Peri-Implant Mucositis and Peri-Implantitis: A Current Understanding of Their Diagnosis, Clinical Implications, and a Report of Treatment Using a Combined Therapy Approach

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INTRODUCTION

Peri-implant disease can be objectified in 2 distinct forms: peri-implant mucositis and peri-implantitis. When a peri-mucositis occurs, the inflammatory reaction is confined to the soft tissues surrounding an implant, with no signs of loss of supporting bone. This reversible condition is clinically characterized by the presence of bleeding on probing and/or suppuration, which are usually associated with probing depths $\geq$4 mm.[1] Differently, peri-implantitis has been described as a destructive inflammatory process around an osseointegrated implant that leads to peri-implant pocket formation and progressive loss of supporting bone. For defining a case as peri-implantitis, the presence of bleeding on probing and/or suppuration with or without concomitant deepening of peri-implant pockets must be present, in association with peri-implant marginal bone loss $\geq$2 mm from the expected marginal bone level following remodeling after implant placement.[2] In addition to the soft tissues inflammation, the typical bone defect is crater-like, runs all around the implant, and is strictly demarcated; however, implant mobility is absent due to the osteointegration that is maintained apically to the defect.[3]

As different thresholds for probing depths and radiographic bone loss were applied in the literature to diagnose the peri-implant disease, the true incidence cannot be stated. A recent meta-analyses estimated weighted mean prevalences of peri-implant mucositis and peri-implantitis of 43% and 22%, respectively; however, the prevalence ranged from 19% to 65% and from 1% to 47%, respectively, due to the heterogeneous use of case definitions.[4] Etiopathologically, a cause and effect relationship between biofilm formation on the implants surface and peri-implant disease has been found[5,6]; however, even nonmicrobial events including implant fractures and submucosal persistence of luting cement could favor the formation of a pathogenic microbiota with the subsequent bacterial insult.[3] It is therefore generally accepted that the elimination of the biofilm from the implant surface is the prime objective when treating peri-implantitis.[1] Basically, a nonsurgical treatment could be advisable during early phases to treat peri-mucositis; however, if the progression of the peri-implant lesion or the bone loss could not be arrested, surgical therapy may be considered due to its superiority in the treatment of peri-implantitis.[7] Several decontamination methods, such as air-powder abrasion, saline wash, citric acid application, laser therapy, peroxide treatment, ultrasonic/manual debridement, and application of topical medication have all been investigated, but a definite gold standard could not be identified.[8] Furthermore, different regenerative protocols have been used to reestablish a proper amount of bone circumferentially around an implant following surgical therapy; however, results were heterogeneous.[9]

The purpose of the present case report was to clinically and radiographically evaluate the use of a titanium brush and antimicrobial photodynamic therapy (aPDT) to decontaminate the implant surface, in association with regenerative procedures by means of autologous bone and demineralized bovine bone mineral (DBBM) in the treatment of peri-implantitis defects.

CASE DESCRIPTION

A male patient, 53 years of age, a nonsmoker, and with no systemic contraindication to oral surgery (American Society of Anesthesiologists [ASA]-1 following the classification of the American Society of Anesthesiologists), indicating neither drug intake nor drug allergies, received 3 single screw-retained metal-ceramic crowns supported by 3e Bicon (501 Arborway, Jamaica Plain, Mass) dental implants in positions 2, 3, and 4 in

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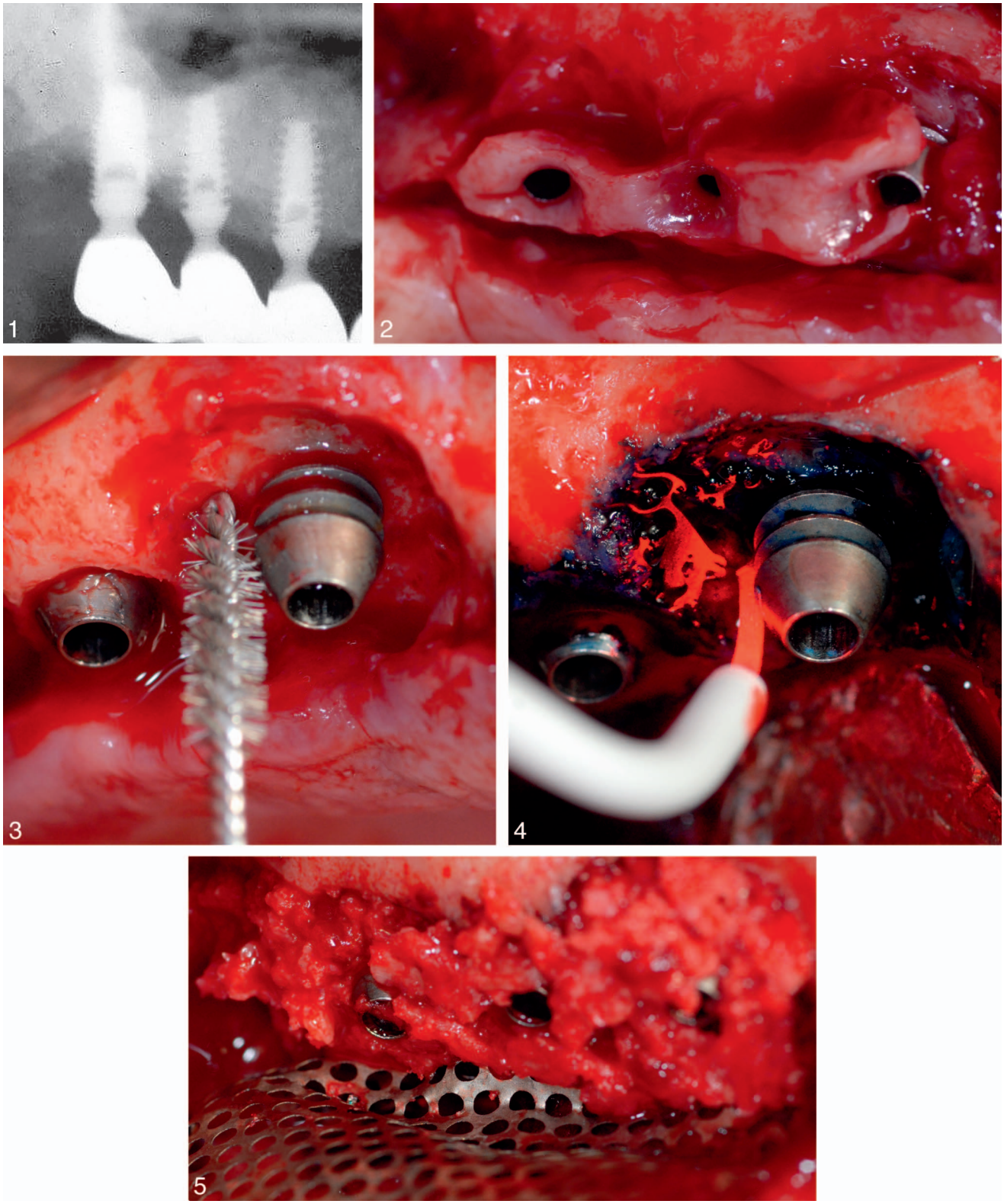
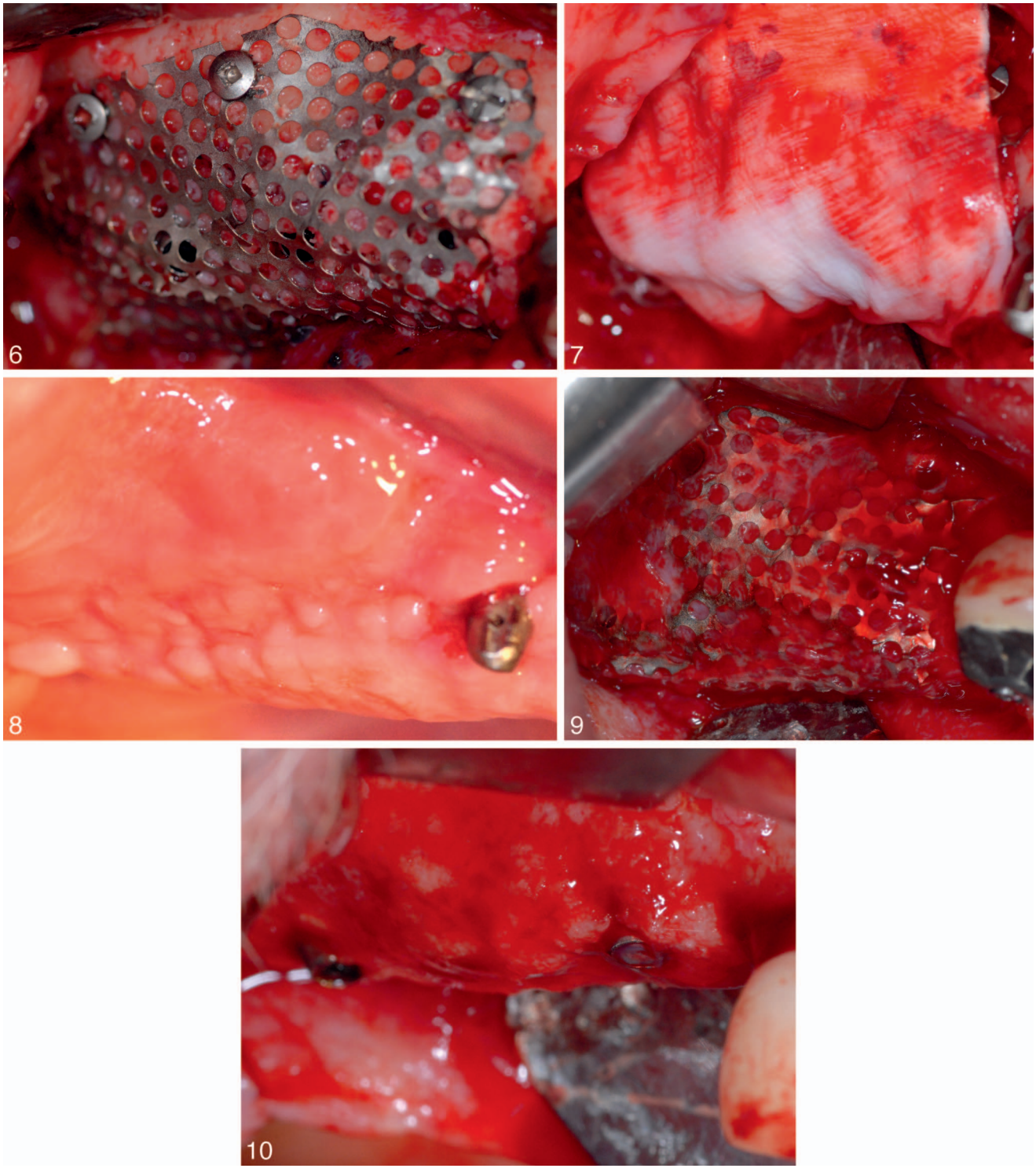
September 2012. The patient could not be enrolled in a recall maintenance program due to temporary work relocation in another city for 2 years. The subject presented to the authors' attention in September 2014, citing bleeding during brushing and flossing associated with sporadic episodes of halitosis in the upper right quadrant. During the first clinical examination, bleeding on probing (BOP) and probing probe depth (PPD) $\geq$5 mm were registered circumferentially around the implants in positions 2 and 4. Bidimensional radiologic evaluation with a panoramic radiograph showed a peri-implant marginal bone loss $\geq$2 mm mesially and distally to the previously mentioned fixtures; therefore, the diagnosis of peri-implantitis was made (Figure 1). The patient was informed about the critical clinical condition of the implants, and a detailed description of the procedure was given. Subsequently, a signed informed consent was obtained. At baseline, the patient was instructed in the use of superfloss (Superfloss Oral-B, Procter & Gamble, Cincinnati, Ohio) and interdental brushes (TePe Munhygienprodukter AB, Malmo, Sweden). Nonsurgical therapy consisted of implant surface debridement under local anesthesia with articaine plus epinephrine 1:100 000 using carbon fiber curettes and curettage of the inflamed peri-implant soft tissue with sharp metal curettes. After mechanical debridement, the pockets around the implants were rinsed with 0.12% chlorhexidine solution (Dentosan, Recordati S.p.A., Milan, Italy). Two weeks later, aPDT was performed to minimize the local infection and to biostimulate the soft tissues with a specific setup (HELBO, Photodynamic Systems GmbH, Wels, Austria). A 0.1-mL solution of dye phenothiazine chloride (HELBO blue photosensitizer, Photodynamic Systems GmbH) was applied submucosally from the bottom to the top of the peri-implant pockets circumferentially around the implants and was left in situ for 3 minutes. Subsequently, the pockets were rinsed for 1 minute with 3% hydrogen peroxide to remove the photosensitizer in excess. A hand-held diode laser with a wavelength of 660 nm and a power density of 100 mW (HELBO TheraLite Laser, Photodynamic Systems GmbH) equipped with a dedicated probe (HELBO 3D Pocket Probe, Photodynamic Systems GmbH) was used to activate the remaining photosensitizer circumferentially at 6 aspects per implant (mesiobuccal, midbuccal, distobuccal, and respective palatal sites) for 10 seconds each. Adjunctive aPDT was repeated 1 week later according to the manufacturers' instructions to reduce the bacterial count and gingival inflammation. The surgical procedure was carried out after a healing period of 2 weeks. The patient was asked to rinse preoperatively with a 0.2% chlorhexidine solution before receiving perioral skin disinfection with benzalkonium chloride. An antibiotic therapy consisting of 2 g amoxicillin clavulanate was administered 1 hour before surgery. Local anesthesia was induced with articaine and epinephrine 1:100 000. Then, 4 mg dexamethasone was injected into the muscles around the surgical site to reduce postoperative swelling. Full-thickness flaps were reflected by means of para-marginal incisions (Figure 2). Subsequently, all granulation tissue was completely removed from the defect area, and the implant surfaces were thoroughly debrided and instrumented using titanium curettes and rotary titanium brushes (Ti-Brush, Straumann, Basel, Switzerland) fixed on a surgical handpiece, oscillating in a clockwise/counterclockwise direction at low speed (800 rpm for 1 minute per surface) under irrigation with sterile saline solution (NaCl) to remove the bacterial biofilm (Figure 3). A copious irrigation with sterile physiologic saline was then performed to cleanse the surgical area. Clinically, the defects were mainly crater-like, characterized by a consistent horizontal bone loss, identifiable as a supra-alveolar exposure of the implants' surface. At this point, aPDT was accomplished with the same modalities adopted during the nonsurgical intervention; that is, the photosensitizer was applied on the implant surfaces and surrounding tissues, left in place for 3 minutes, rinsed for 1 minute with 3% H_2O_2, and photo-activated at 6 sites per implant for 10 seconds each (Figure 4). Autogenous bone chips were then harvested from the zygomatic process of the maxilla and the tuber maxillae of the same side with a bone collector (Safescraper TWIST, Meta, Reggio Emilia, Italy) and trephine burs. Perforations into the marrow space were performed using small round surgical burs to facilitate vascularization of the graft and cell colonization from the bone marrow. A 0.2-mm-thick titanium mesh (KLS Martin, Tuttlingen, Germany) was trimmed and adapted to the surgical defect to create a proper bone contour. The Ti-mesh was shaped, avoiding sharp edges, to prevent soft tissues dehiscence or exposure. Before grafting the defects, plastic caps were inserted into the implants' connection to prevent bone ingrowth. Both the intrabony and the supracrestal part of the peri-implant defects were grafted. Autogenous bone particles were placed in direct contact with the implants' surfaces (Figure 5), and a mixture of autogenous bone chips and DBBM (Bio-Oss, Geistlich, Wolhusen, Switzerland) in a 70:30 ratio was positioned in a way as to homogeneously recreate the alveolar process architecture. The titanium mesh was then placed over the graft and fixed to the palatal and buccal bony walls using cortical screws on each side to prevent any micromovement (Figure 6). A resorbable collagen membrane (Biogide, Geistlich) was finally applied over the titanium mesh to exclude the epithelial cells ingrowth (Figure 7). Periosteal horizontal releasing incisions followed by upper traction were performed to mobilize the buccal flap and obtain a passive closure. A first intention healing of the surgical wound was accomplished with horizontal mattress and single stitches using 3-0 Vicryl and 4-0 silk (Ethicon Inc, Somerville, NJ) sutures. The antibiotic therapy consisted of 1 g amoxicillin clavulanate starting the day before the surgery twice daily for 6 days. Anti-inflammatory and analgesic therapy was prescribed (ibuprofen 600 mg, 3 times daily) during the first 2 days and according to the patient's individual needs thereafter. A soft cold diet was suggested for the first 24 hours after the surgery, together with the application of ice packs for 10 minutes every 30 minutes for the first 4 hours. The patient was also instructed to rinse 3 times daily with 0.2% chlorhexidine mouthwash rinse solution for 1 minute starting the day after the surgery until suture removal. The sutures were removed after 12 days. During the 6-month healing period, no complications occurred (Figure 8). Local anesthesia was induced, and a horizontal incision was performed to reflect a full-thickness flap to uncover and remove the titanium mesh (Figure 9). No clinical signs of inflammation or infection were recorded, and the grid was firmly attached to the newly formed bone underneath. New bone formation was observed filling the entire space under the

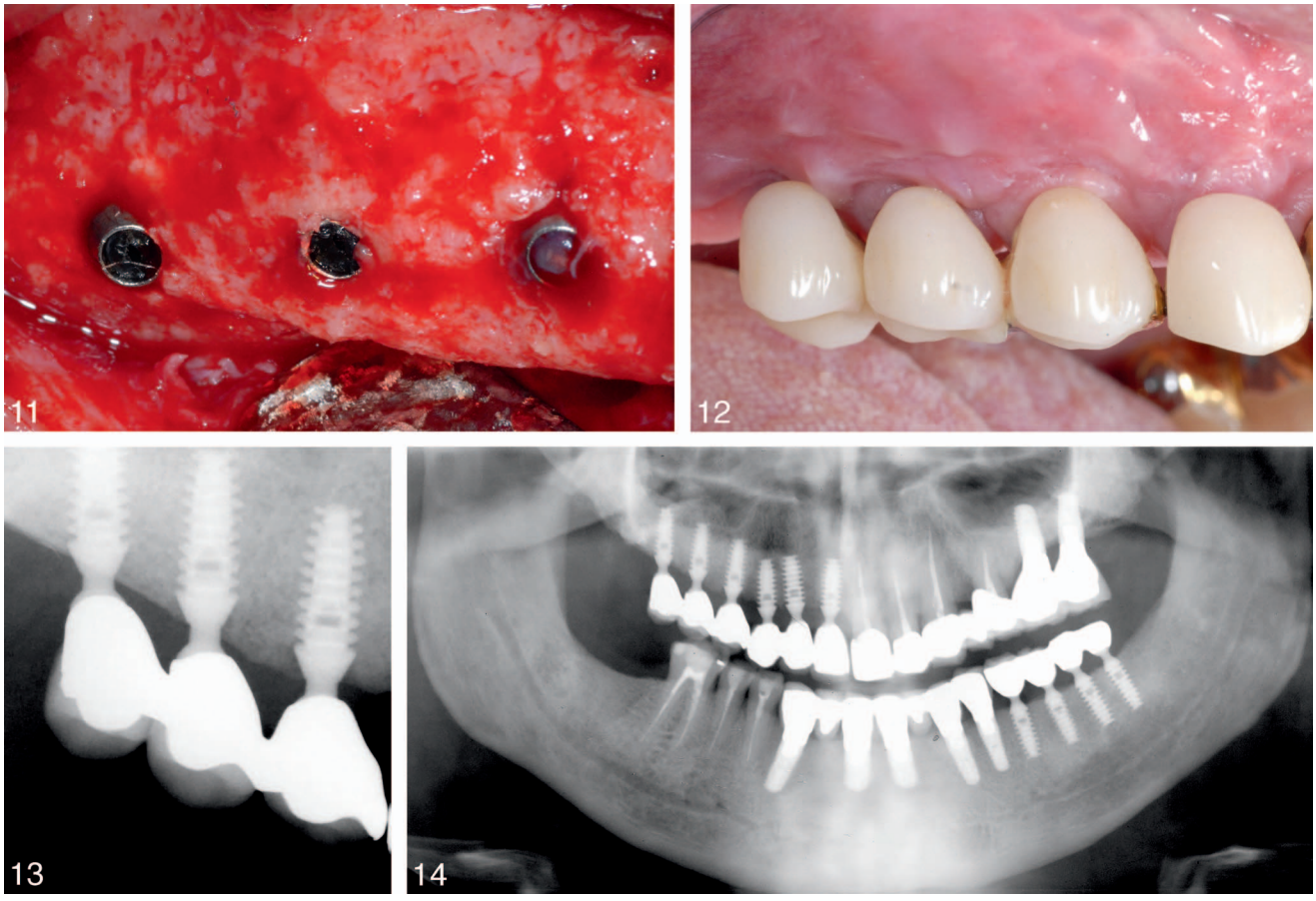


Figures 1–5. Figure 1. Preoperative orthopantomograph. Peri-implantitis defects are mainly visible on implants in position 2 and 4. **Figure 2.** Clinical view of the granulation tissue surrounding the implants in positions 2, 3, and 4. **Figure 3.** Mechanical decontamination of the implants' surfaces and biofilm disruption by means of titanium brushes. **Figure 4.** Antimicrobial photodynamic therapy consisting of phenothiazine chloride photo-activated by a low-level diode laser. **Figure 5.** Autogenous bone particles in direct contact with the decontaminated implants' surfaces.



Figures 6–10. Figure 6. Titanium mesh secured in the proper position with osteosynthesis screws. **Figure 7.** A nonresorbable membrane is placed above the titanium mesh to prevent the soft tissue ingrowth. **Figure 8.** Clinical view of the surgical wound after a 6-month healing period. A first intention sealing has been accomplished. **Figure 9.** Re-entry surgery after 6 months of healing time. **Figure 10.** Clinical view of the previously affected implants' sites. Bone overgrowth is clearly visible at the top of the implant head in position 3.

titanium mesh. The combined defects, mainly characterized by a noncontained component, were completely eliminated. The previously exposed threads were completely covered and, in the case of implant 3, the cover screw was overwhelmed by the regenerated bone (Figure 10). The newly formed tissue was well vascularized and indistinguishable from the host bone (Figure 11). Healing abutments were then screwed to the implant, and a nonsubmerged approach was performed. After 3



Figures 11–14. Figure 11. Clinical view of the newly formed bone, well integrated and indistinguishable with respect to the surrounding hard tissue. **Figure 12.** One-year recall from the connection of the definitive restoration. Wide spaces have been left between the prosthetic crowns, allowing the patient to properly perform ideal oral hygiene procedures. No signs of bleeding on probing or pathologic probing depths have been recorded. **Figure 13.** One-year peri-apical radiograph demonstrating the stability of the mesial and distal bone levels of all the implants. **Figure 14.** One-year orthopantomograph.

weeks, definitive abutments were repositioned to the corresponding implants, and the final prosthesis was delivered (Figure 12). The patient was finally placed on an individually tailored professional maintenance program. After 1 year of follow-up, the implants appeared clinically stable, with no BOP and PPDs $\leq$3 mm. The radiographic examination, consisting in a periapical radiograph (Figure 13) and orthopantomograph (Figure 14) acquired 1 year after the prosthetic connection, confirmed a substantial stability of bone graft without mesial and distal pathologic peri-implant bone loss.

Discussion

The aim of the present case report was to evaluate the clinical and radiologic outcome of a regenerative approach in case of peri-implantitis defects. There is evidence to suggest that nonsurgical therapy is ineffective in advanced peri-implantitis cases where access to the contaminated implant surface is limited.[10] Further, the biological possibility of achieving osseointegration on a previously contaminated implant surface has been demonstrated.[11] To this end, both mechanical and chemical decontamination techniques should be applied alongside regenerative surgical procedures to obtain optimum reosseointegration and successfully treat peri-implantitis.[12] The present therapeutic approach consisted of an access flap, mechanical biofilm disruption by means of titanium brushes, aPDT, and bone regeneration with a mixture of autogenous bone particles and DBBM secured by a titanium mesh. A surgical access of peri-implant lesions facilitates the removal of granulation tissue and allows proper decontamination of the implant surfaces, with long-term predictable results.[13] After mechanical debridement with titanium brushes, the defects appeared clean without any visible signs of granulation tissue and biofilm. This clinical finding corroborated with those reported in previous studies, supporting the fact that titanium bristles might offer easier access to narrow spaces and may adapt closely to the architecture of the implant.[14,15] Moreover, a recent in vitro study showed the treatment with a titanium brush did not significantly change the roughness parameters in sand-blasted and acid-etched surfaces[16] due to a gentler interaction with the implant surface compared with other mechanical instrumentation, because less force is applied on the area.[17] The concept of aPDT is based on the application of red light with a wavelength ranging between 630 and 700 nm on a chemical dye, which leads to the production of singlet

oxygen molecules under aerobic conditions that cause oxidative damage to the target cells. It has been demonstrated that aPDT is effective in blocking bone resorption in moderate peri-implant defects, increasing the expression of receptor activator of nuclear factor-kappa and osteoprotegerin, which in turn leads to a reduction in the osteoclastogenic activity.[18,19] Accordingly, in the present study, no progressive bone loss was observed at the 1-year follow-up examination. Furthermore, new bone formation was clearly recognizable at the stage of the regenerative surgery. This was in agreement with Haas et al, who found a mean radiographic bone gain >2 mm in the case of a peri-implantitis defect treated with aPDT and concomitant application of autogenous bone using nonresorbable membranes for grafting material retention.[20] No complications occurred during the healing period, perhaps due to the aPDT, which is able to up-regulate the expression of fibro growth factor 2, promoting the wound repair.[19] As confirmed by the present study, the bone regeneration by means of a mixture of autogenous bone and DBBM particles maintained in situ by a titanium mesh application might be considered a predictable procedure, even in the case of peri-implantitis treatment.[21,22]

In conclusion, the synergistic interaction of the mechanical and chemical decontamination associated with a regenerative approach led to promising results in the treatment of peri-implantitis.

Abbreviations

aPDT: antimicrobial photodynamic therapy

BOP: bleeding on probing

PPD: probing probe depth

DBBM: demineralized bovine bone mineral

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