td>Intraradicular</td>
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</tr>
<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
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<tr>
<td>0.03</td>
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<tr>
<td>0.33</td>
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Mean bone resected (X) 0.09 0.37 0.06 0.12 0.33 0.22
Standard deviation (G) 0.006 0.419 0.156 0.226 0.527 0.253

Table II
Mean Amount of Bone Loss at Re-entry

<table>
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<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Intraradicular</td>
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<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
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Mean bone loss (X) 0.38 0.84 0.79 0.23 0.55 0.88
Standard deviation (G) 0.445 0.821 0.73 0.302 0.650 0.521

the other comparison) (Table III). In addition, crestal bone loss in the radicular and furcation sites was greater than that observed in the intraradicular sites in both 3 and 6-month groups. However, the differences were significant only between furcation and intraradicular sites (P < 0.01) (Figs. 1–5).

Correlations were computed between the amount of bone resected and the amount of bone loss at each site using Spearman’s rank order correlations. No significant correlations were established. The Spearman’s correlation coefficients were -0.372 for the 3-month group and -0.078 for the 6-month group (Figs. 6 and 7).

Evaluation of Statistical Measurements

Values of the standard deviations reported were exceedingly high and reflected the extensive ranges of responses following surgery between different sites in the same patients and between different patients. Therefore, the reported results represent a series of case reports dealing with the same procedure in different patients rather than a controlled statistical study.

Analysis of Casts

Alveolar bone remodeling was studied by comparing casts which were poured from alginate impressions taken immediately after osseous recontouring and after re-entry procedures. The alterations were visualized in all cases. However, the degree and pattern of bone remodeling were different at each surgical site. It was apparent that the reconoitred alveolar bone was further remodeled in favor of more scalloping.

Intraradicular sluesways which initially were prepared to establish a parabolic architecture, underwent subsequent alveolar bone remodeling, resulting in a
smooth surface or buttressing bone formation (Forty-five out of 78 of the interradicular surfaces examined showed buttressing bone formation) (Fig. 5A, B).

Thinning of alveolar bone was observed primarily at radicular alveolar bone surfaces. Four areas of initial root fenestrations in three patients appeared as root dehisences at the time of re-entry even though the crest was not altered at initial surgery.

**DISCUSSION**

Clinical remodeling of the alveolar crest following osseous recontouring has been the subject of previous investigations.9-11

The present study showed an average radicular crestal loss of 0.84 mm and 0.55 mm in the 3 and 6-month postoperative groups. These results, although somewhat less in magnitude, relate well to the clinical findings obtained by Donnenfeld et al.,10 who reported a 0.1 mm reduction in alveolar bone height 6 months postsurgery, and those reported by Wilderman et al.,11 who showed an 0.8 mm resorption of the alveolar bone crest 3 weeks to 18 months after surgery. Penzel et al.8 reported similar trends postoperatively, i.e., an average reduction of 0.54 mm in crestal height.

An average reduction of 0.38 mm in interradicular alveolar bone crest was noted in the 3-month postoperative group and 0.23 mm in the 6-month group. These findings showed less resorption than those reported by Donnenfeld et al.,10 i.e., 0.6 mm loss after the 6-month postsurgical period. While the reason for this difference is not known, it may relate to their small sample of four patients. Obviously, the smaller the sample, the greater the variation in results. Our data demonstrated this problem in human clinical periodontal research since the range of responses in our sample was exceedingly large. Such a range of responses, in turn, made it difficult to ascertain statistical relevance. We therefore suggest that our results be considered trends observed in a number of case reports.

In animal studies Matherson and Zander,9 Caffesse et al.9 and Haist et al.7 reported minimal or insignificant amounts of crestal resorption, while Lobene and Glickman7 reported 0 to 1.7 mm loss of the alveolar bone crest. Thus, animal responses show ranges of remodeling similar to those obtained in humans, although the human

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**Table III**

<table>
<thead>
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<th>Bone loss</th>
<th>Mean difference</th>
<th>t Value</th>
<th>Significance</th>
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<tr>
<td>Interradicular</td>
<td>0.384</td>
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<td>P &lt; 0.01</td>
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<tr>
<td>Radicular</td>
<td>0.842</td>
<td>3.69</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>Pericrestal</td>
<td>0.792</td>
<td>3.92</td>
<td>P &lt; 0.01</td>
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</table>

**3 MONTHS**

| Interradicular | 0.228 | 2.71 | P < 0.02 |
| Radicular | 0.546 | 3.03 | P < 0.01 |
| Pericrestal | 0.877 | 6.09 | P < 0.01 |

**6 MONTHS**

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**Figure 3A.** Patient T.M. 35-year-old white male taken immediately after recontouring. A slit wound has been created between the two bone surveyors.

**Figure 3B.** Patient shown A 6 months after initial surgery. Buttressing bone formation and disappearance of the slit wound in the interradicular area is evident.

**Figure 4A.** Patient R.S. 58-year-old white female immediately after recontouring. B. Patient 3 months after initial surgery. Buttressing bone has formed in the interradicular areas and thinning of the radicular crestal bone of the first bicuspid is evident.
Figure 5A. Cast of patient G.W., 45-year-old white female taken immediately after recontouring. A: A sleeve was been created at the interradicular surface between the second bicusp and first molar. B: Cast taken 6 months after initial surgery. Note formation of healing bone at the interradicular surface between second bicusp and first molar.

CORRELATION BETWEEN RESECTED AND RESORBED CREST (3M.P.O.)

Figure 6. Correlation between resected and resorbed crest (3 months postoperative evaluation).

CORRELATION BETWEEN RESECTED AND RESORBED CREST (6M.P.O.)

Figure 7. Correlation between resected and resorbed crest (6 months postoperative evaluation).

Responses showed a pattern of more significant crestal
motion in the literature as well as our results consist-
ently showed resorption of the alveolar crest following
osteoplasty and osteectomy procedures. No significant
regeneration at the crest has been noted. Biologically,
this stimulus apparently leads only to resorption and not
crestal regeneration. At this point, one may speculate on
the causes for this response. However, it seems reason-
able to conclude that repair rather than regeneration
follows the surgical procedures performed.

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