J Clin Periodontol 2007; 34: 723–727 doi: 10.1111/j.1600-051X.2007.01098.x

Journal of Clinical Periodontology

Submerged healing following surgical treatment of peri-implantitis: a case series

Ann-Marie Roos-Jansåker[1,2], Helena Renvert[1], Christel Lindahl[1,2], and Stefan Renvert[1,3]

[1]Department of Health Sciences, Kristianstad University, Kristianstad, Sweden; [2]Department of Periodontology, Public Dental Health Service, Kristianstad, Sweden; [3]School of Dental Sciences, Trinity College, Dublin, UK

Roos-Jansåker A-M, Renvert H, Lindahl C, Renvert S. Submerged healing following surgical treatment of peri-implantitis: a case series. J Clin Periodontol 2007; 34: 723–727. doi: 10.1111/j.1600-051X.2007.01098.x.

Abstract

Objectives: The aim was to study a regenerative surgical treatment modality for peri-implantitis employing submerged healing.

Material and Methods: Twelve patients, having a minimum of one osseointegrated implant with peri-implantitis, with a progressive loss of $\geqslant 3$ threads (1.8 mm) following the first year of healing were involved in the study. After surgical exposure of the defect, granulomatous tissue was removed and the implant surface was treated using 3% hydrogen peroxide. The bone defects were filled with a bone substitute (Algipore®), a resorbable membrane (Osseoquest®) was placed over the grafted defect and a cover screw was connected to the fixture. The implant was then covered by flaps and submerged healing was allowed for 6 months. After 6 months the abutment was re-connected to the supra-structure.

Results: A 1-year follow-up demonstrated clinical and radiographic improvements. Probing depth was reduced by 4.2 mm and a mean defect fill of 2.3 mm was obtained.

Conclusion: Treatment of peri-implant defects using a bone graft substitute combined with a resorbable membrane and submerged healing results in defect fill and clinical healthier situations.

Key words: bone substitute; peri-implantitis; resorbable membrane; submerged healing; surgical treatment

Accepted for publication 4 April 2007

Peri-implantitis is defined as an inflammatory reaction with loss of supporting bone around the implant (Albrektsson & Isidor 1994). The frequency of peri-implantitis has been reported in the range of 5–8% for selected implant systems (Berglundh et al. 2002). Similar figures are reported in a recent long-time follow-up study (Roos-Jansåker et al. 2006a). In a recent review, it was concluded that non-surgical therapy may result in resolving peri-implant lesions on a short-time basis (Roos-Jansåker et al. 2003). However, bone loss, and thereby exposure of threads often with rough surface structure, makes it clinically difficult to decontaminate the surface using conventional non-surgical treatment options (Kreisler et al. 2005, Schwarz et al. 2006a). The peri-implantitis defect has been described as crater or saucer shaped (Roos-Jansåker et al. 2003), and accessibility with available non-surgical methods seems difficult.

Different regenerative therapies have been tried to resolve peri-implantitis (for a review, see Roos-Jansåker et al. 2003, Schou et al. 2004). The concept of submerged healing was earlier reported as a treatment option for periodontally involved teeth (Björn et al. 1965). The idea is to allow for an undisturbed healing, reducing the risk of infection. Submerged healing has also been used as a treatment of peri-implantitis. Khoury & Buchmann (2001) reported an average bone fill of 1.7–2.5 mm using autologous bone transplants in the defects, and Schwarz et al. (2006b) in an experimental dog study concluded that submerged healing improved the healing outcome compared with non-submerged healing. Although most cases may not be suitable for surgical procedures involving submerged healing, clinical situations do occur when the infected implant is located in a way allowing for a submerged healing situation using the original supra-structure.

The aim of the present study was to evaluate surgical treatment of peri-implantitis using a bone graft substitute (Algipore®), covered with a resorbable membrane (Osseoquest®) in

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests.

This project was supported by research foundations from the Public Dental Health Service, County of Skåne, Sweden and Kristianstad University, Sweden.

a submerged healing situation. The main outcome variables for this study were probing depth (PD) reduction, probing attachment gain, mucosal recession (MR) and defect fill.

Material and Methods

Subjects

This study was approved by the Institutional Review Board, University of Lund, Sweden. All participating individuals signed an informed consent. Patients for this study were recruited from (i) individuals examined in a survey evaluating the prevalence of peri-implant lesions 9–14 years following placements of Brånemark implants and (ii) patients who had been referred to the Speciality Clinic of Periodontology, Public Dental Health Service and Kristianstad University, for treatment of peri-implantitis.

Twelve patients, having a minimum of one osseointegrated implant with peri-implantitis, defined as progressive bone loss of $\geqslant 3$ threads (1.8 mm) following the first year of healing, in combination with bleeding and/or pus on probing, were involved in the study. A total of 16 implants were treated.

Clinical and radiographic examination

All clinical and radiographic examinations were performed by the same examiner (author A.-M. R. J). Radiographs of implants were obtained in a standardized way, as described in a previous study (Roos-Jansåker et al. 2007). Pre- and post-operative films from the treated implants in all patients were coded and randomly mounted. A specialist in radiology made the measurements from the radiographs at completion of the study. The distance not supported by bone or bone substitute at the mesial and distal site of the implant was evaluated.

An update of the medical and dental history was made. The medical history included questions on smoking habits and reasons for tooth loss. If the patient had periodontal disease at any tooth, periodontal treatment was given before the peri-implant surgery was performed.

After removing the supra-structure the following measurements were performed:

- Probing depth (*PD*) measured in millimetre at four sites (mesial, buccal, distal and lingual) of each implant to the nearest millimetre using a standardized force of 0.25 N (Hawe Click-Probe®, KerrHawe SA, Bioggio, Switzerland) modified with a titanium probe tip graded in millimetre
- *Probing attachment level (PAL)* measured in millimetre from the abutment connection of the supra-structure at four sites.
- Mucosal recession (*MR*) calculated as the difference between PAL and PD at four sites (mesial, buccal, distal and lingual).
- *Bleeding index* measured at the implants after probing at four sites (mesial, buccal, distal and lingual), and graded (0–3): 0 = no bleeding, 1 = spot bleeding, 2 = line bleeding and 3 = profound bleeding.
- *Bleeding on probing (BOP)* measured at implants and teeth at four sites (mesial, buccal, distal and lingual).
- *Suppuration*, if apparent, following probing the sulcus.
- *Full-mouth plaque index* measured at implants and teeth at four sites (mesial, buccal, distal and lingual). Plaque was disclosed using an erythrosine dye (Top Dent Lifco Dental AB, Enköping, Sweden).

Surgical treatment

The patients were prescribed systemic antibiotics, Amoxicillin (375 mg × 3) in combination with Metronidazole (400 mg × 2) for 10 days, starting the day before surgery. In cases of allergy to penicillin, Clindamycin (300 mg) two times a day was prescribed.

The supra-structure was removed and the peri-implant lesion was surgically exposed. Following anaesthesia, a sulcular incision was made around the neck of the implant abutment, and full-thickness flaps were raised at the buccal and lingual surfaces to access the peri-implant defect. The abutment was removed and cleaned. After sterilization, the abutment was saved, to be used at the re-connection surgery at 6 months. All granulomatous tissue was removed in the bone defect using titanium instruments. The threads were carefully cleaned from mineralized calculus and the implant surface was cleansed using hydrogen peroxide (3%), followed by profuse rinsing with saline. A non-bovine-derived bone substitute available on the Swedish market (Algipore®, Friadent, Malmö, Sweden) was mixed with blood and placed in the defect. The transplanted area was covered by a resorbable membrane (OsseoQuest®, W.L. Gore & Associates Inc., Flagstaff, Arizona, USA). The membrane was punched, to be slipped over the implant, and trimmed to cover the defect completely (Fig. 1). A cover screw was connected to the fixture. Then the periosteum was cut, to allow complete wound closure and a stable wound area. The flaps were sutured with non-resorbable sutures (Gore 5–0, W.L. Gore & Associates Inc.). Submerged healing was allowed for 6 months.

Post-operatively, the patients rinsed with Chlorhexidine (0.1%) for 5 weeks. The first 3 days the patients were prescribed an anti-inflammatory drug (Ibuprofen, 400 mg × 3). All patients had to report on the use of antibiotics and the anti-inflammatory drug, and to comment

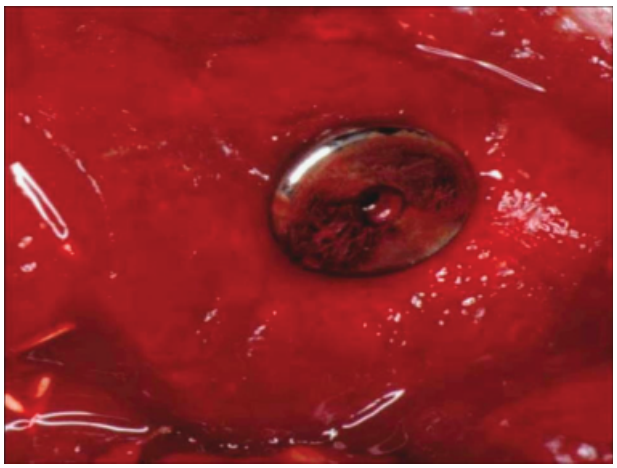

Fig. 1. Membrane placed over the grafted defect.

on any possible adverse events during the healing phase. The sutures were removed after 14 days. Clinically, fixture exposure, membrane exposure and presence of mucosal craters were registered.

After the initial healing phase, the patients were enrolled in a maintenance programme with visits to the dental hygienist every third month (author C. L.). Plaque was disclosed using an erythrosine dye (Top Dent Lifco Dental AB, Enköping, Sweden), and full-mouth plaque scores were obtained. The plaque chart was demonstrated to the patient, and re-motivation and re-instruction in oral hygiene procedures were performed if necessary. Teeth and implants were cleaned using a rubber cup and a low-abrasive paste. At 6 months the supra-structure was again disconnected (Fig. 2). After anaesthesia, a minimal incision was made over the submerged fixture to expose the cover screw. The cover screw was removed and the area was cleaned with saline before the abutment saved from the first surgery was replaced and the supra-structure replaced.

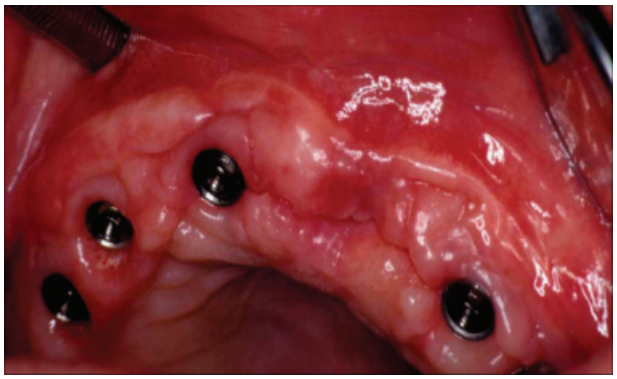

Fig. 2. Supra-structure disconnected after 6 months. Implant positioned in the region of 21 is submerged.

Table 1. Patient characteristics at baseline, $N = 12$

	$N = 12$
Age	64.4 ± 6.0 (56–75)
Female (%)	9 (75)
Current smokers (%)	8 (66.7)
Former smokers (%)	2 (16.7)
Never smoking (%)	2 (16.7)
Packyears (years)	38.6 ± 20.7 (6–75)
Smoking duration (years)	43.6 ± 9.0 (30–62)
Smoked after implant surgery (%)	9 (75)
Tooth loss due to periodontitis	
Yes	9 (75)
No	1 (8.3)
Do not know	2 (16.7)
No. of patients with bone loss ⩾4 mm on ⩾30% of teeth*	7 (77.8)
Teeth with bone loss ⩾4 mm (%)	63.8 ± 39.4 (13–100)
Edentulous	5 (41.7)
Implant age (years)	9.1 ± 2.4 (6–13)
PI	34.5 ± 27.1 (3–84)
BOP	63.2 ± 23.0 (33–100)

Means ± SD (range); numbers (%).
*Figures on nine patients (two patients with bone loss on <30% of their teeth and data missing on three patients due to long time edentulism).
BOP, bleeding on probing; PI, plaque index.

Results

The patient material is presented in Table 1. A majority of the patients were current or former smokers, with a smoking duration around 40 years. Total plaque and bleeding scores were 34.5% and 63.2%. Periodontitis defined as bone loss of ⩾4 mm at ⩾30% of the teeth at implant installation or total extraction was evident in seven of 12 patients.

The mean pocket depth at all sites at baseline was 5.1 mm. Pus occurred at 93.8% of the implants and 81.2% of the implants bled on probing. On implant level, the mean bone loss was 6.3 threads (3.8 mm) (Table 2).

Bleeding on probing at the deepest site was much less frequent at the 1-year

Table 3. Bleeding index score on probing at baseline and 1 year control, at deepest site, $N = 16$

Bleeding score	0	1	2	3
Baseline	25.0	6.3	50.0	18.8
1 year	87.5	12.5	0	0

Table 2. Baseline clinical measurements at implants, $N = 16$

	Mesial sites	Distal sites	Buccal sites	Lingual sites	Deepest site	Implant
PD*	5.3 ± 1.2 (1–3)	4.7 ± 1.7 (2–8)	5.8 ± 1.5 (3–8)	4.9 ± 1.5 (3–9)	6.4 ± 1.3 (4–9)	5.1 ± 1.6 (2–9)
Pus (%)†	52.9	35.3	82.4	23.5	69	93.8
BOP (%)‡	81.2	68.8	50	43.8	75	81.2
Bone loss§ (threads)	6.2 ± 2.0 (3–9)	6.4 ± 1.6 (4–9)	NA	NA	–	6.3 ± 1.8 (3–9)
Bone loss¶ (mm)	3.7 ± 1.2 (1.8–5.4)	3.8 ± 1.0 (2.4–5.4)	NA	NA	–	3.8 ± 1.0 (1.8–5.4)

Means ± SD (range); proportions (%).
*Probing depth.
†Pus on probing.
‡Bleeding on probing the implant sulcus.
§Number of threads not supported by bone on radiographs.
¶Each thread measures 0.6 mm.
NA, not applicable/unknown.

Table 4. Results of treatment after 1 year at deepest site, $N = 16$

PD reduction (mm)	PAL gain (mm)	MR (mm)	Defect fill (threads)	Defect fill (mm)
4.2 ± 1.5 (2; 7)	1.4 ± 1.7 (−2; 4)	−2.8 ± 1.4 (−6; −1)	3.8 ± 2.0 (1; 8.5)	2.3 ± 1.2 (0.6; 5.1)

Means ± SD (range).
MR, mucosal recession; PD, probing depth; PAL, probing attachment level.

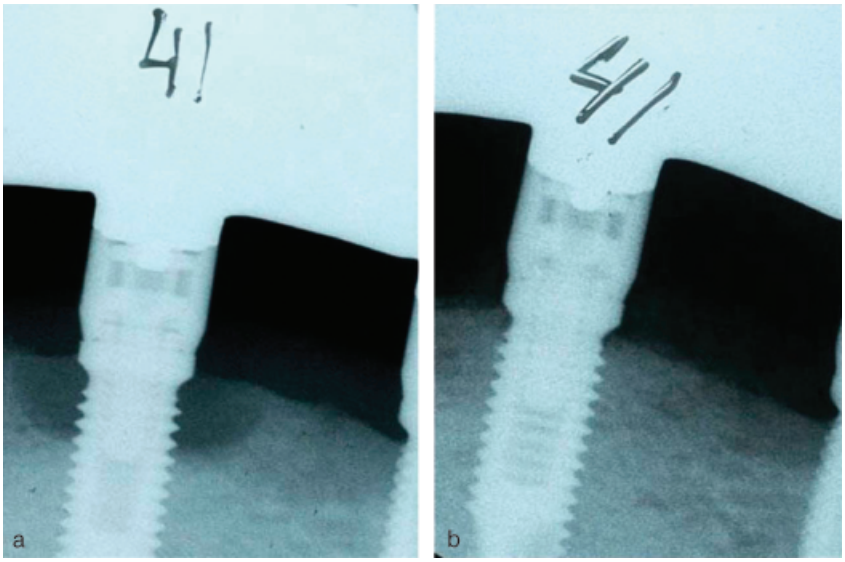

Fig. 3. (a) Radiograph demonstrating peri-implant bone loss before treatment. (b) One-year radiograph demonstrating defect fill.

examination as compared with baseline. At the 1-year examination, 87.5% did not demonstrate bleeding on probing (Table 3).

Clinical and radiographic effects of treatment are presented in Table 4. Mean pocket depth reduction was 4.2 mm, and mean defect fill was 2.3 mm. At the 1-year examination, 81% of the implants had a defect fill of $\geqslant 2$ threads ($\geqslant 1.2$ mm) at proximal sites (Fig. 3a and b). All implants had a defect fill of at least 1 thread (0.6 mm).

A good flap adaptation was accomplished, although in 25% of the sites complete wound closure was not achieved. Two weeks post-operatively, 62.5% implant sites demonstrated inadequate primary healing with the presence of soft tissue craters. At 2-week post-operative control, the resorbable membrane was visible in 31.3% of the implant areas and at 43.8% of the implants the cover screw was visible.

One patient reported postoperative pain, one patient reported allergic reaction to the antibiotic treatment and two patients reported swelling in the surgical area.

Discussion

In this clinical consecutive treatment study of peri-implantitis, surgical open flap debridement and placement of a bone substitute in combination with a resorbable membrane were evaluated, employing a submerged healing situation during the first 6 months.

The majority of patients in the present study were smokers and classified as periodontitis patients. Both smoking and periodontitis have been reported to be patient-related risk factors for peri-implantitis (Karoussis et al. 2004, Roos-Jansåker et al. 2006b). Accordingly, it is possible that the clinical outcome reported in this study was negatively affected by the fact that the majority of the patients were smokers.

The plaque index and bleeding scores improved after the treatment. At baseline bleeding scores 2 and 3 (line or profound bleeding) were found at about 70% of the deepest sites, and 1 year after treatment and bleeding scores of 2 and 3 were not present. The full-mouth bleeding score was 63% at baseline and 17% after treatment. The reduced bleeding scores after treatment in the present study indicate a healthier situation than before treatment.

The mean defect fill was around 4 threads (2.3 mm), with a range from 1 (0.6 mm) to 8.5 threads (5.1 mm). In a recent study by Roos-Jansåker et al. (2007), a similar surgical technique as in the present study was used in one of the groups, with the exception of the submerged healing pattern. The more favourable results obtained in the present study may accordingly be explained by the more undisturbed healing offered in the submerged model. It should, however, be kept in mind that the defects in the present study were somewhat deeper with deeper PDs at baseline. This could also have had an impact on the results. Evaluating submerged *versus* non-submerged healing, the data from this study indicate that it may be an advantage to accomplish undisturbed healing whenever this is possible.

Membrane and cover screw exposure were common complications in the present study. One possible explanation may be that the use of a cover screw and a membrane are space consuming, and thereby create additional tension to the flaps. Blanching in around 25% of the implant sites is also an indication that tension was introduced in the flaps, although the periosteum was cut before suturing. Soft tissue craters were a frequent finding, indicating inadequate primary healing. Many previous studies have reported membrane exposure as a complication following regenerative treatment of peri-implantits (Roos-Jansåker et al. 2003). Surgical technique and flap management have been proposed to influence the healing outcome following periodontal surgery (Cortellini 2006), and most likely this is also the case in trying to obtain regeneration around diseased implants. To perform surgery in peri-implantitis cases may be very difficult. Bone loss around the implants resulting in circumferential craters with granulomatous tissue firmly

attached to a non-keratinized mucosa is a demanding task for a surgeon to handle, and improvements in surgical techniques are desirable. However, in spite of the healing complications reported in this study, the clinical outcome as evidenced by PD reduction, probing attachment gain and defect fill was good.

It can be concluded that surgical treatment of peri-implantitis using a bone substitute and submerged healing resulted in defect fill and clinical improvements of peri-implantitis defects.

Acknowledgements

We acknowledge and thank Professor Ulf Strömberg, University of Lund for help with the statistic analyses, senior consultant in maxillofacial radiology Håkan Håkansson, Kristianstad Hospital, Sweden for help with examining the radiographs, senior consultant in prosthodontics Torgil Rundqrantz for help with removing the supra-structures in the first patients and dental technician Magnus Erlvik for modifying the probe.

References

Albrektsson, T. & Isidor, F. (1994) Consensus report of session IV. In: Lang, N. P. & Karring, T. (eds). *Proceedings of the First European Workshop on Periodontology*, pp. 365–369. London: Quintessence.

Berglundh, T., Persson, L. & Klinge, B. (2002) A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *Journal of Clinical Periodontology* **29** (Suppl. 3), 197–212.

Björn, H., Hollender, L. & Lindhe, J. (1965) Tissue regeneration in patients with periodontal disease. *Odontologisk Revy* **16**, 317–326.

Cortellini, P. (2006) Reconstructive periodontal surgery: a challenge for modern periodontology. *International Dental Journal* **56** (Suppl. 1), 250–255.

Karoussis, I., Müller, S., Salvi, G., Heitz-Mayfield, L., Brägger, U. & Lang, N. P. (2004) Assosiation between periodontal and peri-implant conditions. A 10-year prospective study. *Clinical Oral Implants Research* **15**, 1–7.

Khoury, F. & Buchmann, R. (2001) Surgical therapy of peri-implant disease: a 3-year follow-up study of cases treated with 3 different techniques of bone regeneration. *Journal of Periodontology* **72**, 1498–1508.

Kreisler, M., Kohnen, W., Christoffers, A. B., Gotz, H., Jansen, B., Duschner, H. & d'Hoedt, B. (2005) *In vitro* evaluation of the biocompatibility of contaminated implant surfaces treated with an Er: YAG laser and an air powder system. *Clinical Oral Implants Research* **16**, 36–43.

Roos-Jansåker, A. M., Renvert, S. & Egelberg, J. (2003) Treatment of peri-implant infections: a literature review. *Journal of Clinical Periodontology* **30**, 467–485.

Roos-Jansåker, A. M., Lindahl, C., Renvert, H. & Renvert, S. (2006a) Nine to fourteen year follow-up of implant treatment. Part II. presence of peri-implant lesions. *Journal of Clinical Periodontology* **33**, 290–295.

Roos-Jansåker, A. M., Lindahl, C., Renvert, H. & Renvert, S. (2006b) Nine to fourteen year follow-up of implant treatment. Part III. factors associated with peri-implant lesions. *Journal of Clinical Periodontology* **33**, 296–301.

Roos-Jansåker, A. M., Renvert, H., Lindahl, C. & Renvert, S. (2007) Surgical treatment of peri-implantitis using a bone substitute with or without a resorbable membrane: a prospective cohort study. *Journal of Clinical Periodontology* **34**, 625–632.

Schou, S., Berglundh, T. & Lang, N. P. (2004) Surgical treatment of peri-implantitis. *International Journal of Oral and Maxillofacial Implants* **19** (Suppl.), 140–149.

Schwarz, F., Papanicolau, P., Rothamel, D., Beck, B., Herten, M. & Becker, J. (2006a) Influence of plaque biofilm removal on establishment of the biocompatibility of contaminated titanium surfaces. *Journal of Biomedical Materials and Research A* **77**, 437–444.

Schwarz, F., Jepsen, S., Herten, M., Sager, M., Rothamel, D. & Becker, J. (2006b) Influence of different approaches on non-submerged and submerged healing of ligature induced peri-implantitis lesions: an experimental study in dogs. *Journal of Clinical Periodontology* **33**, 584–595.

Address:
Stefan Renvert
Department of Health Sciences
Kristianstad University
291 88 Kristianstad
Sweden
E-mail: stefan.renvert@hv.hkr.se

Clinical Relevance

Scientific rationale for the study: Limited information is available regarding bone regeneration after submerged healing of peri-implantitis lesions.

Principal findings: One year following surgery using a bone substitute and a resorbable membrane, clinical and radiographic improvements were achieved.

Practical implications: When submerged healing is possible, this method may be advantageous.