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Long-term stability of surgical bone regenerative procedures of peri-implantitis lesions in a prospective case–control study over 3 years

Ann-Marie Roos-Jansåker[1], Christel Lindahl[2], G. Rutger Persson[2,3,4] and Stefan Renvert[2,5,6]

[1]Department of Periodontology, Public Dental Health Service, Kristianstad, Sweden; [2]Department of Oral Sciences, Kristianstad University, Kristianstad, Sweden; [3]Departments of Periodontics and Oral Medicine, University of Washington, Seattle, WA, USA; [4]Department of Periodontology, University of Bern, Bern, Switzerland; [5]School of Dental Sciences, Trinity Collage, Dublin, Ireland; [6]Blekinge Institute of Technology, Karlskrona, Sweden

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Abstract

Objectives: To evaluate the extent of bone fill over 3 years following the surgical treatment of peri-implantitis with bone grafting with or without a membrane.

Material and Methods: In a non-submerged wound-healing mode, 15 subjects with 27 implants were treated with a bone substitute (Algipore®) alone and 17 subjects with 29 implants were treated with the bone substitute and a resorbable membrane (Osseoquest®). Implants with radiographic bone loss $\geq$ 1.8 mm following the first year in function and with bleeding and/or pus on probing were included. Following surgery, subjects were given systemic antibiotics (10 days) and rinsed with chlorhexidine. After initial healing, the subjects were enrolled in a strict maintenance programme.

Results: Statistical analysis failed to demonstrate changes in bone fill between 1 and 3 years both between and within procedure groups. The mean defect fill at 3 years was 1.3 $\pm$ (SD) 1.3 mm if treated with the bone substitute alone and 1.6 $\pm$ (SD) 1.2 mm if treated with an adjunct resorbable membrane, ($p = 0.40$). The plaque index decreased from approximately 40–10%, remaining stable during the following 2 years.

Conclusion: Defect fill using a bone substitute with or without a membrane technique in the treatment of peri-implantitis can be maintained over 3 years.

Key words: bone graft; defect fill; membrane; peri-implantitis; plaque index; surgery

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It is well established that peri-implantitis has an infectious aetiology. A complex biofilm around implants with peri-implantitis has been identified (Renvert et al. 2007, 2008, Shibli et al. 2008). The infection results in a pathology that includes soft tissue inflammation and loss of implant surrounding alveolar bone. In the progression of peri-implantitis, severe bone lesions with crater formed defect characteristics can be found (Schwarz et al. 2007). Data suggest that the prevalence of peri-implantitis is high (Roos-Jansåker et al. 2006a, Fransson et al. 2009, Koldsland et al. 2010). Data also suggest that within the same subject with peri-implantitis, the characteristics of the bony lesions are similar and that the rates of untreated lesions appear to increase over time (Fransson et al. 2010). There is no evidence that the implant surface characteristics influence the initiation of peri-implantitis (Renvert et al. 2011). Surgical treatment of peri-implantitis lesions with an intra-bony component has a favourable treatment outcome (Schwarz et al. 2010).

Non-surgical therapy of peri-implantitis does not seem to be efficacious (Schwarz et al. 2006b, Renvert et al. 2009, Persson et al. 2010). Surgical intervention and cleaning of implants with hydrogen peroxide and adjunct systemic antibiotics have demonstrated limited success over a 5-year period (Leonhardt et al. 2003).

Conflict of interest and sources of funding statement

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Resective surgery and implantoplasty of cases with peri-implantitis seems to be effective over a 3-year period (Romeo et al. 2005).

Different bone regenerative therapies have been used attempting to accomplish healing of peri-implantitis defects in humans. A useful surgical treatment modality including bone grafts covered by ePTFE membranes in animal with experimentally induced peri-implantitis is effective in the management of peri-implantitis (Schou et al. 2003, Fiorellini et al. 2007). Surgical treatment of circumferential defects around implants in humans using bone grafting and collagen membranes has been shown to be useful (Schwarz et al. 2009, 2010). Available data also suggest that surgical treatment of non-submerged implants with bony dehiscence can be treated successfully with a stiff non-resorbable membrane combined with a xenograft (De Boever & De Boever 2005).

Other studies in humans have shown that the surgical treatment of implants with bone lesions that were ≥ 4 mm and with circumferential crater defects can effectively be treated with a mixture of autogenous and xenogenous bone (Wiltfang et al. 2010). Almost complete bone fill in subjects with peri-implantitis treated with a surgical intervention using laser debridement and application of bone grafts with collagen membrane coverage has been demonstrated (Romanos & Nentwig 2008). These findings are supported by other studies demonstrating that the surgical treatment of peri-implant defects with bone graft substitutes combined with resorbable membrane methods and submerged healing or regenerative treatment with a bone substitute alone or in combination with a resorbable membrane in a non-submerged model results in defect fill (Roos-Jansåker et al. 2007). The aim of the present study was to evaluate the 3-year stability of defect fill after surgical regenerative therapy of peri-implantitis including the use of a bone graft material with or with a resorbable membrane in a non-submerged mode of wound healing.

Material and Methods

Study design

The study design was a human prospective case–control, single-blinded, longitudinal study comparing the radiographic outcome after 3 years.

Study population

The Institutional Review Board at the University of Lund, Sweden, approved the study. All participating individuals signed an informed consent. The CONSORT guidelines for clinical trials were followed (Fig. 1). Study subjects were recruited from (I) individuals examined in a survey evaluating the prevalence of peri-implantitis 9–14 years following placements of Brånemark implants (Brånemark system®, Nobel Pharma, Göteborg, Sweden) and (II) subjects who had been referred for the treatment of peri-implantitis to the Clinic of Periodontology, Public Dental health Services and University of Kristianstad, Sweden. The present paper is a follow-up report based on the publication by Roos-Jansåker et al. (2007).

Thirty-eight consecutive consenting subjects scheduled by the surgeon for surgical treatment of peri-implantitis were enrolled. In order to be included, the subject had a minimum of one osseo-integrated implant with peri-implantitis. In order to be included, the subject must have an implant demonstrating a progressive bone loss of ≥ 3 threads (≥ 1.8 mm) following the first year of healing (Renvert et al. 2007). In addition, bleeding on probing with or without suppuration must be present at enrolment. This is in agreement with the consensus report of the 7th European Workshop on Periodontology (Lang & Berglundh 2011). Furthermore, efforts must first have been to treat the condition using a non-surgical protocol, and that such treatments had failed. Subjects with radiographic evidence of horizontal bone loss only and without evidence of a vertical crater-like defect were not included.

All subjects had surgical regenerative treatment using a bone graft substitute (Algipore®, Friadent, Malmö, Sweden). The first 19 subjects were treated with the graft substitute that was covered with a resorbable membrane (Osseoquest®, W.L. Gore & Associates Inc., Flagstaff, AZ, USA). The next 19 subjects were treated with the bone graft substitute alone.

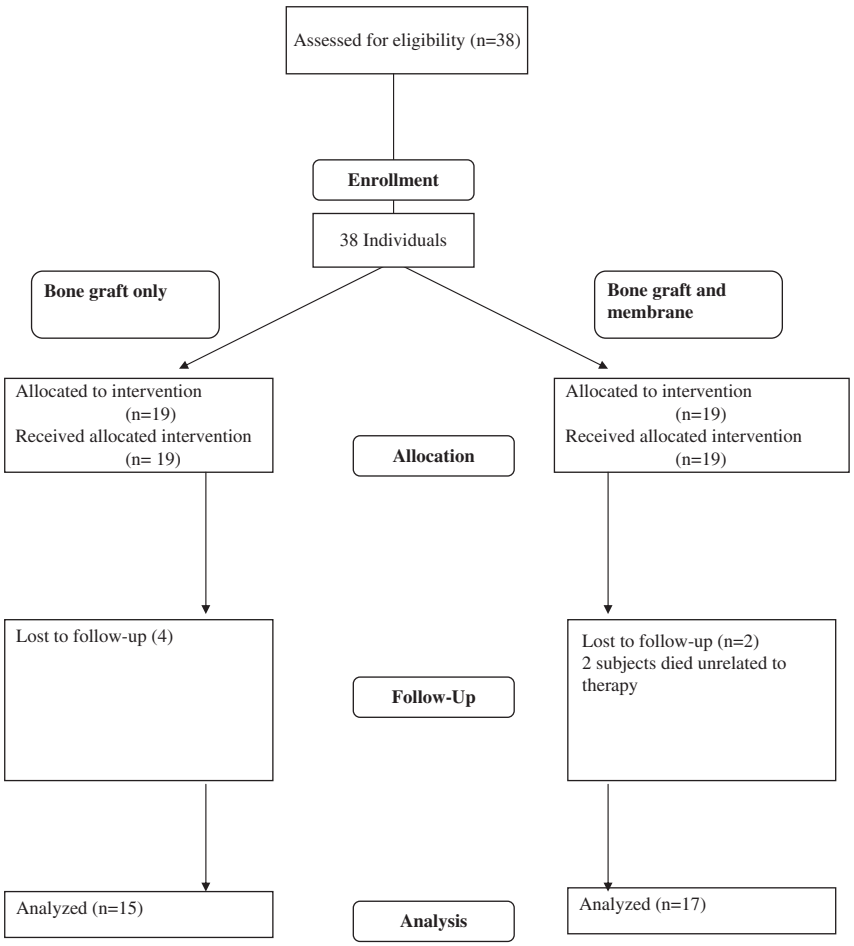

Fig. 1. CONSORT flowchart.

Clinical and radiographic examination

At baseline and year 3, the same examiner (A-M. R. J) performed the radiographic examinations. At the time of assessment of the radiographs, the examiner had access only to coded radiographs. Radiographs of implants were obtained using individually made bite-blocks on an Eggen holder (Renvert et al. 1981). The bite-blocks were made of Provil® Novo, Putty Soft (Heraeus Kulzer GmbH I, Hanau, Germany). The X-ray films (Kodak Insight, EKC, Rochester, NY, USA) were supported by the bite-block to avoid displacement and curving of the films. Attempts were made to place the film parallel to the long axis of the implant examined. During the exposure, the extension arm of the film holder was inserted into an acrylic track mounted on the long cone of the X-ray apparatus. Threads not supported by bone at the mesial and distal sites of the implants were assessed. Plaque index was defined as visible or not visible at the implant. Probing pocket depth measurements were deferred at year 3 as the superstructures remained in place. Hence, the values would not be comparable to the pre-surgical baseline.

Surgical treatment

The study population and the surgical techniques have been described in detail previously (Roos-Jansåker et al. 2007). All subjects received antibiotic coverage (amoxicillin 375 mg × 3 per day and metronidazole 400 mg × 2 per day) during the first 10 days following surgery. Briefly, following the removal of the supra-structure granulomatous tissue was removed. The exposed implant threads were carefully debrided, treated with hydrogen peroxide (3%), and rinsed with copious amounts of a saline solution. The osseous defects were filled with a bone graft substitute (Algipore®). Before insertion of the Algipore® bone fill material, the bone graft material was mixed with blood from the subject. The first 19 consecutive subjects had a resorbable membrane (Osseoquest®, W.L. Gore & Associates Inc.), placed over the filled defect. The following 19 consecutive subjects were treated with the bone graft substitute without a resorbable membrane. The abutments were then reconnected and the flaps were sutured with non-resorbable sutures (Gore 5-0, W.L. Gore & Associates) and the supra-structures were re-mounted. The wound healing was performed in a non-submerged mode.

During the first 5 weeks, all subjects rinsed with 0.1% chlorhexidine. During the first 3 days, all subjects also received an anti-inflammatory and analgesic drug (Ibuprofen 400 mg × 3 days). Six weeks after surgery, the first supportive therapy was given, and the subjects were enrolled in a maintenance programme with visits every third month. At the visits, full-mouth plaque scores were obtained. Plaque was disclosed using an erythrosine dye (Top Dent Lifco Dental AB, Enköping, Sweden). Re-instruction in oral hygiene procedures was performed as necessary. Teeth and implants were cleaned using a rubber cup and a low-abrasive paste. During the follow-up period, none of the subjects was prescribed antibiotics.

Statistical methods

Parametric tests (independent *t*-tests, equal variance not assumed) and non-parametric tests (Mann–Whitney *U*-test, Wilcoxon's test, and Pearson's χ^2) were performed to assess differences over time and between groups. Statistical significance was declared at $p < 0.05$. The Kolmogorov–Smirnov test was used to define whether the data presented with a normal distribution or not. The SPSS PASW 18.0 statistical software (SPSS Inc., Chicago IL, USA) for PC was used in the analysis.

Results

The subject characteristics at study baseline are presented (Table 1). At baseline, a total of 38 subjects were enrolled. Two subjects died before the 1-year control, leaving 17 subjects, with 29 treated implants in the group receiving bone graft and membrane treatment and 19 subjects with 36 treated implants in the group treated with bone graft alone. Four subjects in the group treated with bone graft alone were lost to follow-up during the 3-year period, leaving 15 subjects with 27 implants in this group after 3 years. In the present analysis, only the 32 subjects who returned to the follow-up examination and had radiographs taken could be assessed. During the present study period, no clinical complications as a result of the interventions were found in any of the subjects.

One subject in each group had received Astra implants (Astra Tech system®, Astra Tech, Mölndal, Sweden). These implants had the same thread distance between threads as for the Brånemark implants (0.6 mm); other

Table 1. Subject characteristics at study baseline (IDDM: diabetes mellitus)

		Bone graft only including 15 subjects		Bone graft and membrane including 17 subjects
Age	Mean	65.6	Mean	66.3
	SD	7.4	SD	6.7
	Range	54–76	Range	55–79
Gender	Female	57.9%	Female	58.8%
Years of education	Mean	9.3	Mean	9.1
	SD	3.6	SD	2.7
	Range	6–17	Range	6–15
Systemic conditions	Health	64.7%	Health	52.6%
	IDDM	5.9%	IDDM	10.5%
	Heart disease	17.6%	Heart disease	15.8%
	Other	11.8%	Other	21.1%
Current smokers		68.4%		70.6%
Never smoked		10.5%		5.9%
Number of smoke years	Mean	40.5	Mean	38.6
	SD	12.0	SD	15.9
	Range	0–57	Range	0–62
Tooth loss	Unknown	43.8%	Unknown	50.0%
	Periodontitis	56.3%	Periodontitis	50.0%
Teeth	Edentulous maxilla	94.1%	Edentulous maxilla	78.9%
	Edentulous mandible	41.4%	Edentulous mandible	26.3%
	Total edentulous	52.9%	Total edentulous	36.8%
% bone loss at teeth if present	Mean	69.5%	Mean	69.3%
	SD	27.8%	SD	35.5%
	Range	33–88%	Range	21–88%

subjects had received machined-surfaced implants (Brånemark system®, Nobel Pharma). Subject characteristics are presented (Table 1). Analysis by the Mann–Whitney *U*-test confirmed the lack of difference by study method.

The radiographic evidence of defect mean improvement with defect fill between baseline and year 3 at implants treated with bone graft and membrane was a mean gain of 1.6 mm (S.D ± 1.2 mm, range: −1 to +7) (Figs 2 and 3). The corresponding improvement with defect fill at implants treated with bone graft alone was a mean gain of 1.3 mm (SD ± 1.3, range −2 to +6 threads) (NS). Statistical analysis failed to demonstrate differences in the extent of defect fill (mean difference: 0.3 mm, SE difference: 0.3 mm, 95% CI: −1.0 to +0.4 mm, $p = 0.34$). In the group treated with bone graft material and membrane, a total of 15 implants (51.7%) had a defect fill ≥ 1.8 mm. In the group treated with bone graft alone, a total of 12 implants (44.4%) gained >1.8 mm in defect fill.

When the data based on radiographic assessments between baseline and year 3 were dicotomized as either (I) no change/more implant threads exposed or (II) bone gain with fewer threads exposed at year 3, statistical analysis (Pearson's χ^2) failed to demonstrate a difference in bone changes as a result of treatment modality ($p = 0.89$). The distributions of bone-level changes in the two study groups between baseline and year three after surgery are presented (Table 2).

Statistical analysis failed to demonstrate differences in the extent of defect fill both with regard to the number of threads filled and defect fill in mm by study group assignment. The distributions of bone-level changes in the two study groups between baseline and year 3 after surgery are presented (Table 3).

Analysis by the Mann–Whitney *U*-test failed to demonstrate a difference in bone fill between year 1 and year 3 between the two study groups ($p = 0.36$). Within each study group, related samples Wilcoxon's signed rank test failed to demonstrate a difference in bone fill between year 1 and year 3 in the group receiving bone graft alone ($p = 0.18$) or in the group treated with bone fill and membrane ($p = 0.42$).

Bone fill mean values, SD, and range of fill are presented (Table 4).

Non-parametric Wilcoxon's test identified that the plaque index continued to improve between year 1 and year 3 after surgery ($p = 0.02$). Statistical analysis (Mann–Whitney *U*-test) failed to demonstrate differences in this change of plaque scores by intervention ($p = 0.43$). The distributions of changes in the mean % plaque scores at various time points up to year 3 are presented (Fig. 4).

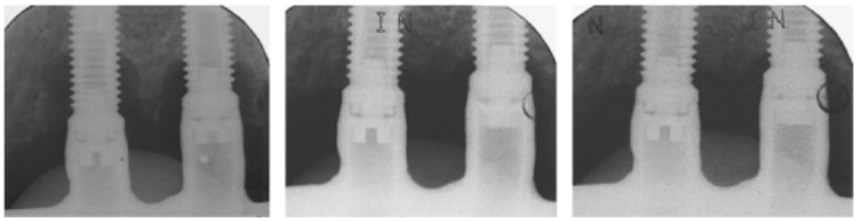

Fig. 2. Examples of radiographs taken from one subject at baseline, year 1, and year 3 after follow-up.

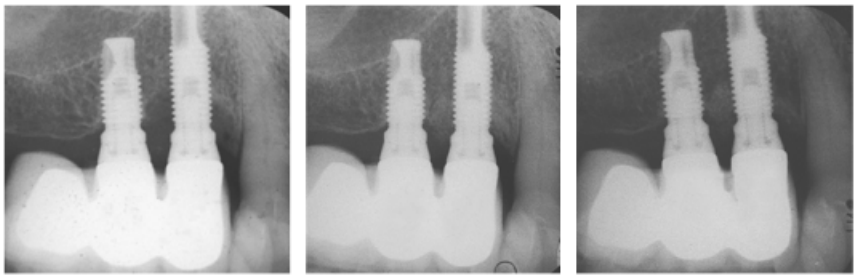

Fig. 3. Example of radiographs taken from another subject at baseline, year 1, and year 3 after follow-up.

Table 2. Defect changes between baseline and year 3 after surgery (implant level)

Bone-level change (mm)	Bone graft and membrane including 29 implants		Bone graft alone including 27 implants	
	number	%	number	%
−1.2	0	0	1	4
−0.6	2	7	2	7
0.0	3	10	4	15
0.6	2	7	3	11
1.2	4	14	5	18
1.8	6	21	4	15
2.4	5	17	2	7
3.0	5	17	4	15
3.6	0	0	2	7
4.2	2	7	0	0

Table 3. Defect changes between year 1 and year 3 of follow-up after surgery (implant level)

Bone-level change (mm)	Bone graft and membrane including 29 implants		Bone graft alone including 27 implants	
	number	%	number	%
−1.8	1	3	0	0
−1.2	0	0	0	0
−0.6	1	3	1	4
0.0	21	73	24	89
0.6	3	10	0	0
1.2	2	7	1	4
1.8	1	3	0	0
2.4	0	0	1	4

Examples of treatment outcome at year 3

Background clinical information and radiographs from before treatment of peri-implantitis and at year 3 are presented for one selected case defined as a non-responding case and from one case

Table 4. Results of treatment at the implant level observed after 3 years compared with 1 year for implants treated with bone graft and membrane, or bone graft alone

Variable	Bone graft and membrane		Bone graft alone	
	mean SD	range	mean SD	range
Defect fill (number of threads)	0.2 ± 0.9	2.5–3.0	0.2 ± 0.8	3.5–1.0
Defect fill (mm)	0.1 ± 0.5	1.5–1.8	0.1 ± 0.5	2.1–0.6

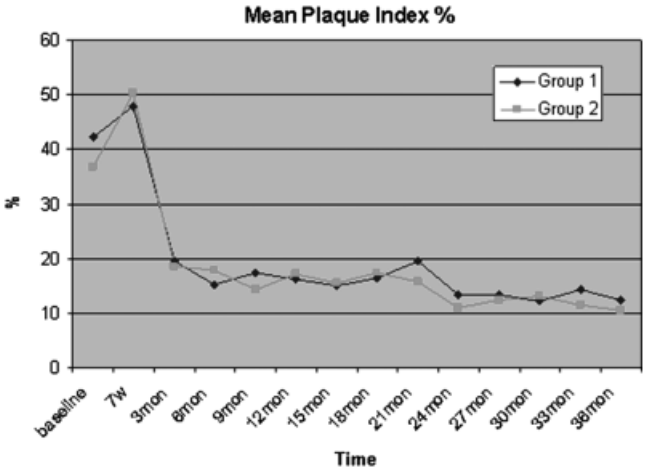

Fig. 4. Mean plaque index from baseline to 3 years in Group 1 (bone graft substitute+membrane) and Group 2 (bone graft substitute).

defined as successfully treated (Table 5). Intra-oral radiographs taken immediately before and at 3 years after the surgical treatment of peri-implantitis representing a non-responding treatment outcome (Fig. 5a and b) and a successfully treated case (Fig. 6a and b) are shown. In these cases, the immediate postoperative wound healing was uneventful. The maintenance protocol was highly effective as illustrated by the low plaque scores during the study period.

Discussion

In a previous report, 1-year data following surgical treatment of peri-implantitis using a bone graft substitute demonstrated that the clinical conditions and radiographic conditions had improved (Roos-Jansåker et al. 2007). These results had occurred in spite of the fact that a majority of the subjects included were smokers and with a past history of periodontitis (Roos-Jansåker et al. 2007). It has been discussed previously that a smoking history and having a history of periodontitis can negatively influence the outcome of surgical treatment and reconstruction of defects around dental implants (Karoussis et al. 2004, Roos-Jansåker et al. 2006b, Máximo et al. 2008). Smoking has also been considered as a risk factor during wound healing following implant placement (Sadig & Almas 2004). The fact that smoking may have a negative influence on regenerative procedures in the management of periodontitis is well established (Tonetti et al. 1995, Rosen et al. 1996, Mayfield et al. 1998, Trombelli et al. 1997, Kornman & Robertson 2000). It is therefore of interest that also in smokers, the use of a bone graft material placed in bone defects around implants can remain stable at 3 years after intervention. Our findings are consistent with the results reported elsewhere using bone substitutes in a non-smoking study population (Schwarz et al. 2008).

Subjects with a history of periodontitis and specifically in men with dental implants appear to be at risk for peri-implantitis. A history of smoking may be of less significance as a risk factor for peri-implantitis (Koldsland et al. 2011). In spite of the accrued risk factors in the present study population, it should be emphasized that both surgical study modalities resulted in a successful 3-year outcome of surgical treatment re-establishing bone fill around implants with a previous history of peri-implantitis.

The importance of plaque control after periodontal therapy and supportive therapy has been described extensively (i.e. Nyman et al. 1975, 1977, Rosling 1983, Rosling et al. 2001). In the present study, the post-surgical management was focused on a strict oral hygiene programme that continued during the study. Thus, the overall average plaque score at year 3 was very low. This may explain the good results reported. In a previous study using non-surgical management of peri-implantitis, it was not possible to reach a similar oral hygiene level, which in part may explain the less favourable clinical outcome (Renvert et al. 2009, Persson et al. 2010). It is possible that the surgical intervention in this study resulted in an improved soft tissue architecture after wound healing-facilitating oral hygiene measures. This may, in part, explain the differences in plaque control efficacy in the present surgical intervention study compared with the non-surgical intervention reported in previous papers. Nevertheless, other studies using surgical intervention in non-smokers with peri-implantitis reported higher plaque scores. However, they also reported a gradual deterioration of the primary results obtained (Schwarz et al. 2006a). Plaque scores higher than those reported in the present study have also been reported in a long-term retrospective study (Matarasso et al. 2010). Thus, the surgical procedure and the wound healing may not be effective without good plaque control during the follow-up period.

The present follow-up study, 3 years after surgical intervention comparing a bone substitute with or without the adjunct treatment with a resorbable membrane, demonstrated that the additional effort to obtain stability did no seem to result in enhanced 3-year results as assessed by radiographs. Our results are consistent with those reported from studies of experimental healing in dogs (Nociti et al. 2000) or in a non-human primate model (Schou et al. 2003). It is possible that the use of a bone graft with the additional placement of a membrane may be more efficient in specific bone lesions around implants (Schwarz et al. 2010). Although somewhat better results have been presented in a 10-year follow-up clinical trial using bone grafts with the adjunct use of resorbable membranes in comparison with not using such membranes, the clinical relevance appeared to be negligible

Table 5. Characteristic findings for two cases illustrating either a non-responding or a responding outcome of surgical treatment of peri-implantitis, and with an observation period of 3 years

Variables	Non-responding case	Responding case
Gender and age	Male, 68 years	Female, 69 years
Medical/smoking	Diabetes mellitus (type II), Former smoker	No systemic diseases reported Former smoker
Periodontal therapy	No case history	Periodontal therapy in the past
Peri-implantitis	Previous treatment at other implants	Previous treatment for peri-implantitis at this location
Implant (location and years in function	24, 10 years	14; 5 years
Probing pocket depth	Mes: 4 mm, buc: 4 mm Dist: 4 mm, pal: 4 mm	Mes: 6 mm, buc: 5 mm Dist: 5 mm, pal: 6 mm
Bone sounding	Mes: 7 mm, buc: 8 mm Dist: 8 mm, pal: 6 mm	Mes: 10 mm, buc: 12 mm Dist: 10 mm, pal: 11 mm
Surgical procedure	Open flap debridement with Algipore® treatment without membrane technique, antibiotic coverage	Open flap debridement with Algipore® treatment without membrane technique, antibiotic coverage
Baseline thread exposure (X-ray)	Mes: 6 threads and dist: 6 threads	Mes: 4 threads and dist: 5 threads
Threads exposed at surgery	Mes: 6, buc: 7 dist: 7, pal: 7	Mes: 3, buc: 6, dist: 6, pal: 7
Horizontal destruction at surgery	Mes 3 mm, buc: 5 mm Dist: 2 mm, pal: 5 mm	Mes: 0 mm, buc: 5 mm, Dist: 0 mm, pal: 3 mm
Vertical destruction assessed at surgery (depth)	Mes: 2 mm, buc: 0 mm dist: 3 mm, pal: 0 mm Circumferential	Mes: 3 mm buc;0 mm, dist: 1 mm, pal: 2 mm Circumferential
Year 3 mesial thread exposure (X-ray)	6	0
Year 3 distal thread exposure (X-ray)	6	0
Buccal mucosa baseline	Non-keratinized, no change to year 3	Keratinized 3 mm, no change to year 3
Mucosal recession baseline	Buccal: 4 mm, pal: 2 mm	
Bacterial findings at the time of surgery	Enterococci positive Antibiotic resistance consistent with Pseudomonas infection	*Staphylococcus epidermis*, *Fusobacterium nucleatum*, *Streptococcus sanguinis*
Bacterial findings at year 3	Negative	Negative
Oral hygiene	Excellent, plaque scores on average $<10\%$	Excellent plaque scores on average $<10\%$

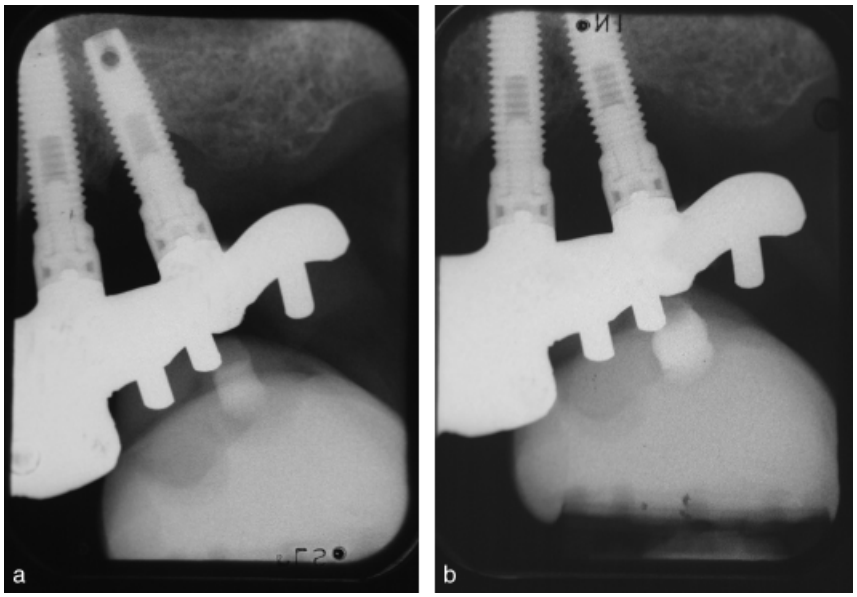

Fig. 5. (a) Baseline radiograph illustrating the alveolar bone conditions at the implant (replacing tooth 24) at a non-responding defect. Notice the number of implant threads not supported by bone and the crater defect. The opaque area visible on the radiograph is part of the stent used to standardize the positioning before image exposure. Clinical details are presented in Table 5. (b) Radiograph from year 3 after surgical intervention and placement of bone graft material illustrating the alveolar conditions at the implant (replacing tooth 24) at a non-responding defect, and similar extent of bone defect and implant threads exposed as at baseline. Notice the number of implant threads not supported by bone and the crater defect. Clinical details are presented in Table 5.

(Nygaard-Østby et al. 2010). The study by Nygaard-Østby et al. (2010) also identified that the resolution of deep intra-bony periodontal defects requires a structured maintenance programme emphasizing high oral hygiene standards.

In the present study, the extent of bone fill obtained at 1 year after surgical treatment using either a bone graft alone or a bone graft and a resorbable membrane could be maintained up to 3 years after treatment. Thus, provided oral hygiene is excellent, both procedures resulted in a clinically relevant defect fill. A pre-requisite for a successful treatment outcome might also be the anatomy of the bone defect. A well-defined crater-like defect might be the most reliable factor for stable conditions.

The limitation of using the radiographic assessment method used in the present study is obvious. The radiographic evaluation does not allow distinguishing between osseo-integration of the graft in direct contact with the implant or if the bone graft simply remains as a defect fill. However, in comparison with the 1-year results (Roos-Jansåker et al. 2007), the present

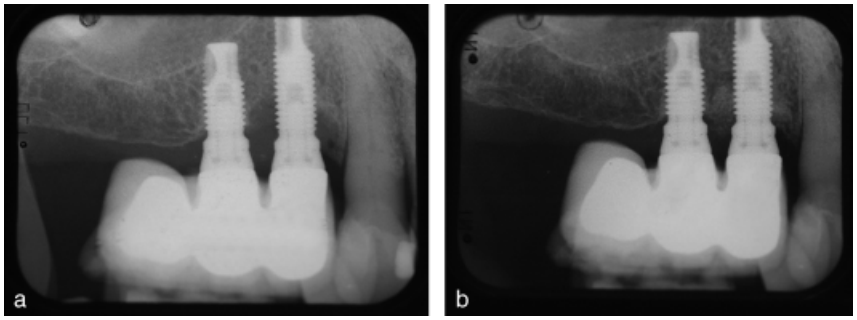

Fig. 6. (a) Intra-oral radiograph from baseline illustrating the alveolar bone conditions at the implant (replacing tooth 14). Notice the number of implant threads not supported by bone and the crater defect. Clinical details are presented in Table 5. (b) Radiograph from year 3 after surgical intervention and placement of bone graft material illustrating the alveolar conditions at the implant (replacing tooth 14), and in principle, complete fill of crater defect with bone fill material used. Notice that no threads are exposed. Clinical details are presented in Table 5. The image suggests that the lesion has been filled with radiopaque material and this should not be interpreted as bone regeneration or ''osseo-integration''.

findings at 3 years demonstrated stable results without progression of bone loss. Our results are consistent with histological results obtained from animal studies demonstrating that hard tissue fill and osseo-integration can occur in experimentally created defects around implants (Abushahba et al. 2008). This would also be the result at implants previously exposed to an infectious biofilm. It has also been demonstrated in animal studies that it is possible to obtain re-osseointegration on previously infected implant surfaces (Alhag et al. 2008).

The two cases identified with the similar age and clinical conditions, albeit of different genders, represent examples of a successful and a non-successful treatment outcome of circumferential advanced lesions at implants placed in the maxilla. Both subjects had had a previous history of peri-implantitis at the same or other implants, and both of them were former smokers. At the time of surgical intervention in the study, the clinical conditions were similar in both cases. The presence of circumferential defects with a significant vertical component was, in both cases, suitable for the assigned therapy. The study treatment was the same in both cases using a bone graft material without membrane coverage. Both subjects complied with the post-surgical instructions and maintained excellent oral hygiene. The differences identified between the two cases were that the subject with a non-successful outcome had a medical diagnosis of diabetes mellitus and clinical lack of keratinized and attached mucosa at the buccal aspect of the implant in treatment. Furthermore, the infection at the implant appeared to harbour pathogens that are commonly therapy resistant. The present observations from these two cases and the observations made should only be used to spur further studies on the role of keratinized attached tissues, systemic health, and local infection in relation to therapy in cases with peri-implantitis.

In conclusion, defect fill obtained at 1 year after surgical treatment with a bone graft and membrane or with a bone graft alone remains stable between 1 and 3 years in cases on maintenance care.

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

Clinical Relevance

Scientific rationale for the study: Limited information is available regarding the long-term prognosis of regenerative treatment of intraosseous defects following surgical treatment of peri-implantitis lesions in humans.

Principal findings: Over a follow-up period of 3 years, a similar extent of radiographic evidence of bone fill following placement of a bone graft material with or without the concomitant use of a resorbable membrane in osseous defects adjacent to implants was identified. No changes were observed between year 1 and year 3 and both procedures appear to provide stable results with regard to radiographic evidence of bone fill.

Practical implications: Bone fill obtained following the surgical treatment of peri-implantiits lesions can be obtained, and remains stable if subjects comply with supportive therapy visits and maintain good oral hygiene.