Long-Term Outcome of Surgical Regenerative Treatment of Peri-implantitis: A 2- to 21-Year Retrospective Evaluation

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The aim of this retrospective study was to evaluate long-term clinical and radiologic outcomes of submerged and nonsubmerged guided bone regenerative treatments for peri-implantitis lesions. Strict methods of implant-surface decontamination and detoxification were performed. Data on clinical probing depth, soft tissue measures, and marginal bone level that were documented by comparative radiographs were obtained from 45 patients, for a total of 57 implants prior to treatment and at the latest follow-up. The average follow-up period was 6.9 years (range: 2 to 21 years). Analysis of implant-based data revealed a success rate of 70.2% for a total of 40 implants. Recurrence of peri-implantitis was observed on 9 implants, and 8 implants were removed. The regenerative procedures, under a strict periodontal control, were effective in the treatment of moderate to advanced peri-implantitis lesions. Int J Periodontics Restorative Dent 2020;40:487–496. doi: 10.11607/prd.4647

Peri-implantitis is defined as an inflammatory process around an implant characterized by both soft tissue inflammation and progressive loss of supporting bone beyond biologic bone remodeling, affecting considerable proportions of the dental implants that were inserted and initially osseointegrated in the oral cavity.4–6

Defect identification is crucial to reach a correct diagnosis, which consequently can direct adequate treatment.7 Different surgical treatment modalities have been described with different results,8–16 and several bone regenerative procedures, combined with concomitant soft tissue augmentation,16 have been proposed to reduce objectionable esthetic effects; but these procedures have a limited long-term follow-up,10,15,16 small sample size, and different treatment protocols and outcome measures.17–23

Long-term results on surgical regenerative treatment of peri-implantitis have been based on a few studies, and some on a reduced number of patients or with inconsistent results, which rarely included evaluations of bone level changes.24–26

The aim of this retrospective observational study was to evaluate the long-term clinical and radiologic outcomes following surgical regenerative treatment of peri-implant
defects, including comparative pre- and posttreatment longitudinal assessments. The clinical relevance of this long-term evaluation is: Improve the prognosis of implants and prolong their function with undisputed benefits for the patient and great satisfaction for the clinician.

Materials and Methods

Medical records and related radiographic documentation from patients, who had received regenerative surgical peri-implantitis treatment in a private specialist practice of two principle investigators (S.P.B. and C.T.) from January 1998 to April 2019, were retrieved and analyzed. The study was performed in accordance with the principles stated in the Declaration of Helsinki and Good Clinical Practice Guidelines. All patients gave informed consent for the statistical analysis of data documented during the periodontal therapy. Patients qualified for participation in the study if they:

- Had at least one properly positioned implant diagnosed with peri-implantitis based on initial probing depth (PD) ≥ 6 mm; presence of bleeding on probing (BoP) and/or suppuration on probing; and radiographic marginal bone loss ≥ 3 mm, without mobility
- Were in good general health
- Had received regenerative treatment aiming at resolution of a peri-implantitis bony lesion
- Were placed on an individually tailored supportive therapy

- Had complete clinical and radiologic documentation with an observation period ≥ 2 years

Surgical Procedures

All patients received appropriate nonsurgical periodontal therapy that varied by case but consisted of motivation, oral hygiene instruction, scaling and root planing, and regularly providing home care reinforcement. No surgery was planned if the patient was not complying with the recommended home care procedures nor closely adhering to the personalized maintenance program. All patients reached full-mouth plaque and bleeding scores ≤ 20% prior to implant surgery.

The surgical regenerative treatment selected was either one- or two-stage guided bone regeneration (GBR) procedure, based on defect diagnosis, as reported in previous articles. All surgeries were performed by two periodontal surgeons (S.P.B. and C.T.), both with more than 30 years of experience in periodontal surgery.

All surgical procedures were executed under local anesthesia (lidocaine HCl 2% with 1:100,000 epinephrine) and oral sedation (diazepam, 5 to 10 mg 30 minutes before the procedure). With minor changes, the surgical regenerative technique was very similar to the one described by the present authors for vertical ridge augmentation. The peri-implant bone defect debridement, implant-surface decontamination, and implant-surface detoxification have been described in detail in recent publications.

Postsurgical Instructions and Clinical Follow-up

Patients were instructed to take 875 mg of amoxicillin plus 125 mg of clavulanic acid (Augmentin, GlaxoSmithKline) twice daily for 6 days, starting at least 1 hour prior to surgery, and nonsteroidal analgesics as needed. Instructions in proper home-care techniques were reinforced, also recommending the daily repeated use of medicated gauze soaked in chlorhexidine 0.12% (Digital Brush, Ena Oral Care), especially for the first 3 weeks after surgery. The patient had to wrap the gauze around the index finger and use a sweeping motion in an apico-occlusal direction, from oral mucosa to the implant/tooth surfaces, similar to the roll brushing technique, both at the treated site and in the entire oral cavity.

Patients were seen weekly for the first month to monitor the healing phase and thereafter they were placed on an individually tailored maintenance care program. Sutures were removed after 14 days.

Patient Data and Clinical and Radiologic Assessments

After pseudonymization, demographic information and peri-implant clinical data recorded at baseline and at the latest follow-up were entered into a dataset for statistical analysis. They included PD,
mucosal recession (MR), keratinized tissue width (KTW), presence of BoP, and suppurration. The bone level on the mesial and distal surfaces of the treated implants was measured on standardized periapical radiographs, obtained with the long cone paralleling technique and personalized film holders, at baseline, and the latest follow-up and was calculated as the distance in millimeters from a reference point on each implant system to the bottom of the bone defect and/or the most coronal visible bone-to-implant contact. Bone level change was determined as the difference in bone level between the baseline and the latest follow-up radiographs.

**Statistical Analysis**

Descriptive statistics, including mean values, standard deviations, and frequency distribution, were used for the presentation of the clinical and radiographic variables at both patient and implant levels. Clinical parameters were categorized for implant surface (turned vs modified) and treatment outcome. Treatment outcome (disease resolution, failure, implant removal) was calculated at implant level at the latest follow-up after treatment. Disease resolution was defined as implant survival and absence of a peri-implant site with a PD ≥ 5 mm with concomitant BoP and/or suppurration on probing and no further bone loss. To test whether quantitative data were normally distributed, Shapiro-Wilk test was done. Parametric (paired and unpaired t test) and nonparametric tests (Wilcoxon rank sum test, Mann-Whitney U test, Pearson $\chi^2$ test) were used to assess for significant changes over time in mean PD, mean radiographic bone level, and percentage of sites with BoP and suppurration on probing at the treated implants and for between-group comparisons. Differences among treatment outcome categories were tested using one-way analysis of variance or the Kruskal-Wallis test for quantitative variables and Pearson $\chi^2$ test for qualitative variables. Multiple comparisons were conducted with the post-hoc Tukey test or the Dunn test, as appropriate. All significance tests were two-tailed and conducted at a 5% level of significance. All analyses were performed using a commercially available software program (SPSS for Mac, version 24.0, IBM).

**Results**

The present analysis was based on 45 patients (10 men and 35 women; mean age: 64.1 ± 8.7 years; range: 47 to 88 years), contributing a total of 57 implants diagnosed with peri-implantitis. Characteristics of patients and implant types are presented in Appendix Tables 1 and 2, respectively (All Appendix Tables can be found in the online version of this article at quintpub.com/journals). The majority of patients were nonsmokers (57.8%) with a history of treated periodontitis (62%). Thirty-seven patients contributed 3 implants, 1 implant, 4 patients contributed 2 implants, and the remaining 4 patients contributed 3 implants. Implants replacing mandibular first molars (35%), mandibular second premolars (17.6%), and maxillary first premolars (13.3%) were the most frequently involved with peri-implantitis. At the time of regenerative therapy, the average function time of implants was 8.2 ± 4.7 years and 79% of the implants were in function more than 5 years. A resorbable membrane was used for treatment of peri-implant bone loss in 33 implants (57.9%) and a nonresorbable membrane in 14 implants (24.6%). In 10.5% of implants, a mucogingival treatment was performed to increase the band of keratinized tissue.

A one-stage regenerative approach was performed on 46 implants (80.7%) and a two-stage approach on the remaining 11 implants (19.3%). In all patients, surgery and the healing process proceeded uneventfully with minimal postoperative discomfort and no complications. At the time of suture removal, the wound healing was fully satisfactory at all implant sites. None of the surgical sites displayed signs of membrane exposure, washed-out filling material, or wound dehiscence during the entire healing period.

The follow-up period after surgical therapy varied between 2 and 21 years with a mean of 6.9 ± 3.4 years. About 63% of implants had a follow-up period between 5 and 10 years. Cases with implants with turned surfaces exhibited longer function times (11.6 vs. 7.6 years) and follow-up periods (9.6 vs. 6.4 years) than those with modified surfaces ($P = .037$ and $P = .019$, respectively).
Successful treatment was achieved, when the following clinical parameters were met: PD ≤ 5 mm, absence of bleeding/suppuration on probing, and no further bone loss. Of all implants, 70.2% (40/57) were successfully treated with no recurrence of peri-implantitis. Further, 15.8% (9/57) survived but did not show complete defect resolution, and 14.0% (8/57) were explanted at the time of latest follow-up. The follow-up period after surgical therapy was 8.1 ± 3.3 years (3 to 21 years) for successfully treated implants, 5.6 ± 1.8 years (3 to 8 years) for failed implants, and 4.9 ± 2.7 years (2 to 10 years) for implants that underwent explantation (P = .009). All implants that failed or were lost during the observation period had modified surfaces.

Clinical and radiographic characteristics at baseline and the latest follow-up are presented in Appendix Tables 3 and 4 at the patient and implant levels, respectively. As summarized in Appendix Table 3, statistically significant improvements in all clinical parameters were recorded at the latest follow-up compared with baseline values (P < .001). Differences in PD reduction, frequency of BoP, and bone level changes between implants with turned and modified surfaces were small (P > .05). When data were stratified by treatment outcomes (Appendix Table 4), the mean PD reduction, bone level change, frequency of BoP, and suppuration at latest follow-up for successfully treated implants were 4.7 ± 1.6 mm, 5.9 ± 2.0 mm, 20%, and 0%, respectively. Clinical behavior of failing implants was not statistically different from those of implants that were removed. Successful treatment outcome was related to periodontal conditions (P = .021), but was unrelated to smoking habits (P = .239), to the type of membrane barrier (P = .586), and to the surgical procedure (one-stage vs two-stage, P = .861). As reported in Appendix Table 5, the MR and KTW values at treatment time were 0.5 ± 1.4 mm and 2.6 ± 1.7 mm, respectively, and at the last follow-up they were 0.6 ± 1.2 mm and 2.9 ± 1.5 mm, respectively. A greater stability of peri-implant soft tissue marginal level as well as a greater increase in KTW was observed around successfully treated implants. Figures 1 through 4 show the clinical cases of four different patients.

Discussion

The present long-term retrospective study demonstrated that the GBR treatment was effective on 40 out of 57 treated implants (70.2%), with no recurrence of peri-implantitis. Nine implants (15.8%) survived but did not show complete radiographic resolution of the defect, and 8 implants (14.0%), all with modified surfaces, were explanted. Successful treatment outcome was mainly related to periodontal conditions, unrelated to smoking habits and to membrane/barrier type. Regenerative-approach objectives are to resolve inflammatory lesions, to stop and prevent further bone loss, and to regenerate the peri-implant bony lesion. Compared with baseline values, all clinical parameters showed statistically significant improvements at the latest follow-up visit: 4.7-mm average PD reduction, 5.9-mm average bone level gain, 62% mean BoP decrease, and a total absence of suppuration. These findings compare very favorably with previous published long-term outcomes,\textsuperscript{19,21,24,26} especially with regard to bone fill, extending the success of the same regenerative protocol, described in a reentry procedure peri-implantitis study, where 4.88 mm mean bone gain was reported.\textsuperscript{30}

Three elements are utterly crucial to clinical success: (1) accurate diagnosis of the peri-implant defect, (2) effective decontamination and detoxification of the exposed implant thread, and (3) successful GBR procedure performed by experienced surgeons. Soft tissue quality/quantity and prosthetic suprastructure retrievability are key factors for selecting the therapeutic approach. The use of a connective graft is highly recommended when keratinized tissue is scarcely represented, and coronally advanced flaps would contribute to both desired clinical objectives.\textsuperscript{16,26,33} In esthetic areas, a regenerative approach was primarily used to avoid gingival recession (Appendix Table 5).

Following a protocol applied by some authors of this article for more than 20 years,\textsuperscript{32} as well as in many other subsequent articles,\textsuperscript{7,31–33} adequate access is critical (ie, the removal of the prosthetic suprastructure in suitable cases) in order reach and obtain an effective biofilm removal on the exposed implant thread. Decontamination and detoxification efficacy were confirmed by uneventful healing process, especially in the 9- to 12-month submerged mode.
Residual inflammation, especially in guided bone/tissue regeneration techniques, would rapidly lead to short- and long-term follow-up complications despite the use of systemic antibiotics. The use of an airborne-particle abrasion system, has proved particularly effective.25,34 The proper tip is positioned very close to the exposed threads, also using moist gauze pads, to avoid the risk of air embolism. The protocol can be considered applicable to all implant surfaces, turned or variously modified.

Fig 1 Patient 1. (a) After prosthetic component removal, a follow-up radiographic image revealed a marked radiolucency involving two-thirds of the implant surface. (b) Periodontal probing on the lingual side ranged from 10 to 12 mm, associated with bleeding on both mesial and distal aspects. An adequate dimension of keratinized mucosa was present at the buccal and lingual surfaces. (c) Lingual view of the peri-implant defect. On the mesial and distal aspects, the bone lesion has a contained intrabony component, whereas it is severely noncontained on the lingual side. (d) Lingual view at the reentry procedure. A slight residual defect is still present. (e) Periapical radiograph taken at the 6-year follow-up of a treated moderate to severe peri-implantitis lesion.
Fig 2  Patient 2. (a) Clinical and (b) periapical radiographic views showing a peri-implantitis lesion on a machined implant replacing the maxillary right first premolar. Using a 15-mm UNC periodontal probe, a 10-mm probing depth was detected on the mesiobuccal aspect. (c) Buccal view of the peri-implant bony defect after the decontamination and detoxification phases. There was a moderate to advanced buccal dehiscence associated with the defect, with two-wall components on both mesial and distal buccal aspects, and nine exposed implant threads. (d) Occlusal-buccal view of clinical evaluation at 2 years after peri-implantitis treatment and regenerative techniques. Note the increased buccal bony thickness and the ideal convex anatomy. Surgical reentry was planned for a crown-lengthening procedure for restorative reasons at the distal aspect of the adjacent tooth. (e) Clinical and (f) radiographic views at the 7-year follow-up after regenerative surgical treatment of peri-implantitis. The probing depth at the implant site was reduced to 3 mm on the mesial aspect (a). No bleeding or purulent exudate was detected on probing. All periodontal biometric parameters are within normal limits. The patient did not report any symptoms and she was very pleased with the result of the previous surgery.
Fig 3 Patient 3. (a) Clinical view of a three-unit screw- and cement-retained fixed implant restoration on three implants positioned in native bone in the mandibular right sextant for 7 years. (b) A radiograph revealed a radiolucency of a higher degree at the intermediate implant and of a lower degree on the distal aspect of the mesial implant. (c) Buccal aspect and (d) lingual view of the peri-implant bony defects showing five and six exposed implant threads, respectively. (e) A reentry procedure was performed 11 months later for repositioning of the original fixed prosthesis. Newly regenerated bonelike tissue reaches the cover screw, indistinguishable from the host contiguous bone. (f) Clinical and (g) radiographic views at the 6-year follow-up showed stable outcomes.
The most frequently diagnosed bony defect is the combined lesion, a walled defect with an apical intrabony vertical component and a supracrestal noncontained coronal defect. GBR technique is the third decisive and crucial factor. Out of 57 implants, 47 were treated using a resorbable membrane (33 cases) and a nonresorbable one in the remaining 14 cases. In 6 of the last 10 cases, a connective tissue graft was utilized, replacing a membrane.

The rationale for using different types of membranes or connective tissue grafts includes blood clot protection, stabilizing the particulated graft material (mineralized, freeze-dried human bone allograft, and xenograft bone), maintaining space, and excluding soft-tissue ingrowth in the defect region.

This study does not report the same high long-term success rate of a previously published article by Froum et al., which had an average final postoperative follow-up time of 3.6 years. In the present article, 63% of implants had a long-term 5- to 10-year follow-up with higher number of implant loss, but with a success rate of 70.2%, mainly in average follow-up periods ≥ 5 years.

Fig 4 Patient 4. (a) Clinical and (b) radiographic views before treatment. The implants had been placed 8 years earlier in native bone. The mesial implant reports a 4-mm pretreatment defect depth on the distal aspect. The distal implant presents a prevailing horizontal component, compared with the vertical component, with a 5-mm pretreatment defect depth. (c) Buccal view at the 9-month reentry for abutment connection, after removal of the titanium-reinforced membrane. All space underneath the barrier membrane was completely filled with regenerated tissue. The two most coronal threads of the mesial implant were covered by connective tissue. A small vertical incision was made at the newly formed tissue, present in the inter-implant space, with the aim of appreciating the quantity and quality of this tissue. Moreover, this allowed clinicians to visualize the underlying calcified neoforming tissue. (d) Radiograph taken 9 years after regenerative peri-implantitis treatment.
This is in line with the outcomes reported by La Monaca et al., demonstrating progressively unstable values except for BoP; nevertheless, no implants were lost.

Regenerative surgeries must always follow a thorough patient selection and defect diagnosis. Furthermore, treatment outcomes are affected by the experience of the surgical team. Moreover, considering the chronic feature of peri-implant disease, like periodontitis, the clinician must predict a possible unstable condition over time.

Conclusions

This long-term retrospective study showed that, under a strict periodontal control, GBR procedures were effective in the treatment of moderate to advanced peri-implantitis lesions for the majority of the treated implants. Strict methods of implant-surface decontamination and detoxification were performed on all patients, regardless of implant surface characteristics.

Analysis of implant-based data revealed a success rate of 70.2% for a total of 40 implants. Recurrence of peri-implantitis was observed on 9 implants, and 8 implants, all with modified surfaces, were removed.

Complete resolution of peri-implantitis, defined as the absence of BoP and deep pockets at all sites, is not easy to achieve. Therefore, all clinicians faced with treatment vs explantation should not only assess an accurate diagnosis, but should also estimate patient-related factors in terms of subsequent additional single or multiple reconstructive surgeries, pain, and cost necessary to insert a replacement implant.

Acknowledgments

The authors declare no conflicts of interest.

References


Appendix

### Appendix Table 1 Patient Demographic Data

<table>
<thead>
<tr>
<th>Total patients, n</th>
<th>45</th>
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<tbody>
<tr>
<td><strong>Age, y</strong></td>
<td></td>
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<tr>
<td>Mean ± SD</td>
<td>64.1 ± 8.7</td>
</tr>
<tr>
<td>Range</td>
<td>47–88</td>
</tr>
<tr>
<td><strong>Gender, n (%)</strong></td>
<td></td>
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<tr>
<td>Male</td>
<td>10 (22.2)</td>
</tr>
<tr>
<td>Female</td>
<td>35 (77.8)</td>
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<tr>
<td><strong>Smoking habits, n (%)</strong></td>
<td></td>
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<tr>
<td>Smokers</td>
<td>19 (42.2)</td>
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<tr>
<td>Nonsmokers</td>
<td>26 (57.8)</td>
</tr>
<tr>
<td><strong>Periodontitis, n (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28 (62.2)</td>
</tr>
<tr>
<td>No</td>
<td>17 (37.8)</td>
</tr>
<tr>
<td><strong>Implant function time at the treatment, y</strong></td>
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<tr>
<td>Mean ± SD</td>
<td>8.2 ± 4.7</td>
</tr>
<tr>
<td>Range</td>
<td>2–23</td>
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<tr>
<td><strong>Follow-up time after treatment, y</strong></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>6.9 ± 3.4</td>
</tr>
<tr>
<td>Range</td>
<td>2–21</td>
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</table>

SD = standard deviation.

### Appendix Table 2 Characteristics of Patients and Implant Type

<table>
<thead>
<tr>
<th>Implant type</th>
<th>Patients, n</th>
<th>Implants, n (%)</th>
<th>Periodontitis,a n (%)</th>
<th>Smoking,a n (%)</th>
<th>Function time at the treatment, y Mean ± SD (range)</th>
<th>Follow-up time after treatment, y Mean ± SD (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turned</td>
<td>7</td>
<td>10 (17.5)</td>
<td>4 (57.2)</td>
<td>2 (28.6)</td>
<td>11.57 ± 6.5 (5–23)b</td>
<td>9.57 ± 5.13 (7–21)c</td>
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<tr>
<td></td>
<td></td>
<td>3 (42.8)</td>
<td>5 (71.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified</td>
<td>38</td>
<td>47 (82.5)</td>
<td>24 (63.2)</td>
<td>17 (44.7)</td>
<td>7.56 ± 3.98 (2–16)</td>
<td>6.39 ± 2.7 (2–13)</td>
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<td></td>
<td></td>
<td>14 (36.8)</td>
<td>21 (55.3)</td>
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</table>

a Turned vs modified implants, Pearson χ² test (P > .05).
b Turned vs modified implants, Mann-Whitney U test (P = .037).
c Turned vs modified implants, Mann-Whitney U test (P = .019).
### Appendix Table 3 Patient-Level Clinical and Radiographic Characteristics at Baseline and Follow-up

<table>
<thead>
<tr>
<th>Implant type</th>
<th>Patients, n (%)</th>
<th>Implants, n (%)</th>
<th>PD, mm</th>
<th>Bone level, mm</th>
<th>Baseline BoP, n (%)</th>
<th>Post-tx BoP, n (%)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Baseline</td>
<td>Post-tx</td>
<td>Baseline</td>
<td>Post-tx</td>
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<tr>
<td>All</td>
<td>45</td>
<td>57 (100)</td>
<td>7.2 ± 2.1</td>
<td>3.1 ± 1.8</td>
<td>7.7 ± 2.6</td>
<td>3.2 ± 2.8</td>
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<tr>
<td>Turned</td>
<td>7</td>
<td>10 (17.5)</td>
<td>7.4 ± 2.1</td>
<td>2.7 ± 1.3</td>
<td>8.2 ± 2.6</td>
<td>1.9 ± 2.0</td>
</tr>
<tr>
<td>Modified</td>
<td>38</td>
<td>47 (82.5)</td>
<td>7.3 ± 2.2</td>
<td>3.3 ± 1.9</td>
<td>7.8 ± 2.5</td>
<td>3.5 ± 2.9</td>
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PD = probing depth; tx = treatment; BoP = bleeding on probing.

### Appendix Table 4 Implant-Level Clinical and Radiographic Characteristics at Baseline and Follow-up by Treatment Outcome

<table>
<thead>
<tr>
<th>Treatment outcome</th>
<th>Implants, n (%)</th>
<th>PD, mm</th>
<th>Bone level, mm</th>
<th>BoP-positive, n (%)</th>
<th>Suppuration, n (%)</th>
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<tr>
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<td></td>
<td>Baseline</td>
<td>Post-tx</td>
<td>Baseline</td>
<td>Post-tx</td>
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<tr>
<td>Success</td>
<td>40 (70.2)</td>
<td>7.4 ± 1.9</td>
<td>2.7 ± 1.3</td>
<td>7.9 ± 2.4</td>
<td>2.0 ± 1.8</td>
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<tr>
<td>Failure</td>
<td>9 (15.8)</td>
<td>6.7 ± 1.7</td>
<td>4.8 ± 2.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.9 ± 2.7</td>
<td>6.6 ± 1.9&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Implant explantation</td>
<td>8 (14.0)</td>
<td>7.5 ± 3.5</td>
<td>6.6 ± 3.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.4 ± 3.7</td>
<td>8.9 ± 2.2&lt;sup&gt;c&lt;/sup&gt;</td>
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</table>

PD = probing depth; tx = treatment; BoP = bleeding on probing.

<sup>a</sup>P < .0001. Comparisons among the three groups (analysis of variance or Kruskal-Wallis test).

<sup>b</sup>P < .005. Comparison between successfully treated and failing implants (Tukey test or Dunn test).

<sup>c</sup>P < .005. Comparison between successfully treated and explanted implants (Tukey test or Dunn test).

### Appendix Table 5 Mean Soft Tissue Changes from Baseline to the Latest Follow-up Time

<table>
<thead>
<tr>
<th>MR, mm</th>
<th>KTW, mm</th>
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<tr>
<td></td>
<td>Baseline</td>
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<tr>
<td>All implants</td>
<td>0.5 ± 1.4</td>
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<tr>
<td>Turned</td>
<td>0.3 ± 0.5</td>
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<tr>
<td>Modified</td>
<td>0.6 ± 1.4</td>
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<tr>
<td>P</td>
<td>NS</td>
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MR = mucosal recession; KTW = keratinized tissue width; tx = treatment; NS = not statistically significant (P > .05).