Surgical Reconstruction of Peri-Implant Bone Defects with Prehydrated and Collagenated Porcine Bone and Collagen Barriers: Case Presentations

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ABSTRACT

Background: Surgical reconstruction of peri-implant defects is challenging and unpredictable due to, for example, the extent of the bone defect or the osteogenic potential of adjunctive materials used.

Purpose: To study the healing capacity of a new bone xenograft material in the treatment of peri-implant defects.

Material and Methods: In three cases with advanced peri-implant defects, flap surgery was performed. After thorough debridement including cleaning of the exposed implant surface, prehydrated and collagenated porcine bone (PCPB) particles were placed into the defect. A bioresorbable collagen barrier was adapted and placed over the defect and the flaps were relocated. After 6 and 12 months of healing, clinical and radiographic examinations were done. In one case, the surgical procedure was repeated 6 months postoperatively. One year after the second surgery, a bone biopsy was harvested and analyzed with histology.

Results: All defects healed uneventfully. At 6 months, probing depths were reduced by 3–4 mm with no bleeding on probing or pus formation. At 12 months, healthy peri-implant conditions were found. Intra-oral radiographs showed gain of the marginal bone level by 2–4 mm. In the case where reconstructive surgery was repeated, histology showed osteoconductive properties as bone formation with typical osteoblastic seams was observed directly on the surface of the grafted particles.

Conclusion: The presented cases show that PCPB have favorable properties enhancing bone regeneration in peri-implant bone defects.

KEY WORDS: bone substitute, peri-implantitis, xenogeneic bone, xenograft

INTRODUCTION

Since the advent of oral implant treatment in the 1970s, an increasing number of patients and implants is accumulating, increasing the number of implants at risk for biological complications.[1] Plaque accumulation around implants over time may lead to bleeding on probing/pus formation and loss of marginal bone, and has been reported to occur in 12–43% of the implant sites.[2] Also, early bone loss as a result of bone remodeling or trauma to the bone tissue during surgery is another reality and may predispose to secondary peri-implant infection.[3] Treatment of such conditions aims to control infection, arrest inflammation, and prevent further bone loss.[4] However, the precise treatment approach is not well documented[5] and remains a challenge for the clinician.[6] In many situations, surgery is necessary to get access to clean the implant surface and debride the surrounding bone defect.[4,7,8] At present, no single surgical technique has yet been designated as the treatment of choice.[5,9,10] To date, only one study has reported results of open flap debridement.[6] This treatment was combined with

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systemic antibiotics in 9 patients and 26 implants. Healing was obtained in 15 of the implants, while 7 implants were lost and 4 showed further bone loss and residual pocket depths. Resective therapy, aiming at osseous recontouring, and apical positioning of the flaps to minimize peri-implant pocket depths[11] is not always preferable, especially in the esthetic zone. Therefore, a reconstructive approach to surgically gain peri-implant bone tissue may be desirable in situations with advanced bone breakdown. However, various amounts of bone gain have been found in animal studies[9,12] although some studies have shown better results of regenerative treatment of sites at rough implant surfaces.[13] The clinical evidence to support this approach at present is considered weak,[5,9,10] and is mainly based on case reports/series[14–19] and a few controlled studies.[20–24]

Over the years, various techniques have been proposed to achieve reestablishment of lost peri-implant bone. Barrier technique has been shown to reduce defect depth in case presentations.[16,17] Some reports have shown enhanced outcome with a combination of barriers and autogenous bone grafts in animal experiments[25] as well as in humans.[15,19] In contrast, Khoury & Buchmann[20] failed to demonstrate that adjunctive use of barriers improved the outcome of autogenous bone grafting.

A wide variety of bone substitutes for regenerative/reconstructive purposes are available on the market. Among these, xenogeneic bone in general and bovine bone mineral in particular, for example Bio-Oss® (Geistlich AG, Wolhusen, Switzerland), is also frequently used for peri-implant surgical reconstruction. These materials are mostly mineralized and deproteinized, showing good integration with surrounding bone.[26–28] However, the mineralization rate of the newly formed contigious osteoid is claimed to be slow.[29,30] In addition, studies have shown slow or no resorption of the implanted bovine bone mineral over time.[26,31] In a randomized clinical study, Schwarz et al.[22,24] compared surgical treatment peri-implant defects with Bio-Oss® or HA crystals and found significant differences in favor of Bio-Oss®.

Recently, a xenogeneic, prehydrated and collagenated porcine bone (PCPB) substitute has been introduced on the market. Preclinical studies have shown excellent integration with bone and also a high remodeling rate due to stimulation of osteoclast formation.[32,33] Clinical reports on maxillary sinus bone augmentation with PCPB have demonstrated considerable gain of new bone[34] and also indicated early mineralization of augmented bone.[35] Also, these studies have shown that with time, the material is being resorbed and, hence, being replaced by newly formed bone.[33–35]

The aim of this case report was to evaluate the healing capacity of PCPB material in the surgical reconstruction of long-standing chronically infected peri-implant defects.

MATERIALS AND METHODS

Bone Mineral

PCPB particles (granulometry 250–1000 mm, Mp3®, Tecnoss, Turin, Italy) were used as defect-filling material.

Bioresorbable Barriers

A bioresorbable collagen barrier, Bio-Gide® (Geistlich AG, Wolhusen, Switzerland) were used to cover the defects and the implanted bone mineral.

Patients

The study protocol was approved by the Ethical Research Committee at Linköping University, Sweden (Dnr M147-08). Three patients referred to the Department of Periodontology at the Institute for Postgraduate Dental Education, Jönköping, Sweden for treatment of advanced peri-implant infection and bone loss around one or more implants participated in this case study. They were thoroughly informed about the treatment and the follow-up procedure and gave written consent to participate. In all, four implants showing various degrees of marginal bone loss were treated (one implant in two patients and two implants in one patient). Initially, the patients were instructed in proper oral hygiene technique and the diseased peri-implant areas were debrided. After re-evaluation, it was decided to perform surgery and the patients were enrolled in the study.

Clinical Assessments

Immediately before the surgical procedure, presurgical baseline recordings were assessed – probing pocket depth (PPD), bleeding on probing (BoP), and pus formation. These recordings were repeated 6 and 12 months after treatment. The examination during surgery comprised of measurements of the depth and the width of the peri-implant defects. All measurements

were done with a mm-graded periodontal probe (PCP-UNC 15, Hu-Friedy, Chicago, IL).

Radiographic Assessments

Intra-oral radiographs were obtained by parallel standardized technique at baseline, 6 and 12 months postoperatively.

Surgical Procedure

After local anesthesia, buccal and lingual full-thickness flaps were raised. The defects were meticulously debrided, and the implant surfaces were cleaned with 3% hydrogen peroxide and saline. Mp3® was applied into the defects. The Bio-Gide® barriers were adjusted and placed to cover defects and implants, and extended approximately 2 mm beyond the defect margins. In one case (patient 2), the implants were submerged after flap suturing. In the other two patients (patient 1 and 3), it was not possible to submerge the implants. Therefore, the barriers were instead adapted tightly around the implants. The flaps were relocated and sutured with the implants non-submerged. Incisions were made in the periosteum to establish tension-free suturing. All patients received postoperative antibiotics (phenoximethyl-penicillin 4 g daily for 7 days) and were advised to rinse twice daily for 6 weeks with a 0.1% chlorhexidine digluconate solution (Hexident™, Meda AB, Solna, Sweden). Analgetics were given immediately after surgery and were thereafter prescribed when indicated.

Postoperative Follow-Up

Sutures were removed after 2 weeks. After 6 weeks, the patients stopped rinsing with Hexident™. Instead, they were instructed to clean the implants with a soft toothbrush together with a 1% chlorhexidine gel (Corsodyl™, GlaxoSmithKline, Malmö, Sweden). The patients were recalled for professional tooth cleaning on an individual basis at least three to four times during the first year. During this period, no submarginal debridement of the implants was done. After 6 and 12 months, the patients were recalled to the Department of Periodontology for examination, reinstructed in proper oral hygiene when needed, and sites were rescaled when indicated.

Re-Entry Surgery and Bone Biopsy

In *Patient 1*, a re-entry operation was done 1 year after the second surgery. A minor flap was raised to expose the bone that had been augmented after removal of implant 14 and a 3 × 3 mm bone biopsy was harvested and placed in 4% formalin. Specimens were decalcified in EDTA (10%) for a period of 10 days and thereafter X-rayed in order to verify the decalcification procedure. After dehydration in graded series of ethanol, the specimens were embedded in paraffine, sectioned (3–5-μm sections), and stained with hematoxyline–eosine and modified Mallory aniline blue. Examinations were performed in a Nikon Eclipse 80i microscope (Teknooptik AB, Huddinge, Sweden) equipped with an EasyImage 2000 system (Teknooptik AB) using ×4 to ×60 objectives.

RESULTS

Patient 1

In a 64-year-old healthy woman with no history of periodontal disease, two ITI implants with a titanium plasma sprayed (TPS) surface (Straumann, Waldenburg, Switzerland) in positions 13 and 14 (Federation Dentaire Internationale notification system) placed in the right maxilla showed severe breakdown of peri-implant marginal bone 8 years after placement. Both these implants showed BoP and extensive pus formation with PPDs >12 mm (Figure 1A). They were judged hopeless and it was decided to make a surgical exploration to remove the implants and augment the alveolar bone. When the screw retained fixed prosthesis was removed, implant 14 exfoliated due to complete loss of osseointegration and left a 6–7-mm-deep and 7 × 7-mm-wide bone crater. Implant 13 showed circular bone loss and the remaining bone support was 4–5 mm from all aspects of the implant (Figure 1B). The implant was regarded as 'hopeless' but it was decided to maintain it temporarily to support the prosthesis during bone healing and later placement of a new implant in position 14.

After debriding the defects, Mp3® and Bio-Gide® were placed to cover the exposed implant surface in position 13 and the bone crater defect in position 14 (Figure 1C).

Clinical and radiographic evaluation after 6 months revealed a substantial bone gain in position 14. a substantial PPD reduction and bone gain was found at the implant in position 13. However, a 7-mm-deep pocket with BoP with a vertical bone defect remained mesially.

It was decided to perform a second surgery. About 1–2 mm bone gain was found around implant 13, but three to four threads were still exposed at the mesial, buccal, and distal aspects, and two threads at the palatal

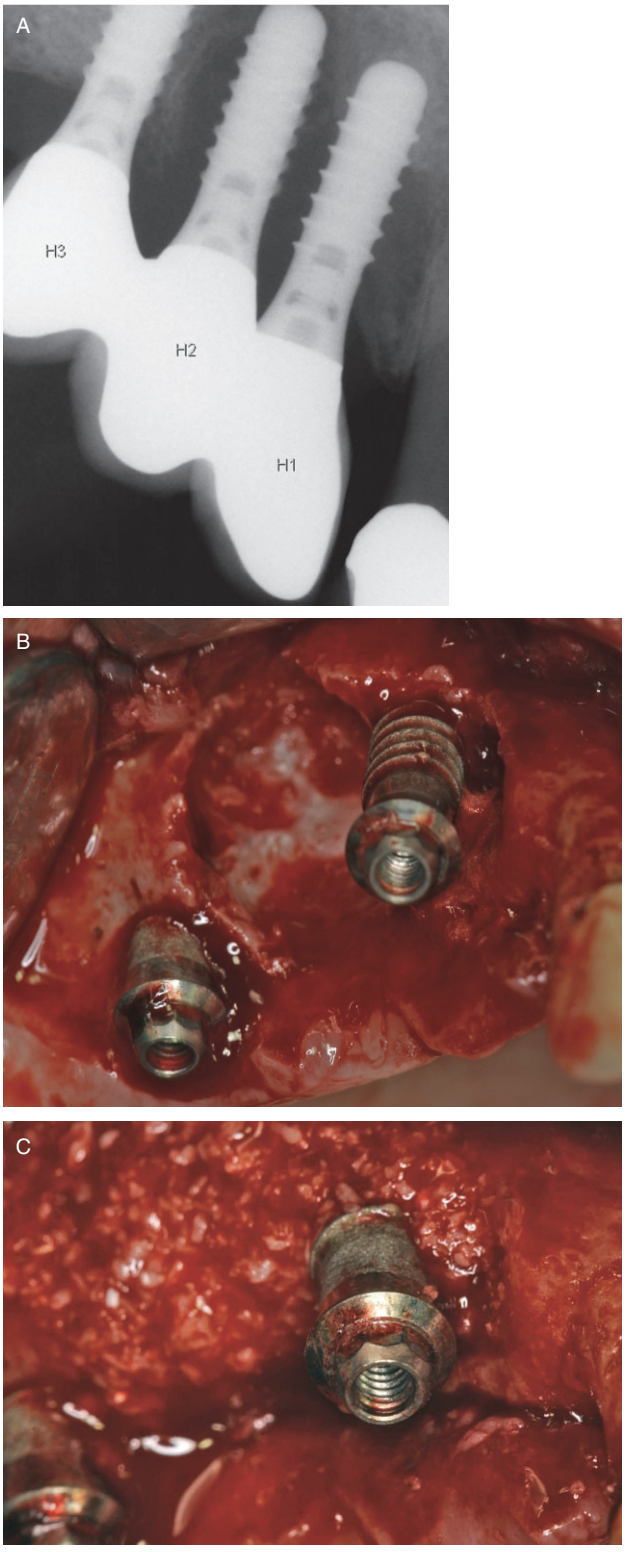

Figure 1 *Patient 1. A*, Radiographic appearance. Severe peri-implant bone breakdown around implants in positions 13 and 14. *B*, Surgical exposure. Implant 14 has exfoliated due to complete loss of osseointegration and left a 6–7-mm-deep and 7 × 7-mm-wide bone crater. Implant 13 shows circular bone loss up to >2/3 of its length. *C*, Mp3® and E: Bio-Gide® placed to cover the exposed implant surface in position 13 and the bone defect in position 14. Bio-Gide® not shown.

side (Figure 2A). Mesially, the bone defect was 6 mm deep, as assessed from the bottom of the defect to the demarcation of the TPS surface and the polished part of the implant. The regenerative procedure was repeated. After another 6 months of healing healthy peri-implant conditions were found. A 5 mm pocket remained at the mesial side of the implant but with no BoP or pus formation (Figure 2B). An intra-oral radiograph showed a total remineralization at the former implant site 14 and 3–4 mm bone gain inter-proximally at the implant in position 13 (Figure 2C).

The histological bone biopsy analysis of horizontal sections, at a depth of approximately 3 mm, verified ongoing bone regeneration. The material showed osteoconductive properties as bone formation with typical osteoblastic seams was observed directly on the surface of grafted particles. The interface between newly formed bone and the PCPB particles was in most areas tight and it was impossible to distinguish a gap in between. Angiogenesis also took place since newly formed capillaries and venules were recorded both within and in conjunction to PCPB particles. In no sections signs of inflammation or adverse reactions could be seen (Figure 3A–C).

Patient 2

A 63-year-old generally healthy woman, smoking 8–10 cigarettes a day and with a history of periodontitis, was referred to the department of periodontology for treatment of deep pockets around two implants in the left upper jaw (Figure 4A). Seven years previously, she had received one Brånemark TiUnite™ implant in position 24 and one turned Brånemark implant in position 26 (both implants from Nobel Biocare, Göteborg, Sweden). During examination, 6–8-mm-deep pockets and BoP/pus formation were found around both implants. A misfit of the fixed prosthesis was found at the implant position 26. After initial treatment, surgery was performed. Implant 24 displayed a bone crater with a depth of 7 mm mesially, 5 mm buccally, 5 mm distally, and 6 mm palatally. Implant 26 displayed a bone crater with a depth of 5 mm mesially, 4 mm buccally, 5 mm distally, and 4 mm palatally (Figure 4B). After debridement of the defects, Mp3® and Bio-Gide® were placed and the implants were submerged. Subsequently, the implants were exposed, and a new fixed prosthesis was made. After 12 months, the PPD at implant 24 were 3 mm at all surfaces with no BoP, while

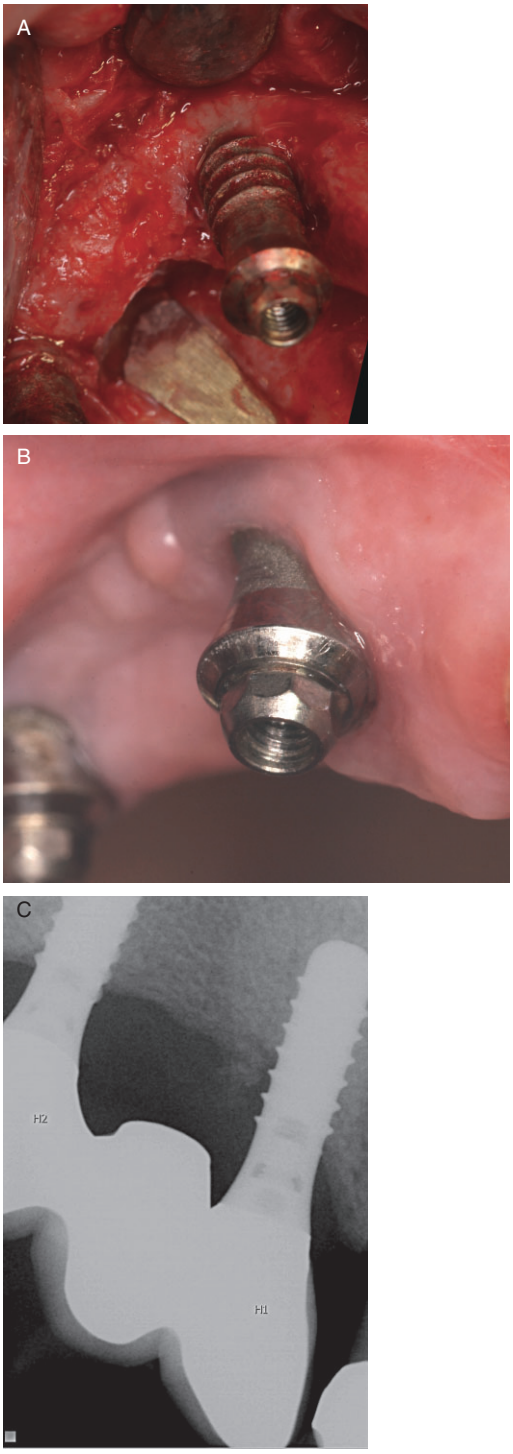

Figure 2 *Patient 1. A*, surgical exposure 6 months after previous surgery reveals a substantial gain of bone in position 14 and about 1–2 mm bone gain at implant 13. Still, three to four implant threads are exposed at the mesial, buccal, and distal aspects, and two threads at the palatal side. A 6-mm-deep bone defect is found mesially. The regenerative procedure is repeated and Mp3® and Bio-Gide® are placed to cover defect and exposed threads. *B*, After another 6 months of healing, healthy peri-implant conditions are found. A 5-mm pocket remains at the mesial side of the implant but with no BoP or pus formation. *C*, An intra-oral radiograph shows 3–4-mm bone gain inter-proximally.

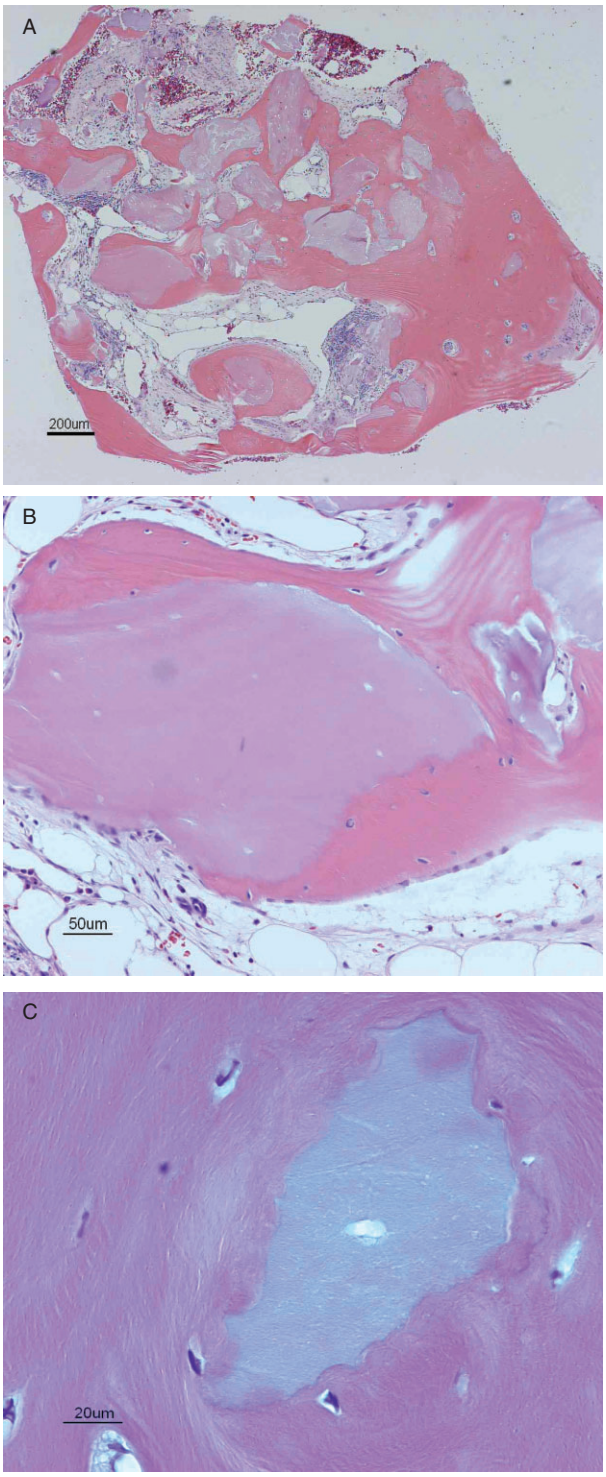

Figure 3 *Patient 1. A–C*, The histological analysis of horizontal sections, at a depth of approximately 3 mm, verifies ongoing bone regeneration. The material shows osteoconductive properties as bone formation with typical osteoblastic seams is observed directly on the surface of grafted particles. The interface between newly formed bone and the PCPB particles is tight in most areas, and it is impossible to distinguish a gap in between. Angiogenesis also take place since newly formed capillaries and venules are recorded both within and in conjunction to PCPB particles. In no sections can signs of inflammation or adverse reactions be seen.

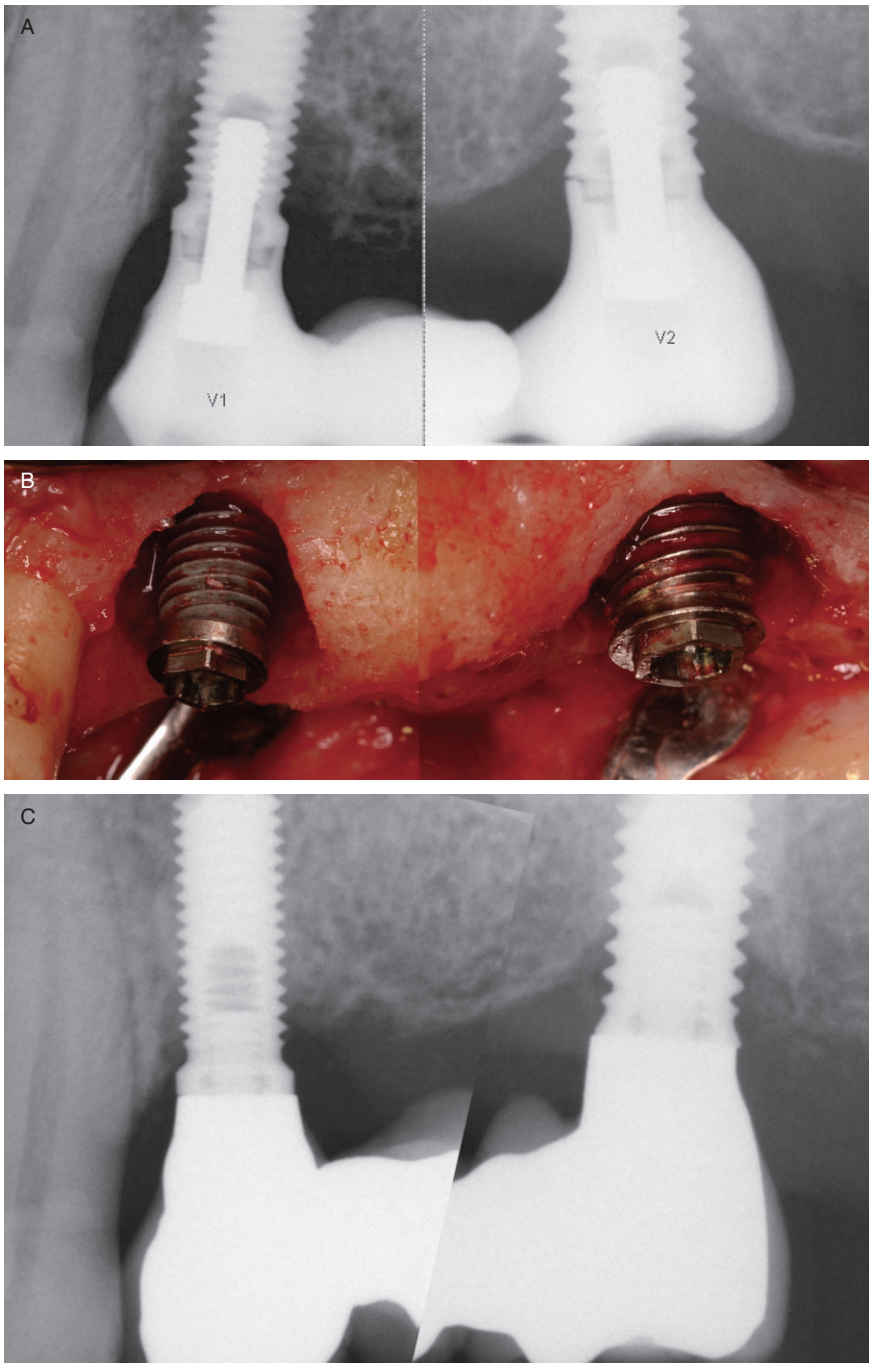

Figure 4 *Patient 2. A*, Intra-oral radiographs reveal significant bone loss at two implants in the left upper jaw 7 years after placement. *B*, Circular bone defects are found around the implants. *C*, After 12 months, intra-oral radiographs show 2–3 mm bone gain at implant 24 and 1–3 mm at implant 26. Images are composites.

at implant 26 a 5-mm PPD was found mesially and palatally, 2 mm buccally, and 3 mm distally; not one showed BoP. Intra-oral radiographs showed interproximal bone gain of 3–4 mm at both implants (Figure 4C).

Patient 3

A 23-year-old healthy man, smoking 15 cigarettes/day, developed marginal bone breakdown and deep pockets around a single-tooth Brånemark TiUnite™ implant with a cemented metal ceramic crown in position 12. The implant, placed 3 years previously, showed an 8-mm pocket mesially, 5 mm buccally, and 6 mm distally with BoP at all surfaces. An intra-oral radiograph showed bone loss of 3 mm at the mesial and distal aspects of the implant. In addition, a cement-like material was detected at the inter-proximal surfaces (Figure 5A).

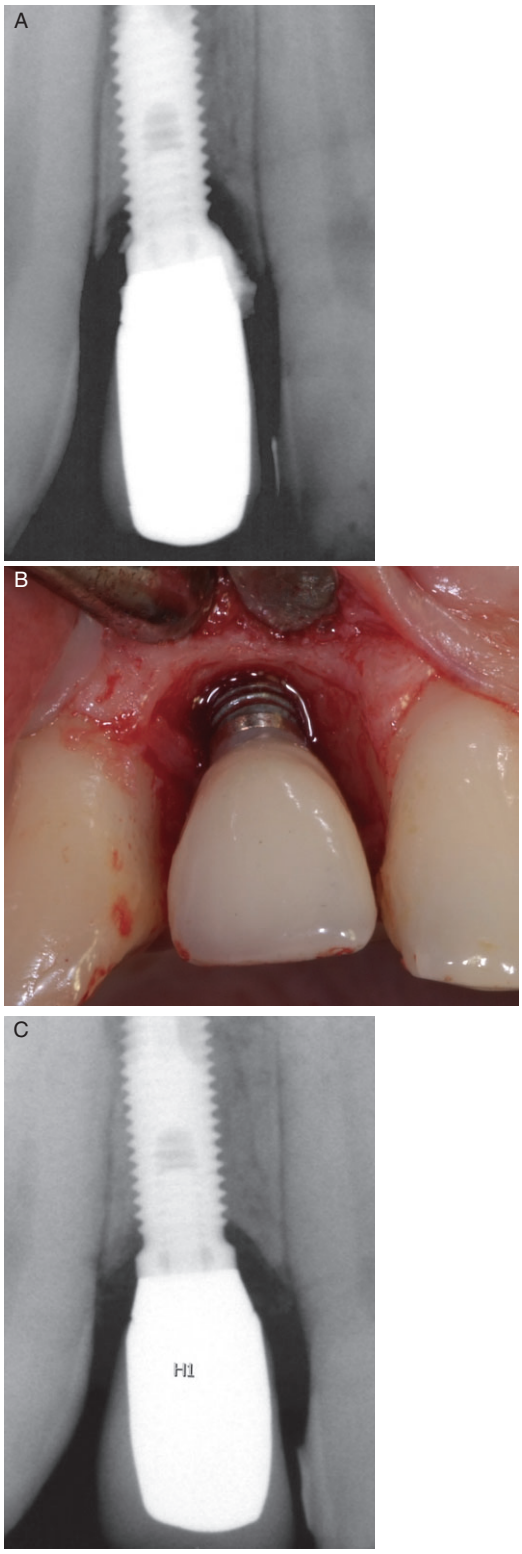

Figure 5 *Patient 3*. *A*, Intra-oral radiograph shows marginal bone loss of 5 mm at the mesial and 4 mm at the distal aspects of a single-tooth Brånemark TiUnite™ implant with a cemented metal ceramic crown in position 12 placed 3 years previously. In addition, a cement-like material can be seen. *B*, Defect after debridement and removal of cement material. *C*, An intra-oral radiograph obtained 6 months postoperatively shows almost complete bone-fill inter-proximally.

A 3-mm-deep and 2-mm-wide defect was surgically exposed and debrided and cement material was removed (Figure 5B). The implant was cleaned and Mp3® and Bio-Gide® were placed.

At re-evaluation 6 months postoperatively, PPD were reduced to 5 mm mesially, 4 mm buccally and distally showing no BoP. An intra-oral radiograph showed almost complete bone-fill interproximally (Figure 5C).

DISCUSSION

This study showed a substantial reduction of PPD and BoP together with 2–4 mm bone gain after reconstructive surgical treatment with the use of PCPB of long-standing, chronically infected peri-implant defects in three patients. In general, the outcome of peri-implant surgery as well as periodontal surgery seems to depend on various interacting factors, for example the wound healing mechanisms *per se*, the defect morphology, and the properties of materials used.[36] In addition, the surgical handling[37] together with prevention of reinfection in the wound area[38] is mandatory.

Bone wound healing is a complex spatial and timely orchestration of cellular and molecular reactions starting with extravasation of relevant cells, clot formation and inflammation; further with angiogenesis, migration of matrix producing cells and deposition of collagen, and finally mineralization and remodeling. The timing of various events is critical, and not easy to mimic.

In the present study, the peri-implant bone defects were circumferential/crater-like in *patient 2 and 3* while in *patient 1* the defect at implant 13 was *much* more complicated, showing horizontal bone loss distally with a large adjacent bone defect after the lost implant in position 14, a buccal dehiscence, and a one-walled defect mesially. In our opinion, this most likely influenced bone healing after the first surgery. In the second operation, the situation was found much improved, which facilitated further bone formation after the repeated reconstructive procedure. Studies on periodontal reconstructive surgery have shown a significant influence of defect morphology on the healing outcome.[39–41] Similarly, a few reports have also claimed this in reconstructive peri-implant surgery.[23,42] In a human study, Schwarz et al.[23] studied the influence of defect morphology on the reduction of PPD and CAL gain 12 months after surgery. Although not statistically supported, they asserted that crater-like circumferential defects were favorable to combined circumferential and dehiscence

defects. However, insufficient data are yet available to fully establish this relationship and to provide clinical guidelines when to use graft materials in peri-implant surgery.

It might be claimed that a peri-implant defect caused by cement rests (as in patient 3) will resolve by sole removal of cement and that adding a bone substitute material is unnecessary. However, it has not been shown that defects due to cementum rests is a specific entity showing a more favorable healing response.

The aim of submerged healing is to prevent downgrowth of junctional epithelium and early repopulation of bacteria in the wound.[38] In the present study, both submerged and non-submerged techniques were used. In all cases bone gain was found. This finding is in concert with animal studies[43,44] showing that both techniques allow bone to regenerate in the peri-implant area. Therefore, non-submerged healing may not prevent a successful outcome.

Two of the patients were regular smokers. During the initial treatment, they were informed on the harmful effects of smoking but were not enrolled in a smoking cessation program. The smoking habit in these patients did not seem to prevent the healing outcome. However, the defects in those patients were, as described earlier, not as advanced as in the non-smoking *patient 1*. It can be speculated that larger defects heal less favorably if a smoking habit is present.[45]

Xenogeneic bone substitutes have previously been regarded as inert materials enhancing matrix formation/mineralization due to porosities and surface roughness. Furthermore, as suggested by Malmström et al., material chemistry also influences bone-bonding capacity.[46] However, these materials seem to resorb slowly or not at all.[26,31] While a protected environment – for example the maxillary sinus area – may favor optimal healing, the situation around an implant with a surrounding infiltrate and oral microbiota may be more prone to suboptimal healing or even complications. Therefore, higher standards can be set on the properties of a bone substitute to be used in this area, for example on the promotion of matrix formation and mineralization. In contrast to other xenogeneic materials, as found in the present study and recently,[33,34] PCPB seems to activate the Bone Metabolic Units (BMU) by triggering phagocytosis of the graft material and subsequently favor deposition of new matrix and subsequent mineralization. The preparation of PCPB does not involve a high heating process (<120°C) destroying every organic components, instead leaving the collagen intact which most probably will have an effect on both cellular activity and motility, However, the precise mechanism of this is not known at present. For example, the influence of the collagen content on the cellular and molecular activity remain to be investigated.

The encouraging treatment outcome of reconstructive surgery found here is based on three cases and must consequently be considered with caution. However, it can still serve as a promising topic for future short- and long-term studies.

CONCLUSION

The presented cases show that PCPB have favorable properties enhancing bone regeneration in peri-implant bone defects.

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