Bone and Soft Tissue Modifications in Immediate Implants Versus Delayed Implants Inserted Following Alveolar Ridge Preservation: A Randomized Controlled Clinical Trial. Part II: Radiographic Outcomes

Daniele Cardaropoli, DDS¹
Miriana Bellomo, DDS²
Lorenzo Tamagnone, DDS³
Rosalia Leonardi, MD, DDS⁴

This study evaluated the radiographic alterations that occur in immediate postextraction implants and in delayed implants inserted in a preserved ridge. In group A, an implant was placed immediately after tooth extraction, grafting the bone-to-implant gap. In group B, alveolar ridge preservation was performed after tooth extraction, and delayed implant placement was performed 4 months later. The final follow-up was 1 year after prosthetic loading in both groups. The marginal bone level (MBL) was measured at implant insertion (T1), at loading (T2), and at the final follow-up, 12 months after prosthetic loading (T3). At tooth extraction (T0) and T3, the horizontal ridge width (HW) was measured on CBCT scans at three different levels. No statistically significant differences in MBL or HW were found between the two study groups. The outcomes suggest that it is possible to maintain MBL and alveolar bone volumes regardless of whether the procedure is performed through immediate postextraction implant placement or through delayed implant placement in a preserved ridge. Int J Periodontics Restorative Dent 2022;42:487–494. doi: 10.11607/prd.5567

Following extraction, the supporting tissues around the teeth undergo a remodeling process.¹,² This physiologic process involves a partial loss of alveolar bone³ both vertically and horizontally. Schropp et al⁴ demonstrated that after tooth extraction, the horizontal ridge width reduces by an average of 50% after 1 year. Alveolar ridge preservation (ARP) is a bone augmentation technique designed to modify the healing of postextraction sites, where the socket is grafted in order to preserve the alveolar ridge volume by compensating for marginal remodeling. Cardaropoli et al⁵ demonstrated that with ridge preservation, horizontal alveolar ridge loss was limited to 7% (1 mm) compared to 34% (4.5 mm) following spontaneous healing. Thus, ARP seems to be effective in maintaining the three-dimensional bone volume of the ridge⁶,⁷ and supporting delayed implant placement. Experimental clinical studies have also evaluated the application of bone augmentation procedures in immediate implant placement when the bone-to-implant gap is grafted with a bone substitute to counteract remodeling of the postextraction site.⁸ The use of a bone graft inside the bone-to-implant gap may compensate for marginal bone remodeling and maintain the original bone crest volume.⁹–¹¹ The present study aimed

¹ProEd Institute for Professional Education in Dentistry, Torino, Italy; School of Dentistry, University of Catania, Italy; Giuseppe Cardaropoli Foundation, Torino, Italy.
²University of Catania, Catania, Italy.
³ProEd Institute for Professional Education in Dentistry, Torino, Italy.
⁴Department of Orthodontics, School of Dentistry, University of Catania, Catania, Italy.

Correspondence to: Prof Dr Daniele Cardaropoli, ProEd Institute, Corso Galileo Ferraris 148, 10129 Torino, Italy. Fax: +39.011.323683. Email: d.cardaropoli@proed.it

to compare the radiographic alterations that occur in implants placed immediately postextraction (with grafting of the bone-to-implant gap) and in delayed implants inserted in preserved bone over an observation time of 1 year. Soft tissue evaluation and esthetic outcomes are reported in a separate paper.12

Materials and Methods

A total of 48 patients (26 women, 22 men) with a mean age of 55.17 ± 14.06 years (range: 22 to 78 years) who were undergoing dental treatment at a private periodontology practice in Turin, Italy, were recruited. The proposed treatment plan was described to each patient, and all patients signed an informed consent document. The study protocol was approved by the ProEd Ethical Committee (Torino, Italy). This randomized controlled clinical trial was designed following the guidelines from the Consolidated Standards of Reporting Trials (CONSORT) statement and was conducted in accordance with 1975 Declaration of Helsinki, as revised in 2008.

Before extraction, all patients underwent clinical and radiologic periodontal evaluation and professional oral hygiene through scaling and root planing (if needed) and were given related instructions for home oral hygiene in order to obtain full-mouth plaque and bleeding scores below 20%. All patients required a single tooth extraction in the anterior maxilla (premolar to premolar). The absence of gingival recessions and the integrity of soft tissue contour were verified at patient recruitment. The reasons for tooth extraction were dental fracture (coronal and/or radicular), late-stage carious lesions, or failure of previous endodontic treatments. The local pathologic conditions that immediately resulted in exclusion from the study were as follows: acute periapical and/or periodontal infections, gum recessions, and absence of integrity of the alveolar walls. The systemic conditions that led to study exclusion were as follows: pregnancy, metabolic bone diseases, history of radiotherapy or chemotherapy for cancer within the past 5 years, and history of autoimmune diseases. Patients taking drugs that may interfere with implant therapy were also excluded, as were heavy smokers (> 10 cigarettes/day). Patients who smoked ≤ 10 cigarettes/day were asked to quit smoking for 4 weeks (from 14 days before surgery to 14 days after). Patients were randomly placed into group A or group B using a computer-generated randomization list (SPSS version 16 for Mac OS X, IBM). In group A, an implant was placed immediately postextraction, and the bone-to-implant gap was filled with an osteoconductive biomaterial. In group B, the ARP technique was performed postextraction, and the implant was placed 4 months later.

Group A comprised 8 men and 16 women (mean age: 57.83 ± 12.97 years). Group B comprised 14 men and 10 women (mean age: 52.5 ± 15.07 years). In both groups, tooth extraction was performed throughout a flapless procedure. After administration of local anesthetic with 4% articaine and adrenaline (1:100,000), teeth were luxated with periotomes and gently extracted with forceps. Any granulation tissue was removed by debridement of the postextraction socket and rinsing with a physiologic solution. The integrity of the alveolar wall was detected with a periodontal probe. In order to expose the underlying connective tissue and promote tissue healing, the junctional and sulcular epithelium was excised and removed using a scalpel blade. A total of 48 conical implants with a highly hydrophilic surface (Bone Level Tapered SLActive, Straumann) were inserted. The implant diameters were 2.9, 3.3, 4.1, and 4.8 mm, while the lengths were 8, 10, 12, and 14 mm.

In group A, a surgical guide was fabricated for each patient in order to achieve correct implant positioning, leaving a buccal bone-to-implant gap of at least 2 mm and positioned with respect to the occlusal plane: centric, if the extracted tooth was a premolar; or slightly palatal, if the extracted tooth was an incisor or canine. The implant site osteotomy was performed following the surgical protocol set out by the manufacturer. Only the final use of the low-speed drill (200 revolutions per minute) was altered from the instructions in order to under-prepare the surgical site and consequently favor the primary implant stability. The most apical portion of the osteotomy was inserted inside the apical and palatal triangle of bone at the root apex. The implant platform was
placed subcrestally, 1 mm apical to the buccal bone margin. Implants were then inserted and reached a final insertion torque > 35 Ncm. After implant placement, the bone-to-implant gap was grafted with a deproteinized bovine bone mineral blended with collagen (DBBM-C; Bio-Oss Collagen, Geistlich). At the end of surgery, a titanium healing abutment was delivered. Antibiotic therapy was prescribed with 1 g of amoxicillin plus clavulanic acid every 12 hours for 6 days in addition to ibuprofen (600 mg, twice daily for 3 days). Patients were asked to rinse with 0.2% chlorhexidine gluconate every 8 hours for 14 days. Crown delivery was scheduled 12 weeks after implant placement (Fig 1).

In group B, following tooth extraction, the 24 postextraction sites were immediately filled with DBBM-C up to the marginal/coronal portion of the alveolar bone. This graft was covered with a porcine collagen matrix (Mucograft, Geistlich). This matrix was secured with single interrupted or horizontal crossing mattress sutures. The collagen matrix was left intentionally exposed, promoting open healing. Sutures were removed 14 days later. This group was prescribed the same antibiotic, analgesic, and antiseptic therapies prescribed to group A. Four months after tooth extraction, implant placement was performed. Crown delivery was scheduled 6 weeks after implant placement (Fig 2).

In both groups, the final follow-up was 12 months after tooth extraction.

Radiologic Measurements

Standardized digital intraoral periapical radiographs were taken using the parallel long-cone technique and were acquired and evaluated using ImageJ software.

Fig 1 Group A: Immediate implant placement. (a) After flapless tooth extraction, the implant site is prepared (prosthetically driven). (b) The implant is inserted, and the bone-to-implant gap is grafted with bovine bone mineral.

Fig 2 Group B: Delayed implant placement. (a) An example postextraction socket with intact bony walls. (b) The ARP procedure was performed by grafting the alveolus with bovine bone mineral. (c) An implant was placed in the preserved socket 4 months after surgery.
The software was calibrated for each individual image using the known length of the implant. Linear measurements on digital radiographs were performed using the appropriate measurement tool of the software. Marginal bone level (MBL) was the distance from the interproximal bone to the reference point on the outer side of the implant shoulder; this parameter was evaluated on both the mesial and distal sides, and the average values were calculated. MBL was measured at the time of implant insertion (T1), at the time of loading (T2), and at the final follow-up, 12 months after prosthetic loading (T3) (Figs 3 and 4).

**CBCT Measurements**

CBCT evaluation was performed using a 4 × 4–cm field of view (Hyperion X9 pro, MyRay), taking scans at the time of tooth extraction (T0) and at T3 (Figs 5 and 6). Horizontal ridge width (HW) represents the horizontal thickness of the alveolar ridge, measured at 1, 3, and 5 mm from the crest (Fig 7). It was possible to carry out radiographic measurements and comparisons by converting CBCT scans into 3D segments using an open-source software (ITK-SNAP, version 3.4.0). This made it possible to define the anatomical regions of interest, such as the postextraction alveolus. By recording the corresponding voxels, 3D surface mesh models were obtained (3D Slicer, version 4.6.2). Volumetric measurements were performed using CloudCompare (version 2.8).

**Statistical Analyses**

All measured clinical parameters were collected in a Microsoft Excel table, and the descriptive statistics
of the sample under examination were processed. All statistical analyses were processed using SPSS (version 25, IBM). Statistical analyses were conducted following multiple algorithms: Shapiro-Wilk test for normality of data distribution; Friedman test for comparison (k) of related samples; Dunn test with Bonferroni correction for post hoc comparisons of two related samples; Wilcoxon test for comparison of two related samples; and Mann-Whitney test for comparison of two independent samples. Data were presented as mean ± standard deviation. Statistical significance was established at \( P < .05 \).

**Results**

The study sample consisted of 48 patients divided into two groups (immediate postextraction implants, group A; and delayed implants, group B), comprising 54.1% women and 45.83% men, and mean patient age was 55.17 ± 14.06 years. All patients concluded the treatment plan without any complications; both the surgical protocol and the subsequent prosthetic rehabilitation were performed without any modifications to the previously established treatment plan. Table 1 reports the mean loss of distal, mean, and mesial MBL at various time points in both groups. In group A, the mean MBL was –2.06 ± 0.60 mm at T1, –2.00 ± 0.61 mm at T2, and –1.75 ± 0.60 mm at T3 \( (P < .05) \). In group B, the mean MBL was –0.03 ± 0.08 mm at T1, –0.09 ± 0.16 mm...
at T2, and –0.20 ± 0.20 mm at T3 (P < .05). The differences between T2 and T3 MBL values for both groups are reported in Table 2. The difference between T2 and T3 relative to the mean MBL was –0.25 ± 0.14 mm in group A and 0.10 ± 0.18 mm in group B (P < .05 between the two groups). Mean HW values measured 1, 3, and 5 mm from the crest at T0 and T3 are reported for both groups in Table 3, and the differences between these T0 and T3 measurements are reported in Table 4. The difference between T0 and T3 for HW at 1 mm (HW-1) was 0.65 ± 0.18 mm (6.9% ± 1.78%) in group A and 0.65 ± 0.19 mm (7.07% ± 2.17%) in group B (P > .05).

Discussion

This study was performed to evaluate the dimensional changes that occur in the alveolar ridge after tooth extraction and immediate/delayed implant placement. Intraoral radiographic parameters were evaluated at T1, T2, and T3. Tridimensional radiographic parameters were evaluated at T0 and T3. In group A, treatment comprised implant placement immediately postextraction. This choice reduces treatment times and morbidity, thus increasing patient compliance. In the present study, this procedure compensated the spontaneous remodeling of the postextraction site for approximately the 93% of the original volume, reporting a mean horizontal bone loss of 6.9% ± 1.78% from T0 to T3.
However, immediate implant placement does not counteract physiologic postextraction alveolar bone resorption. To overcome this problem, grafting of the bone-to-implant gap has been suggested. In group B, treatment comprised delayed implant placement following ARP. Socket preservation techniques help counteract the spontaneous resorption of the postextraction alveolus. In the present study, the insertion of the bone graft inside the socket helped the bone tissue maintain approximately 93% of its original volume, resulting in a horizontal bone loss of 7.07% ± 2.17% from T0 to T3.

When comparing the HW values, no statistically significant difference was found between the two groups, confirming recent literature data. In addition, a statistically significant difference was found in MBL between T2 and T3, but MBL remained < 1 mm during the first year of function in both groups, meeting the implant success criteria. In group A, where implants were immediately inserted into a fresh socket below the bone crest, the MBL values increased over the follow-up period, while in group B, where implants were inserted into a healed socket at the bone level, the MBL values decreased. This is because immediate implants are placed in a subcrestal position; because the alveolus still has an upward concavity at the immediate postextraction phase, as it has yet to heal. Therefore, the progressive increase in MBL is an index of the healing itself. In a delayed implant placement situation, the implant is placed in a crestal position because healing has already occurred.

### Table 4 Comparison of Differences in Horizontal Ridge Width (from T0 to T3) Between Groups

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>P</th>
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<tbody>
<tr>
<td>T0–T3, mm</td>
<td></td>
<td></td>
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<tr>
<td>HW-1</td>
<td>−0.65 ± 0.18</td>
<td>−0.65 ± 0.19</td>
<td>.11</td>
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<tr>
<td>HW-3</td>
<td>−0.66 ± 0.19</td>
<td>−0.61 ± 0.25</td>
<td>.857</td>
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<tr>
<td>HW-5</td>
<td>−0.63 ± 0.29</td>
<td>−0.43 ± 0.18</td>
<td>.244</td>
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<tr>
<td>T0–T3, %</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HW-1</td>
<td>−6.9 ± 1.78</td>
<td>−7.07 ± 2.17</td>
<td>.216</td>
</tr>
<tr>
<td>HW-3</td>
<td>−6.79 ± 1.79</td>
<td>−6.56 ± 2.7</td>
<td>.62</td>
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<tr>
<td>HW-5</td>
<td>−6.28 ± 2.83</td>
<td>−4.42 ± 1.93</td>
<td>.47</td>
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HW = horizontal ridge width at 1 mm (HW-1), 3 mm (HW-3), and 5 mm (HW-5) from the crest; T0 = tooth extraction; T3 = 1 year after implant loading. Statistical significance established at P < .05.

### Conclusions

Both immediate implant placement with grafting of the bone-to-implant gap and delayed implant placement after ARP have proven to be effective in compensating the remodeling process of a postextraction socket. The present results suggest that alveolar bone volumes can be maintained regardless of which procedure is used. Immediate postextraction implant insertion with filling of the bone-to-implant gap can be considered as ARP with simultaneous implant placement, thus adding the advantages of immediate implant insertion to the classic alveolar preservation.

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### References


