Preservation of the Postextraction Alveolar Ridge: A Clinical and Histologic Study

Daniele Cardaropi, DDS*
Giuseppe Cardaropi, DDS, PhD**

The aim of this investigation was to assess the possibility of preserving the buccal and lingual plates of a postextraction socket from resorption using bone filler after tooth extraction. In 10 patients, 10 single extraction sites in the posterior area received a bone substitute. The osteoconductive material was covered by a collagen membrane in all cases. Contour changes of the alveolar process were evaluated intraorally using a surgical caliper over a 4-month period. Four months after extraction, a specimen was harvested from the area previously augmented with bone filler, and histologic analysis was performed. The results demonstrated that it was possible to preserve about 85% of the initial ridge dimensions, allowing for correct implant placement. From a histologic point of view, new bone formation was detected in all sites, with a 25% average residual presence of the graft particles. This investigation confirms the benefit of augmenting an extraction socket with bone substitutes. (Int J Periodontics Restorative Dent 2008;28:469-477.)

To achieve endosseous implant positioning that is prosthetically guided with the correct crown-to-root ratio and esthetically maintainable with good soft tissue support, an adequate width of the surgical site is essential. Unfortunately, the spontaneous healing process at an extraction wound leads to bone remodeling and resorption. Several studies have examined the dynamics of tissue alteration after tooth extraction.1-7

Clinical and histologic investigations in animals and humans have clearly demonstrated that resorption of the alveolar process after tooth extraction is significantly greater at the buccal aspect than at the lingual aspect of both the maxilla and mandible; as a consequence, the center of the ridge shifts palatally/lingually. Further, the reduction in width of the maxillary alveolar ridge is greater than the loss in height. The primary loss of tissue contour takes place during the first month following tooth extraction.

Alveolar bone is a tooth-dependent structure that develops in conjunction with eruption, and the topography is determined by the form of the teeth and their axis of eruption.8
In the first phase of remodeling of the buccal/lingual walls of the extraction site, the bundle bone is resorbed and replaced with woven bone. Since the crest of the buccal bone wall is composed solely of bundle bone, this remodeling results in substantial vertical reduction of the buccal crest. The primary stage of resorption occurs during the first 4 to 5 weeks after tooth extraction,\(^4,7\) stabilizing after 6 months in the range of 3 to 5 mm. In a clinical study of 46 patients, Schropp et al\(^8\) reported a reduction of approximately 50% in the buccolingual width of post-extraction posterior sites after 12 months. Based on this report, it is necessary to preserve the dimension of the alveolus if implant placement is planned. A number of studies have reported outcomes of different ridge preservation procedures, including the use of barrier membranes and bone fillers.\(^7-13\) All of these studies confirmed that filling and covering the postextraction alveolus preserve the bone volume more predictably than does spontaneous healing.

On the other hand, split-mouth studies,\(^14\) long-term follow-up studies,\(^15\) and literature reviews\(^16,17\) have clearly demonstrated that osseointegrated implants inserted into regenerated bone show success rates similar to those reported for implants inserted into preexisting native bone.

Some controversy exists regarding the quality of the tissue augmented in the extraction site. Histologic studies of human extraction sockets filled with different graft materials reported the permanence of graft particles in the healed alveolus after 6 to 9 months,\(^18-20\) while other studies reported no residual bone filler after 6 months.\(^21\) From a clinical point of view, it seems that successful implant placement can be achieved, even with 40% of the grafting material in contact with newly formed woven bone.\(^19\) A number of variables, such as the anatomy of the sockets, the type of flap closure, and the nature of the bone graft, make it difficult to compare different studies. Nevins et al\(^22\) evaluated the use of an animal-derived bone filler to maintain the form of the edentulous ridge. Computerized tomographic scans were made to assess the buccal plates of nine patients in whom 36 extractions of maxillary anterior teeth were performed. Nineteen test extraction sockets received the xenogenic material, and 17 control sockets received no osteogenic material. The sockets treated with bone filler demonstrated a loss of less than 20% of the buccal plate in 15 of 19 test sites (79%). In contrast, 12 of 17 control sockets (71%) demonstrated a loss of more than 20% of the buccal plate.

In an animal study, the combination of surgical-grade calcium sulfate and platelet-rich plasma for alveolar ridge preservation was evaluated.\(^23\) In five mongrel dogs, experimental extraction sockets were created. At 8 weeks, less ridge resorption was observed in the filled sites compared to in unfilled sites. The addition of platelet-rich plasma to calcium sulfate did not positively influence the outcomes.

In a human study, the healing of 24 postextraction sites of maxillary premolars was evaluated at 4 months.\(^24\) The authors described the clinical, histomorphometric, and radiographic...
healing of the alveolus with or without placement of a putty-form anorganic bovine-derived hydroxyapatite matrix combined with a synthetic cell-binding peptide P-15. A favorable response was observed, suggesting that the use of grafting materials may be useful for alveolar ridge preservation prior to dental implant placement.

The aim of the present study was to assess the possibility of preserving the buccal and lingual plates from resorption using bone filler after posterior tooth extraction.

Method and materials

Ten patients (four women and six men) referred for extraction of a maxillary or mandibular premolar or molar and subsequent single-tooth implant treatment were included in this study. The study teeth comprised two maxillary second premolars, four maxillary first molars, and four mandibular first molars. The mean patient age was 45.9 years (range: 27 to 63 years). The reasons for extraction included root fractures, periodontal involvement, endodontic treatment failures, and advanced caries lesions. Exclusion criteria were existence of metabolic bone disease, pregnancy, history of malignancy or radiotherapy/chemotherapy for malignancy in the past 5 years, and history of autoimmune disease.

Following administration of local anesthesia (4% articain and epinephrine 1:100,000), the teeth were gently luxated with an elevator and carefully extracted with extraction forceps, with care taken to produce as little trauma as possible to the bone around the alveolus. In case of multirooted teeth, the roots were separated. The extraction sockets were carefully curetted to remove granulation tissue. Next, the sockets were filled with a xenograft material (Osteobiol GenOs, Tecnoss). The granules were then covered with a collagen membrane (Osteobiol Evolution, Tecnoss), and the soft tissues were sutured over the membrane without obtaining primary closure. The patients agreed not to wear any prostheses during the healing period. Appropriate antibiotic therapy consisting of amoxicillin/clavulanate potassium (1 g every 12 hours for 6 days) and mouth rinsing with 0.2% chlorhexidine gluconate every 8 hours until suture removal were prescribed.

Clinical evaluation

Clinical measurements of the extraction sites were carried out at baseline (immediately after tooth extraction) and 4 months following tooth extraction. The width of the alveolar ridge (buccolingual dimension) was measured perpendicular to the tangent of the dental arch at the midpoint of the extraction site as the distance between the most prominent points buccally and orally. All measurements were carried out using a bone caliper. At the 4-month visit corresponding to implant placement, the width of the alveolar ridge was measured again and a biopsy specimen was harvested for each augmented extraction socket with the purpose of histologic evaluation.

To assess the level of bone healing at the extraction site, the changes in
bone level at the buccal and lingual aspects of the socket from baseline to 4 months after extraction were calculated.

**Histologic processing**

After flap elevation during the implant placement appointment, a bone biopsy specimen was harvested in the area previously augmented with osteoconductive material using a bone trephine drill.

The specimens were fixed in a solution of 10% neutral buffered formalin, then dehydrated in ethanol and embedded in methyl methacrylate resin. After polymerization, the sections were stained with basic fuchsin and toluidine blue.

**Statistical evaluation**

For the statistical analysis, the t test was used to compare baseline and 4-month measurements. The significance was set at $P < .05$.

**Results**

**Clinical results**

The final results are shown in Table 1, and two clinical cases are shown in Figs 1 and 2. No patients withdrew from the study. At baseline, the mean width of the alveolar ridge was 11.80 ± 1.53 mm (range: 10 to 14 mm). At the 4-month evaluation, a reduction of approximately 15% of the initial bone volume was found, measuring an average of 9.95 ± 2.31 (range: 6 to 13 mm). These data correspond to a mean bone resorption of 1.85 mm (range: 0.5 to 5.5 mm). The final mean alveolar width measurement was 84.32% ± 15.62% of the initial value, resulting in 15% bone resorption after the healing period. The statistical difference between initial and final bone width was not significant ($P = .006$).

### Table 1: Changes in alveolar width and residual graft volume after 4 months

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Tooth no. (FDI)</th>
<th>Initial alveolar width (mm)</th>
<th>Final alveolar width (mm)</th>
<th>Residual graft volume (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Female</td>
<td>25</td>
<td>10</td>
<td>8.5</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>15</td>
<td>11</td>
<td>10.5</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>46</td>
<td>13.5</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>16</td>
<td>14</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>Female</td>
<td>16</td>
<td>12</td>
<td>11.5</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>Female</td>
<td>36</td>
<td>11.5</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>16</td>
<td>13</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>36</td>
<td>13</td>
<td>7.5</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Male</td>
<td>16</td>
<td>10</td>
<td>8.5</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>Female</td>
<td>36</td>
<td>10</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
<td></td>
<td>11.8 ± 1.53</td>
<td>9.95 ± 2.31</td>
<td>24.5 ± 11.65</td>
</tr>
</tbody>
</table>
Fig 1  Patient number 5. (a) Initial occlusal view. (b) Following maxillary first molar extraction. (c) Postextraction alveolus filled with osteoconductive material. (d) Graft covered with a collagen membrane. (e) After 4 months of healing. Note the stability of buccolingual width compared with the baseline image. (f) Intraoperative image during implant placement. Proper bone volume is available. (g) Bone biopsy harvested in the previously augmented area. (h) Higher magnification of the specimen.
Fig 2  Patient number 6. (a) Initial occlusal view. (b) After mandibular first molar extraction. (c) Postextraction alveolus filled with osteoconductive material. (d) Graft covered with a collagen membrane. (e) After 4 months of healing. Note the stability of buccolingual width compared with the baseline image. (f) Intraoperative image during implant placement. Proper bone volume is available. (g) Bone biopsy harvested in the previously augmented area. (h) Higher magnification of the specimen.
Histologic results

GenOs granules were identified in the histologies from the augmented sites (Figs 3 to 5). In the central portion of the alveolus, they were integrated and interconnected with each other by a cancellous bone scaffold. Newly formed bone, both woven and more mature lamellar types, was found in all sites.

Except for one site in patient no. 2, no signs of inflammation were detected. The volume of residual bone grafts present in the specimens after 4 months of healing was calculated, corresponding to a mean value of 24.5% ± 11.65% (range: 10% to 40%).

Discussion

The use of osseointegrated implants requires the evaluation of the available bone volume, since previous extractions may lead to different patterns of bone remodeling and resorption. When a tooth is yet to be extracted, several techniques may help clinicians preserve the alveolar process that houses the roots, thus creating ideal morphology of the implant site. This becomes even more important when the goal is to avoid bone augmentation procedures during implant placement.

Earlier investigations revealed that significant alveolar bone volume will be lost because of resorption after tooth extraction. Up to 50% of the alveolar ridge can be lost over 12 months, and approximately two thirds of this reduction occurs within the first 3 months. Moreover, the loss in width of the alveolar ridge is reported to be greater than the loss in height.
This study investigated the role of a bone substitute material in preserving the ridge after the extraction of posterior teeth. Clinical measurements using a surgical bone caliper were obtained on the day of extraction and after a 4-month healing period, corresponding to the day of implant surgery, to determine the change in form of the alveolar process. At this time, a biopsy specimen was harvested in the area previously augmented with xenograft to determine the percentage of graft particles still unresorbed after 4 months.

The results show that the resorption of the crestal width can be significantly reduced compared to previous studies\(^1\) by the treatment of the extraction socket with a filling material. Over the observation period, the postextraction sites lost, on average, only 15.68% of the initial buccolingual volume. The augmentation of the alveolus after tooth extraction seems to increase the probability of maintaining the original crestal form, allowing ideal implant placement with optimal bone and gingival tissues. Compared to the results of a similar study\(^4\) that evaluated the healing of nonaugmented postextraction sockets, the present investigation shows a 35% reduction in the loss of alveolar width.

The histologic analysis revealed that only residual particles of the bone graft were present after 4 months. The volume of residual bone grafts showed a mean value of 24.5%, which is significantly lower than the limit (40%) set for obtaining successful implant placement.\(^1\)

The formation of new bone tissue, both woven and lamellar, allowed for correct implant placement.

**Conclusions**

Within the limitations of this study's small sample size, the results of the present investigation promote the use of a bone substitute to fill the postextraction site of posterior teeth to avoid alveolar bone loss. Studies with larger patient populations are needed to confirm these results.

**References**


