Evaluation of Dental Implants Placed in Preserved and Nonpreserved Postextraction Ridges: A 12-Month Postloading Study

Daniele Cardaropoli, DDS1
Lorenzo Tamagnone, DDS2
Alessandro Roffredo, DDS2
Lorena Gaveglio, DDS2

Forty-eight single dental implants were inserted 4 months after tooth extraction following ridge preservation (RP; n = 24) or spontaneous healing (EXT; n = 24). During surgery, 1 (7%) of 24 implants in the RP group and 14 (58%) of 24 in the EXT group required additional bone grafting, and the implant stability quotient value was similar in the two groups. The survival rate of the implants in both groups was 100% at the 1-year follow-up. The success rate was 95.83% in the RP group and 91.66% in the EXT group. No statistically significant differences in the marginal bone level were detected between the two groups. Similar outcomes of implants inserted in preserved or spontaneously healed ridges can be anticipated, but the use of an RP procedure reduces the need for further bone augmentation. (Int J Periodontics Restorative Dent 2015;35:677–685. doi: 10.11607/prd.2309)

Extraction of a natural tooth inevitably results in modification of the alveolar ridge, with significant three-dimensional bone resorption.1,2 In the first phase of remodeling of the extraction site, the bundle bone is resorbed because of the lack of nutritive support from the periodontal ligament and later replaced with woven bone.3,4 Consequently, postextraction bone loss is observable. A human study5 reported that, with regard to the horizontal dimension, a reduction of approximately 50% can be found 12 months after extraction, of which two-thirds occurs within the first 3 months of healing.

A systematic review evaluated the dimensional changes of alveolar ridges in extraction sockets, showing an average 3.87-mm reduction in alveolar ridge width.6 Another systematic review7 reported a reduction of the horizontal dimension of the ridge, ranging from 2.6 to 4.6 mm. Similar findings were reported by another study evaluating dental literature to assess the magnitude of alveolar ridge dimensional changes after tooth extraction in humans.8 Mean horizontal dimensional reduction was 3.79 mm at 6 months. Mean horizontal dimensional change was 32% at 3 months, and a wide range of 29% to 63% was reported at 6 to 7 months. Rapid reduction in the first 3 to 6 months was always found, followed

1Scientific Director, PROED Institute for Professional Education in Dentistry, Turin, Italy.
2Private Practice, Consultant, PROED Institute for Professional Education in Dentistry, Turin, Italy.

Correspondence to: Dr Daniele Cardaropoli, Institute for Professional Education in Dentistry, Corso Galileo Ferraris 148, Torino 10129, Italy. Fax: +39011323683.
Email: dacardar@tin.it

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by gradual reduction in dimensions thereafter. Despite the wide range of variability in horizontal bone width healing, it is clear that the bone volume resorption complicates an ideal implant placement and predictable results. To limit the postextraction alveolar bone resorption, several techniques and different biomaterials have been proposed for ridge preservation (RP), intended to preserve the ridge volume in the envelope existing at the time of extraction. The potential benefits of RP therapies were demonstrated, resulting in significantly less horizontal resorption of the alveolar bone crest. Results of a systematic review reported mean horizontal bone changes ranging from 3.25 to –2.50 mm for the RP techniques. Recently, a randomized controlled clinical trial evaluated the use of a bovine bone mineral together with a porcine-derived collagen membrane to preserve the alveolar ridge after single-tooth extraction, compared with spontaneous healed ridge. After 4 months, the RP group showed significantly lower reduction in ridge width (1.04 mm vs 4.48 mm) and height (0.46 mm vs 1.54 mm) compared with the nongrafted group. Histologically, the grafted sockets exhibited various stages of bone maturation and formation without inflammatory responses or fibrous encapsulation of the bovine bone particles. Residual graft particles were embedded in new bone. No significant difference in the mineralized and nonmineralized fractions was noted between the groups in the histomorphometric analysis. Moreover, no correlation was found between the thickness of the buccal bone wall and the alveolar bone loss in the grafted group, whereas an inverse correlation was found in the nongrafted group. Although the topic of “ridge preservation” has been widely debated in the international literature, knowledge regarding placement of dental implants after the healing of preserved or unpreserved extraction sites is poor. The aim of this clinical study was to evaluate the insertion of osseointegrated implants in alveolar ridges previously preserved with a bovine bone mineral and a collagen membrane, and to compare these with osseointegrated implants inserted in spontaneously healed postextraction sites.

Method and materials

Study design

Forty-one patients initially were enrolled in a randomized controlled clinical trial on RP at a private practice in Torino, Italy. All subjects (17 women and 24 men; mean age ± standard deviation: 47.2 ± 12.9 years) were referred for single extraction of one or more maxillary or mandibular premolars or molars, leaving sockets with three walls intact and at least 80% of the fourth wall intact. The study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000. This trial, including study population characteristics, inclusion, and exclusion criteria, was previously detailed in other studies describing 4 months of healing. The reasons for extraction included root fracture, periodontal involvement, endodontic treatment failure, and advanced caries. The sites were randomly divided into a test group (RP, sockets were grafted) and a control group (extraction alone with spontaneous healing [EXT]) (Figs 1a and 2a). Most reduction in width occurs within the first few months after extraction, so the final measurements were recorded after 4 months, which was considered the end of the healing period in both groups.

Surgical and prosthetic procedure

At the time of tooth extraction, using a flapless procedure in the RP group, the alveolus was filled with a bovine bone mineral blended with collagen (Bio-Oss Collagen, Geistlich) and covered by a porcine collagen membrane (Bio-Gide, Geistlich). A cross mattress suture was used to secure the membrane in place, once left intentionally exposed, and sutures were removed after 2 weeks. In the EXT group, no additional treatment was performed and no sutures were placed after tooth extraction to promote spontaneous healing. Patients were instructed to apply a gel rich in hyaluronic acid and amino acids (Aminogam, Errekappa) over the wound three times a day until complete gingival closure. It was planned that patients would receive dental implants at the site of the previous extraction after 4 months (Figs 1b and 2b).
Fig 1a  Maxillary premolar at baseline on the day of extraction.

Fig 1b  Healing after 4 months following ridge preservation with bovine bone and collagen membrane.

Fig 1c  Implant inserted in the preserved ridge after flap elevation.

Fig 1d  Periapical radiograph after implant placement.

Fig 1e  Occlusal view of the final ceramic restoration at 1-year follow-up.

Fig 1f  Lateral view of the final ceramic restoration at 1-year follow-up.

Fig 1g  Periapical radiograph with the definitive restoration at 1-year follow-up.

Fig 2a  Mandibular premolar at baseline on the day of extraction.

Fig 2b  Healing after 4 months following spontaneous blood clot stabilization.

Fig 2c  Implants inserted in the nonpreserved ridge presenting dehiscences.

Fig 2d  Bone regeneration procedure by means of bovine bone substitute and collagen membrane.

Fig 2e  Periapical radiograph with the definitive restoration at 1-year follow-up.
At this time, after achieving local anesthesia using 4% articaine plus epinephrine 1:100,000, a full-thickness mucoperiosteal flap was elevated and an osteotomy was performed to prepare for implant placement according to the manufacturer’s surgical protocol, with the exception that the final bur was used at a low speed (400 revolutions/min [rpm] in the maxilla and 800 rpm in the mandible). A total of 48 conical-shaped implants (Osseotite Tapered Certain, Biomet/3i) were inserted. To avoid any bias in evaluating the results of this study, it was decided to use only regular diameter implants (ie, 4-mm-diameter implants in the premolar sites and 5-mm-diameter implants in the molar sites).

After final implant seating, the implant stability quotient (ISQ) was measured using a dedicated ultrasonic device (Osstel, Mentor). If peri-implant bone defects were encountered after fixture placement, a guided bone regeneration procedure was performed using granules of a bovine-derived biomaterial (Bio-Oss, Geistlich) further covered with a bilayer porcine-derived collagen membrane (Bio-Gide, Geistlich) (Figs 2c and 2d). In cases in which the implants were inserted in pristine bone without any augmentation procedure, healing abutments were immediately screwed and flaps were sutured for transmucosal healing (Figs 1c and 1d). In cases in which a graft was used, flaps were coronally positioned to fully cover the regeneration material for two-stage submerged healing. In all augmented cases, reopening with connection of the healing abutment was scheduled 4 months after implant placement. Fixture level impressions of the implants were taken 6 weeks after implant placement for implants inserted in pristine bone, and 6 weeks after reopening for implants inserted in deficient bone volume. After 2 more weeks, implants were then loaded; a definitive titanium abutment was screwed (GingiHue, Biomet-3i) and an acrylic resin provisional crown was cemented. After 2 months, a definitive ceramic crown was cemented.

Radiologic examination

At implant placement and 12 months after loading, standardized digital intraoral radiographs were taken for each implant. The paralleling long-cone technique was followed using individual sensor holders, standardized by means of polyvinylsiloxane impression material as previously described. The individual sensor holder was used for both the initial and the final radiographs. All radiographs were taken using a digital video-radiography system with charge-coupled device sensors (Sidexis XG Intraoral X-Ray System, Sirona), and directly used with a dedicated software (Sidexis neXt Generation 1.52, Sirona). Linear measurements on the digital radiographs were performed by a single previously calibrated examiner (L.T.) using the measurement tool specifically designated for the software. Marginal bone level (MBL), defined as the distance from the alveolar bone in direct contact with the implant surface at the mesial and distal aspect of the implant to the shoulder (level of abutment connection) of the implant was measured at implant placement, at loading, and 12 months after implant loading (Figs 1e to 1g).

Implant success and survival rates

Patients were clinically evaluated every 6 months after implant loading and any mechanical and biological complications were recorded. One year after loading, implants were clinically and radiologically evaluated for survival or success criteria. A successful implant was considered to be any implant in which: (1) clinical testing showed it to be individually immobile; (2) a radiograph did not demonstrate any evidence of peri-implant radiolucency; (3) persistent and/or irreversible signs and symptoms (such as pain, infections, neuropathies, paresthesia, or violation of the mandibular canal) were not present; and (4) MBL changes evaluated on periapical radiographs around dental implants were less than 1 mm during the first year after placement.

A surviving dental implant was considered to be any dental implant with no pain on function, no mobility, radiographic bone loss of 2 to 4 mm, and no history of exudates.

Statistical analysis

A data analysis was performed with descriptive statistics, with mean values and standard deviations, to
evaluate differences between the two treatment groups. The Fisher exact test was used to compare the groups for the need for bone regeneration procedure at the time of implant placement and the success/survival rates. The Mann-Whitney test was used to compare mesial and distal MBLs between the groups and ISQ values between the groups. \( P < .05 \) was considered the threshold for statistical significance.

**Results**

A description of the results is reported in Tables 1 and 2. During the surgical procedure for placement, 15 implants presented with either dehiscence or fenestration defects that required additional bone augmentation. This was performed using bovine bone mineral (Bio-Oss, Geistlich) and a collagen membrane (Bio-Gide, Geistlich). In the RP group, only one implant required additional grafting (corresponding to 4.16%), and in the EXT group, 14 implants required additional grafting (corresponding to 58.33%). The difference between the groups was statistically significant (\( P < .05 \)). Implant sites were 16 premolars and 32 molars. In the RP group, 10 implants were inserted in premolar sites and 14 implants were inserted in molar sites. In the EXT group, 6 implants were inserted in premolar sites and 18 implants were inserted in molar sites. Implants ranged in length from 8.5 to 13 mm, and had diameters of 4 or 5 mm. Only one implant was 8.5 mm in length (in the EXT group), 14 implants were 10 mm, 24 implants were 11.5 mm, and 9 implants were 13 mm (8 in the test group and 1 in the control group). Implants inserted in premolar sites were all 4 mm in diameter, and those inserted in molar sites were all 5 mm in diameter.

At implant placement, mean ISQ value was 69.96 ± 3.24 in the RP group, and 70.21 ± 4.82 in the EXT group. The difference was not statistically significant (\( P = .79 \)). All patients were provided with implant-supported single crowns. For all groups, mean loss in mesial, distal, and total MBLs was calculated. In the test group, mesial MBL ± standard deviation was 0.31 ± 0.30 mm, distal MBL was 0.35 ± 0.26 mm, and total MBL was 0.33 ± 0.28 mm. In the control group, mesial MBL was 0.33 ± 0.30 mm, distal MBL was 0.38 ± 0.27 mm, and total MBL was 0.35 ± 0.28 mm. No statistically significant differences were reported among groups (\( P > .05 \)) for mesial MBL (\( P = .79 \)), distal MBL (\( P = .93 \)), and total MBL (\( P = .80 \)). The survival rate was 100% for both groups 12 months after loading. Regarding success rates, a total of three implants incurred radiographic bone loss greater than 1 mm during the first year of their function and therefore did not fully satisfy the success criteria. Specifically, in the RP group, one implant failed to meet the success criteria, for a success rate of 95.83%, and in the EXT group, two implants failed to meet the success criteria, for a success rate of 91.66%. The difference in success rates between the groups was not statistically significant (\( P = .98 \)).

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<th>Table 1 Implant position according to tooth sites*</th>
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*Frequency distribution of residual bone defects in test and control groups after implant placement is shown. ISQ noted is at implant placement. Statistical significance set at \( P < .05 \).

SD = standard deviation; ISQ = implant stability quotient; RP = ridge preservation; EXT = spontaneous healing; NA = not applicable.

<table>
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<th>Table 2 Mesial, distal, and total MBL at implant sites 1 year after loading*</th>
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<td><strong>Group</strong></td>
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*Frequency distribution of residual bone defects in test and control groups after implant placement is shown.† Mean ± SD. ISQ noted is at implant placement. Statistical significance set at \( P < .05 \).

SD = standard deviation; ISQ = implant stability quotient; RP = ridge preservation; EXT = spontaneous healing.
Discussion

RP procedures have been proposed with the aim of maintaining the tri-dimensional volume of the alveolar ridge and the original contour of the soft tissues that are partially lost after tooth extraction. Because of the physiologic dynamics of healing after tooth extraction, the alveolar process is markedly reduced with respect to both vertical and horizontal dimension, especially at the buccal as compared with the lingual/palatal bone walls. This situation is particularly relevant when implant-supported rehabilitation has been planned, because successful implant prostheses is related to the best bone availability. The overall results from published meta-analyses demonstrated statistically significantly higher alveolar bone crest preservation, in both ridge height and width, in the test groups (procedures for ridge preservation) when compared with the control groups (spontaneous healing). However, these meta-analyses combined studies that used different biomaterials and surgical techniques, as well as different types of sockets, reasons for tooth extraction, and methods of evaluation.

In the present study, 48 dental implants were inserted in 48 previously investigated postextraction sites. Forty-one patients were enrolled in the original trial. They were referred for extraction of one or more maxillary or mandibular premolars or molars (and subsequent single-tooth implant treatment) leaving sockets with three walls intact and at least 80% of the fourth wall intact. The reasons for extraction included root fracture, periodontal involvement, endodontic treatment failure, and advanced caries. All extraction surgeries were performed flapless. The sites were randomly divided into a test group (RP) and a control group (EXT). In the RP group, postextraction sites were filled with a bovine bone mineral and protected using a porcine-derived collagen membrane with an open healing. Considering that the majority of width reduction occurs within the first few months after extraction, the final measurements were recorded after 4 months. Cast model data showed that the RP group experienced minimal loss of horizontal bone width (7.70%) compared with the EXT group (33.48%). Similarly, the vertical ridge change was minimal in the RP group (0.46 mm) and more pronounced in the EXT group (1.54 mm), with a statistically significant difference for both parameters. These positive results were confirmed with intrasurgical measurements. Moreover, no correlation was found between the initial buccal bone plate dimension and the alveolar bone loss, so that the socket grafting seemed to be able to compensate alveolar contraction independently from buccal bone thickness, whereas in the control group, the thinner the buccal bone plate, the greater the alveolar bone loss. The histomorphometric analysis showed a similar mineralized fraction between RP and EXT groups (44.80% and 43.82%, respectively) and the rate of residual graft granules in the test group (18.46%) was substantially lower than the established limit for successful implant placement.

After tooth extraction, the presence of a high percentage of newly formed bone is necessary for implant placement to achieve good primary stability. The bone quality in previously preserved sites has been evaluated in two studies reporting the placement of dental implants after RP procedures (using a sponge of polylactide–polyglycolide acid) after 6 and 3 months of healing, respectively, specifying that all implants achieved good primary stability in both test and control groups. In the present study, implant stability was measured using the ISQ, and both groups reported satisfying values.

Several clinical trials on the placement of implants in previously preserved sites investigated the need for additional bone augmentation. In a study by Fiorellini and coworkers, implants were inserted after 4 months from tooth extraction; statistically significant differences were reported in favor of the test group (using absorbable collagen sponge and recombinant human bone morphogenetic protein 2) compared with the control group (spontaneous healing) in terms of number of secondary augmentation surgeries needed, but no further details were provided with regard to the number and type of these procedures. In the test sites,
56.25% demonstrated adequate bone volume for implant placement, whereas the corresponding number in the control group was only 12.5%. In a clinical study in which dental implants were inserted 8 months after RP procedures, 68% of the implants presented with either dehiscence or fenestration defects and required additional bone augmentation at the time of surgical placement. The results of the present study showed that 95.84% of the preserved sites presented with adequate bone volume on the day of implant placement, whereas only 41.67% of the control group sites were suitable for implant placement without any further augmentation procedure. It can be supposed that the high percentage of sites not requiring additional augmentation procedures in the RP group can be related to the success of the RP technique, and were able to compensate for MBL changes after tooth extraction (92.30% of the initial horizontal dimension was maintained).11,12

Another finding of the present study was that no statistically significant differences were detected in success and survival rates between implants placed in augmented and nonaugmented sockets. These success and survival rates are similar to those reported in previously published studies evaluating implants placed in pristine as well as regenerated bone.22 According to a systematic review,23 the survival rate of implants placed in regenerated sites varies from 79% to 100%, with the majority of studies indicating survival rates higher than 90% after 1 or more year of loading. These survival rates are similar to those generally reported for implants conventionally placed in sites with preexisting bone. In another systematic review, Fiorellini and Nevins24 showed that implants placed using bone augmentation procedures do not perform differently from implants placed in native bone in terms of implant survival—mean survival rates reached 95.8% for the grafted sites, with an observation period of 56.5 months. In a study evaluating the insertion of implants in three different grafted sockets, the survival rate for all implants at 24 months was 100%.25 Similarly, the success and survival rates of the present study can be compared with those reported in studies describing implants placed in preserved ridges. In a clinical study reporting data on implants inserted 3 months after ridge preservation, the survival rate was 100% after 1 year.26 A study in which implants were placed in postextraction sites preserved with corticocancellous porcine bone, the cumulative implant success rate was 95% at the 3-year follow-up.27 In a retrospective study on implants inserted in sockets preserved with demineralized freeze-dried bone allografts and with a mean evaluation period of 12 months, the reported survival rate was 100%.28 In a clinical study with a 12-month follow-up, implants inserted in preserved sites had a mean survival rate of 100% and a mean success rate of 83.95%.21

In the present study, the 1-year peri-implant MBL was 0.33 ± 0.28 mm in the RP group and 0.35 ± 0.28 mm in EXT group. These data are comparable with those reported in the literature for delayed implants inserted in augmented postextraction sockets.21,25–28

The mean ISQ value was 69.96 in the RP group and 70.21 in the EXT group. The intergroup analysis showed similar ISQ values, suggesting that implants inserted in augmented bone can reach the same primary stability as implants inserted in spontaneously healed bone, and that the presence of 18% residual graft does not appear to impede successful early loading. The ISQ values in the present study are beyond the limit usually set for immediate loading (> 60 to 65),29 and the survival and success rates together with the MBL confirm that there are no differences between failure rates of early and conventionally loaded implants.30

**Conclusions**

Within the limitations of the present study, it can be concluded that sockets preserved with the use of bovine bone mineral remain as stable over time as native bone. The 1-year results confirm that implants inserted in augmented sites have success rates and MBLs comparable to those of implants inserted in nonaugmented sites. Moreover, the use of an RP procedure at the time of tooth extraction significantly reduces the need for further bone augmentation at the time of implant placement.
Acknowledgments

The authors reported no conflicts of interest related to this study. Geistlich Pharma supplied the biomaterials (Bio-Oss Collagen and Bio-Gide) used in the original trial.11,12

References