Treatment of ligature-induced peri-implantitis defects by regenerative procedures: A clinical study in dogs


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Abstract: We carried out a clinical evaluation of the hard tissue fill following treatment of ligature-induced peri-implantitis in dogs. Four dogs were used and their mandibular premolars (P2, P3 and P4) were removed. After 3 months of healing, two titanium implants were placed on each side of the mandible. After 3 months, the abutment connection was performed, and experimental peri-implantitis was induced by placement of cotton ligatures in a submarginal position. The ligatures and abutments were removed after one month, and the peri-implant bone defects were assigned randomly to one of the treatments: debridement (control), debridement plus guided bone regeneration (GBR), debridement plus mineralized bone graft (BG), and debridement plus guided bone regeneration associated with a mineralized bone graft (GBR+BG). Clinical measurements of the peri-implant bone defects before and 5 months after treatment revealed no statistically significant differences between the defects treated by GBR, BG and GBR+BG. These 3 treatment methods provided more hard tissue fill than debridement alone (p < 0.05). Thus, it can be concluded that GBR, BG or a combination of the two techniques can enhance the hard tissue fill in defects caused by peri-implantitis in dogs. (J. Oral Sci., 41, 181-185, 1999)

Key words: peri-implantitis; regenerative procedures; PTFE membranes.

Introduction

Previous studies have documented the long-term predictability of osseointegrated dental implants (1). However, a significant number of early and late complications have been reported (2). Progressive bone loss around functioning dental implants is of special concern, since it can jeopardize the prognosis of the prostheses. The peri-implant destruction observed during the implant maintenance phase associated with clinical aspects of periodontitis (ie, redness, increased probing depth, suppurative, radiographic bone loss) is known as peri-implantitis. Some procedures reported for dealing with peri-implant bone defects resulting from peri-implantitis are antimicrobial, resective and regenerative therapies (3,4). As for any treatment modality, optimal treatment of peri-implantitis must include regeneration of lost alveolar support and assure that the regenerated bone is in direct contact with the implant surface previously exposed to contaminants. Guided bone regeneration, when applied to peri-implantitis defects, has resulted in some success; however, results of studies are inconclusive (5,6). Therefore, the purpose of the present study was to clinically evaluate hard tissue healing following treatment of experimental ligature-induced peri-implantitis using guided bone regeneration (PTFE membrane; NAPIO, Bauru, São Paulo, Brazil) alone or in association with a mineralized bone graft (Bio-Oss®: Osteohealth Co., New York, USA).

Materials and Methods

Four 2-year-old mongrel dogs were used in this study. As for any experimental procedure, the animals were premedicated with 1.5 ml/10 kg acepromazine. Surgical anesthesia was obtained by intravenous injection of 25% sodium thiopental solution (0.5 ml/kg) and supplemented with local administration of 2% xylocaine (1:50,000 epinephrine). At the beginning of the experiment, all mandibular premolars were removed. After 3 months of healing, full-thickness flaps were elevated and two commercially available pure titanium implants (Napio System®; Napio, Bauru, São Paulo, Brazil), 8.5 mm in length and 3.75 mm in diameter, were placed on each side of the mandible, followed by repositioning and suturing of the mucoperiosteal flaps.

Three months later, the mucoperiosteal flaps were elevated and titanium abutments positioned. Two weeks after the abutment connection, alginate impressions were taken (bilaterally) and occlusal acrylic stents were prepared for pretreatment and posttreatment measurements of the depth of the bone defects. The stents were reduced and polished for better adaptation. Six points were demarcated with a spherical burr on the surface of the stent: mesio-buccal, mid buccal, disto-buccal, mesio-lingual, mid lingual and disto-lingual. Cotton
ligatures were placed in a submarginal position around the abutments, and the dogs were fed with a soft diet to promote plaque accumulation and induce peri-implant inflammation with loss of bone. After 1 month of plaque accumulation, significant inflammation could be seen at the peri-implant mucosa (Fig. 1), and bone loss was detectable clinically and radiographically (Figs. 2 and 3). At this time, the ligatures were removed, and a plaque-control regime was initiated (hygienic phase) consisting of daily brushing and topical application of 0.12% chlorhexidine gluconate. In addition, systemic administration of metronidazole hydrochloride (250 mg/day) was established for 3 weeks.

Two weeks after the beginning of the hygienic phase, full-thickness flaps were elevated. The abutments were removed, and the granulation tissue around the implants was carefully removed using teflon hand curettes. The implant surface was treated with an air-powder abrasive instrument (Profi 1; Dabi Atlante, Ribeirão Preto, SP, Brazil) for 30 seconds.

The peri-implant bony defects were clinically evaluated (Fig. 4), and pretreatment extension of the defect, ie, the distance from the top of the stent to the bottom of the peri-implant bone defect, was recorded using an orthodontic wire (0.8 mm) and an electronic digital caliper (accurate to 0.01 mm) at six sites around each implant. All measurements throughout the study were made by the same examiner, who did not know the treatment applied for any implant.

Each defect was randomly assigned to one of the following treatments (Figs. 5 and 6):
1. debridement: control
2. debridement plus guided bone regeneration: GBR (PTFE membrane; NAPIO, Bauru, SP, Brazil)
3. debridement plus mineralized bone graft: BG (Bio-Oss; Osteohealth Co., New York, USA).
4. debridement plus GBR and BG

The flaps were repositioned and sutured, the systemic metronidazole administration (Flagyl®) was continued for the following week, and 0.12% chlorhexidine gluconate spray was topically applied for the next 5 months. After a healing period of 4 months, a flap was reflected, and the PTFE membranes were removed. Five months after the treatment procedures, ie, 1 month after the surgical procedure for removing the membranes, clinical parameters were measured. The experimental design (complete randomized block design) provided a total of 16 implants for statistical evaluation. Pretreatment and posttreatment clinical measurements from six sites around each implant were averaged to obtain a mean value for the peri-implant bone defect. One-way analysis of variance (ANOVA) was then performed for the pretreatment and posttreatment mean values, and this permitted comparison of the four treatments. If a significant difference between treatments was detected, the Bonferroni multiple comparison was performed to identify the difference.
Results

Clinical signs of peri-implant inflammation, redness and suppuration, were drastically reduced after 2 weeks of plaque control and systemic antimicrobial treatment. Exposure of the membrane was observed at only one site (see Fig. 8, GBR+BG group, animal 2). The membrane was not removed and the regimen of plaque control was maintained until the end of the experimental period.

At the time for sacrifice of the animals, 5 months after healing, newly regenerated tissue around the implants was evident for all the treatments performed (Fig. 7).

Comparison between pretreatment and posttreatment measurements revealed a significant but varied degree of hard-tissue fill for all treatment procedures, including debridement alone (Table 2).

The Bonferroni test failed to detect any significative differences (p > 0.05) between the true means of gain of new tissue. However, the F test (ANOVA) revealed greater hard-tissue fill for GBR+BG, GBR and BG than that observed for debridement alone (p < 0.05) (Table 2 and Fig. 7).

Fig. 7 Comparisons of hard-tissue fill (mm) between treatments. Control: flap debridement; GBR + BG: debridement plus guided bone regeneration and mineralized bone graft; GBR: debridement plus guided bone regeneration; BG: debridement plus mineralized bone graft.

Fig. 8 Comparisons of hard tissue-fill (mm) between treatments in each animal. Control: flap debridement; GBR + BG: debridement plus guided bone regeneration and mineralized bone graft; GBR: debridement plus guided bone regeneration; BG: debridement plus mineralized bone graft.
Discussion

Because late implant failures are relatively rare, the number of studies evaluating different treatment protocols for peri-implantitis is limited. Reducing inflammation at the peri-implant mucosa has been tried in many ways: subgingival irrigation of the peri-implant space with antiseptic agents (7), systemic antimicrobial treatment (8), and recently, treatment of peri-implant infection using controlled-delivery devices for the local application of tetracycline has been investigated (9). In the present study, as suggested by Hirzeler et al. (1995) (4), a combination of local and systemic treatment was used, and the clinical signs of peri-implant mucosa inflammation were reduced.

After reducing the inflammatory process around the implant, it is worth trying to re-establish osseointegration using regenerative procedures. An increasing number of studies have been tried to document the predictability of regenerative procedures to treat bone defects resulting from infection of the peri-implant mucosa. However the findings have been inconclusive. Grunder et al. (1993) (3) evaluated the treatment of ligature-induced peri-implantitis using guided bone regeneration and two bone grafts alone and in combination. They observed different degrees of hard-tissue fill for all treatment modalities. Guided bone regeneration and guided bone regeneration in combination with grafts resulted in the greatest fill.

In the present investigation, pretreatment and posttreatment clinical measurements revealed a variable degree of appreciable hard-tissue fill of the bone defects for all treatment procedures. The Bonferroni test failed to detect any significant differences (p > 0.05) between the true means of the degree of gain of new tissue. However, the F test (ANOVA) revealed evidence of greater hard-tissue fill for GBR+BG, GBR and BG than that observed for debridement alone (p < 0.05) (Table 2 and Fig. 7).

The procedures adopted for inducing and controlling peri-implantitis were very similar to those reported previously (4) and also resulted in chronic and circumferential bone defects around the implant. However, the peri-implant bone defects were different from those reported by Grunder et al. (1993) (3), probably because of the distance between the implants. The observation of a varied degree of tissue regeneration was in agreement with Hirzeler et al. (1995) (4), and confirms the importance of the morphology of the bone defects for obtaining tissue regeneration.

The idea that membrane exposure can jeopardize tissue regeneration around dental implants (5) seems to have been confirmed by the present investigation. This was observed at only one site exposed in the oral cavity (see Fig. 8, GBR+BG group, animal 2), and beside the rigorous plaque control, impairment of the amount of regenerated tissue around the implant was observed.

Incomplete surface decontamination seems to be another major obstacle for growth of bone onto a previously exposed implant surface. In the present study, it seems that the procedures used for eliminating contaminants of the implant surface were efficient, because although the implant surface was exposed to plaque accumulation, it did not imply an absence of new "bone" formation around the implant. On the limits of the present investigation, it can be concluded that the three regenerative techniques tested here provided a similar hard-tissue fill of the bony defect around dental implants exposed to contaminants.

The results obtained by those investigators were not in agreement with the findings of Dahlin et al. (1989) (10), Becker et al. (1991) (11) or Zablotsky et al. (1991) (12), who were successful in obtaining new bone around exposed implant surfaces. Possible reasons for not attaining similar results could be related to the fact that bone regeneration was attempted around plaque-contaminated implants, or because of premature membrane exposure or the type of bone defect. Hirzeler et al. (1995) (4) evaluated clinically and histologically the treatment of ligature-induced peri-implantitis using guided bone regeneration and two bone grafts alone and in combination. They observed different degrees of hard-tissue fill for all treatment modalities. Guided bone regeneration and guided bone regeneration in combination with grafts resulted in the greatest fill.

Table 1 Mean hard tissue fill (mm) and standard deviation (SD) according to treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>Mean ± SD (mm)</th>
<th>Range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4</td>
<td>0.81 ± 0.4121</td>
<td>1.46 - 0.55</td>
</tr>
<tr>
<td>GBR + BG</td>
<td>4</td>
<td>1.58 ± 1.1219</td>
<td>2.92 - 0.87</td>
</tr>
<tr>
<td>GBR</td>
<td>4</td>
<td>1.37 ± 0.8303</td>
<td>2.33 - 0.80</td>
</tr>
<tr>
<td>BG</td>
<td>4</td>
<td>1.60 ± 0.6262</td>
<td>2.36 - 0.84</td>
</tr>
</tbody>
</table>

n: sample;
Control: flap debridement;
GRB + BG: debridement plus guided bone regeneration and mineralized bone graft;
GRB: debridement plus guided bone regeneration;
BG: debridement plus mineralized bone graft.

Table 2 Bonferroni test of mean hard-tissue fill (mm) according to treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean ± SD (mm)</th>
<th>Mean Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.85 ± 0.4121</td>
<td>A</td>
</tr>
<tr>
<td>GBR+BG</td>
<td>1.58 ± 1.1219</td>
<td>A</td>
</tr>
<tr>
<td>GBR</td>
<td>1.37 ± 0.8303</td>
<td>A</td>
</tr>
<tr>
<td>BG</td>
<td>1.60 ± 0.6262</td>
<td>A</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not significantly different.

Parameters of Bonferroni test:
Alpha = 0.05, df = 9, MSE = 0.199485
Critical Value of t = 3.36
Minimum significant difference = 1.0625

F value (treatment) = 1.91 Pr > F : 0.1989 (ANOVA)
F value (control vs other modalities) = 5.50 Pr > F : 0.0439* (ANOVA)

* statistically different
is the general health of the individual patient for bone regeneration, and especially the condition of the area around the dental implants exposed to contaminants (see Fig. 8). Within the limits of this study it can be concluded that GBR, BG or the association of the two techniques can enhance the hard-tissue fill in defects caused by peri-implantitis in dogs. However, since the study had a small sample size, the findings should be considered with caution.

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REFERENCES