Clinical procedure and practical conclusions

Treating impaired wound healing in retromolar bone grafts

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Bone augmentation procedures to reconstruct defects of the alveolar ridge have become established in dentistry. Augmentation is often required to be able to rehabilitate patients with functional and aesthetic implant-supported restorations [15]. Alveolar ridge defects are generally accompanied by soft-tissue reduction. Hence, it can be difficult not only to secure bone grafts in place but also to cover the augmented ridge with soft tissue [3]. Several procedures for incisions and plastic coverage of bone grafts have been presented and accepted in recent years [16]. In addition to a combination of plastic materials and membranes, autologous grafts, harvested primarily from the mandibular retromolar region, are the best way to rebuild sites with extensive defects or vertical discrepancies [15].

Vertical bone defects often require substantial graft volumes. In connection with the sharp edges of the grafting materials that cannot always be avoided, this may prevent sufficient perfusion of the flap. The resultant secondary healing poses risks to the bony integration of the augmentation material. But low perfusion may also have causes other than those resulting from the surgical management, such as general medical conditions [25]. Examples of such conditions are microangiopathies caused by metabolic diseases such as diabetes mellitus or by hypercholesterolemia. Moreover, it has been shown that wound healing in patients on systemic corticosteroids due to, e.g., rheumatoid disorders may also be additionally impeded by administering immunological preparations (such as MTX/methotrexate or denosumab) [26]. Other risk factors beyond these internal medical factors can also play a role, for example nicotine, which if used persistently may also reduce perfusion of the soft-tissue structures [22] (Figs. 1 to 4).

Ultimately, this results in a self-reinforcing cascade, where the systemic disorder by itself impairs wound healing in afflicted patients directly after the extraction of a tooth or teeth. This in turn is followed by insufficient regeneration of the extraction socket

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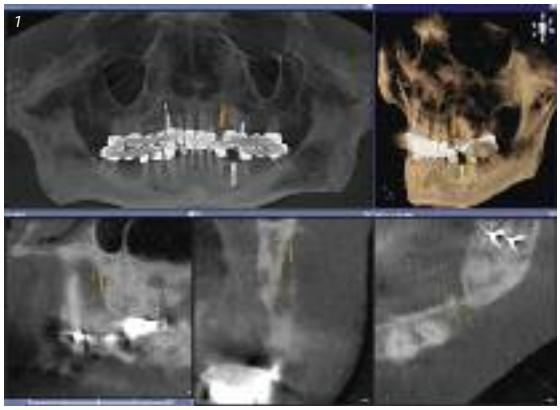


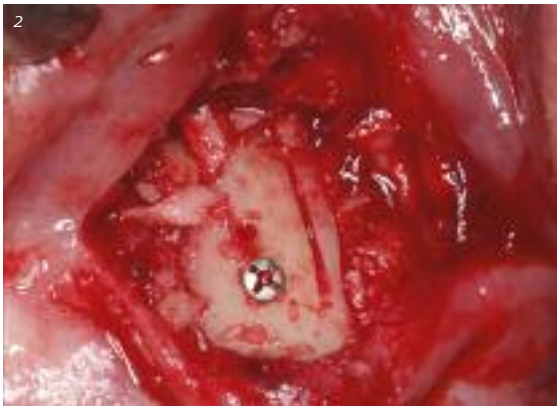


Fig. 1
Preoperative CBCT scan to evaluate the horizontal and vertical bone supply (Galileos, Sirona Dental Systems).

Fig. 2
Vertical augmentation by 3D reconstruction using a plate and particulate bone.

and, possibly, the enclosure of bacterial or fungal reservoirs originating in biofilm [32,33]. Yet these are the very patients for whom alveolar ridge augmentation is indicated. Grafting procedures, including local retromolar bone harvesting and the reconstruction of the alveolar ridge, generally place a significant burden on the patient. Local irradiation of the surgical site by low-level laser therapy (LLLT) at a suitable wavelength has been discussed as the method of choice to reduce this burden and to promote wound healing. Several prospective randomized studies have shown that irradiation with a low-energy non-thermal laser activates the mitochondria of the irradiated cells, which stimulates the granulation process and epithelialization of the wound [7,8,10,13,14,18]. These and other studies were able to show that LLLT not only improves objective wound healing but also reduces the patients' subjective sensation of pain [20, 29]. Although some studies are critical of the LLLT effect, the data demonstrate a predominantly positive influence [21].

As a result of the impaired wound healing above the graft, biofilm-related inflammatory reactions are frequently observed. The low-energy lasers described above are also an essential adjunct of antimicrobial photodynamic therapy (aPDT) [6,12] that stimulates a photodynamic reaction for safe, rapid and gentle reduction of bacteria on the infected tissue [30].

Of the various protocols described, only a few have had their results clinically documented and scientifically evaluated. The procedure presented here, frequently used, investigated and documented in periodontal therapy, works with a sterile light-activated die that is applied to the affected area as a photosensitizer [2,19,23,27]. During the contact period of at least 60 and up to 180 seconds, cationic photosensitizer molecules diffuse into the biofilm and are deposited on the bacterial walls, either on negatively charged centres of LPS (lipopolysaccharides) or, in the case of Gram-positive bacteria, teichoid acid. Excess die is removed as thoroughly as possible after the incubation period using sterile saline solution. This is followed by activation of the photosensitizer molecules with non-thermal laser light [1,5,30,31] (Figs. 5 to 13). This triggers a quantum mechanical process that generates singlet oxygen molecules by way of energy absorption, spin change and spin transfer [4]. Singlet oxygen molecules are powerful oxidants that immediately react with the bacterial wall and cause lethal and irreversible damage to the bacteria, primarily by way of oxidation of membrane lipids [11,17].

The same principle leads to the destruction of fungi [34] and can also be used in the treatment of candidiasis triggered by postoperative antibiotic therapy. The procedure achieves rapid photodynamic decontamination of the infected tissue and the treated surface and, hence, a receding inflammatory reaction. The tissue-friendly nature of this treatment is due to the walls of eukaryotic cells being neutral, as these consist of zwitterionic phosphatidylcholines, sphingomyelins and phosphatidylethanolamines and therefore remain unstained. Consequently, no harmful singlet oxygen is formed on the cell wall.

In the surgical treatment of soft-tissue defects, mucosal grafts and especially subepithelial connective-tissue grafts are recommended to support the regenerative process [9,28]. These grafts are best harvested in the palatal region. However, this also means an additional surgical site, which increases the risk especially in patients who previously experienced impaired wound healing. More recently, therefore, collagen preparations have been proposed as alternative xenogeneic grafting materials [24].

Clinical procedure

In vertical augmentation cases, the tunnelling technique or vestibular incisions usually provide adequate mobilization of the soft tissues in order to achieve complete tension-free coverage of the bone graft. But if one or more of the risk factors described

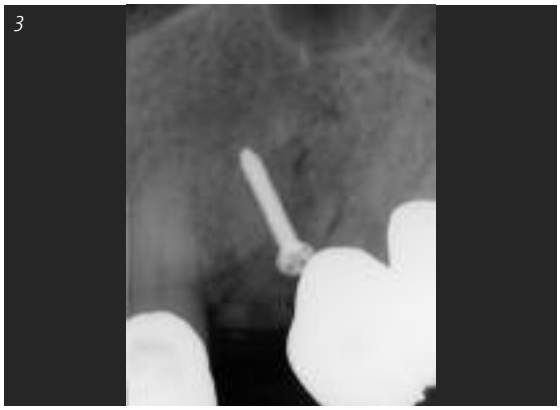


Fig. 3 Radiological check of the extensive vertical and lateral augmentation site.

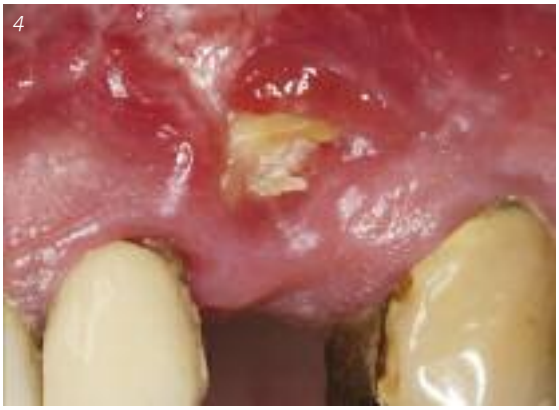


Fig. 4 Secondary wound dehiscence four weeks after augmentation. The patient is a smoker.

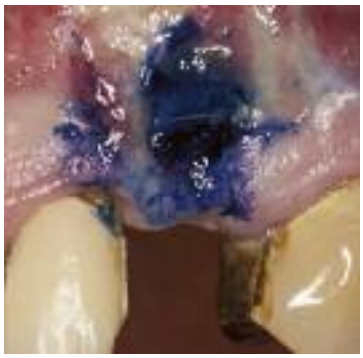


Fig. 5 Applying the photosensitizer for wound disinfection using the antimicrobial photodynamic therapy method (Helbo Blue Photosensitizer, bredent medical).

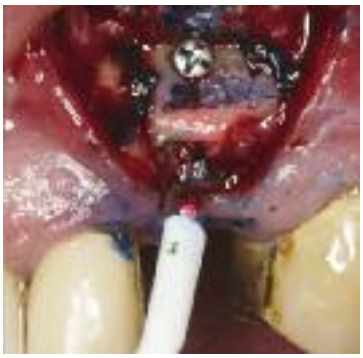


Fig. 6 Activating the photosensitizer in the wound area following re-preparation of a flap.

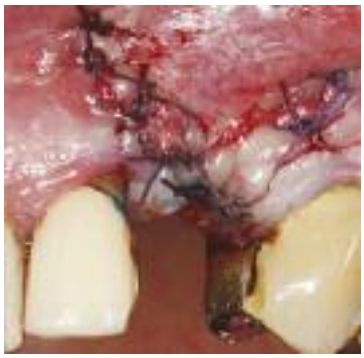


Fig. 7 Plastic coverage after mobilizing the soft tissue using periosteal separation.

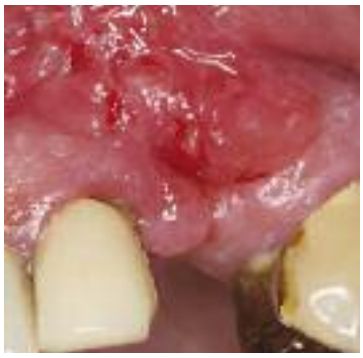


Fig. 8 Prior to inserting the implant. The wound has closed.

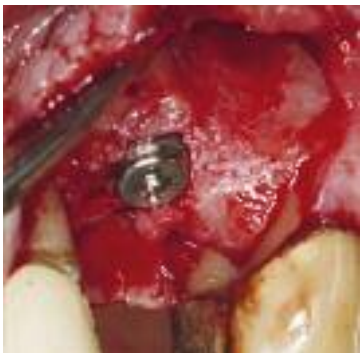
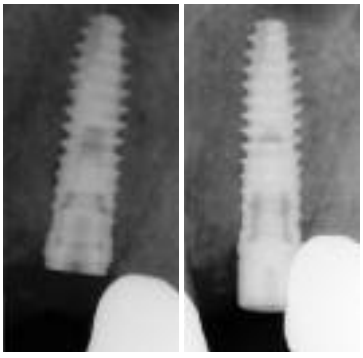


Fig. 9 Inserting the implant into the insufficiently regenerated augmentation area.

Fig. 10 Lateral augmentation using a biphasic bone substitute (Ossceram nano, bredent medical).

Fig. 11 Stabilizing the graft with a porcine pericardial membrane (Angipore, bredent medical).



Figs. 12a and b Radiological check following implant placement and re-entry in the presence of a stable bone level.

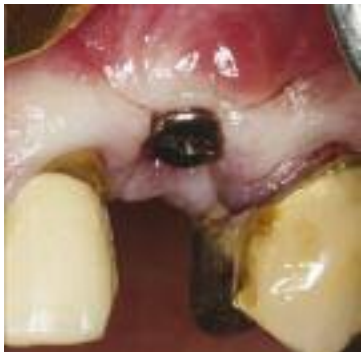


Fig. 13 Stable osseointegration at re-entry prior to restorative treatment by the referring dentist.

are present and a pronounced vertical discrepancy must be compensated for, tissue damage may lead to partial or complete flap necrosis. In other words, the graft is exposed, requiring renewed plastic coverage. This risk is all the greater if the flap has already been perforated or otherwise damaged intraoperatively during the augmentation procedure.

In the 3D technique, volume is created by a plate reduced to 1–2 mm in thickness on top of a cavity filled with particulate bone. This allows for very easy revascularization of the pseudo-spongious graft; the vestibular plate provides biologic stabilization (Figs. 14 to 17).

If a suture dehiscence or partial or a complete necrosis of the flap occurs during the wound-healing process, the first thing is to check whether the edges of the usually thin graft have created tension within the flap, reducing perfusion. If some of the particulate bone has been lost, the vestibular plate must be reduced to the point where it no longer protrudes

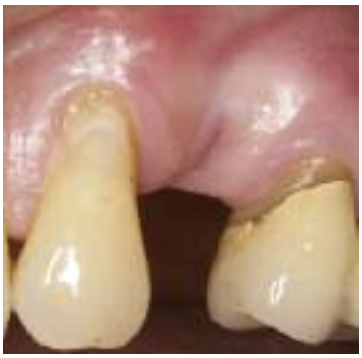


Fig. 14 Extensive defect with missing palatal bone substance.

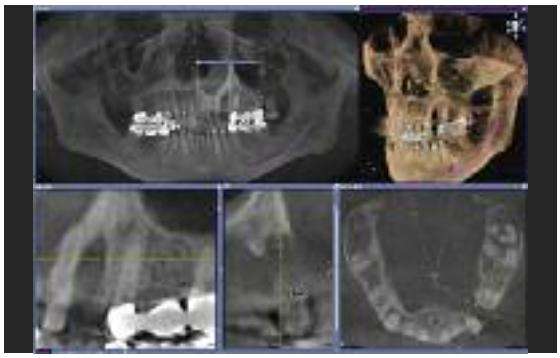


Fig. 15 CBCT scans to evaluate the defect configuration and the donor site (Galileos, Sirona Dental Systems).

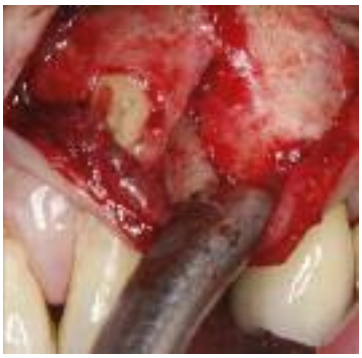


Fig. 16 Introduction of a monocortical plate to reconstruct the palatal defect.

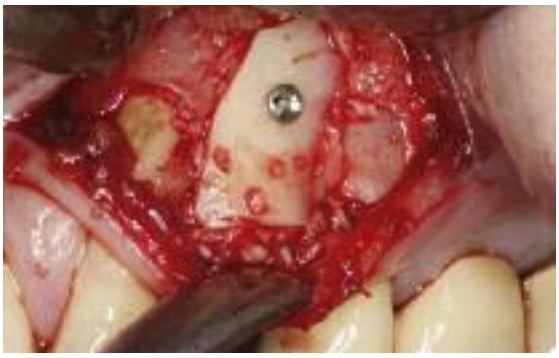


Fig. 17 3D reconstruction using an additional plate and particulate bone. Vestibular incision.

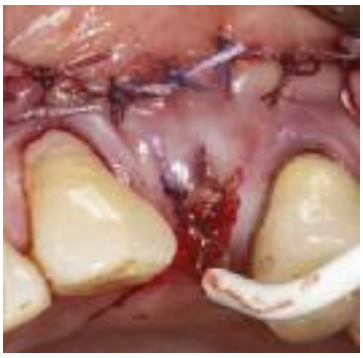


Fig. 18 Initial low-level laser treatment of a crestal preparation defect (Helbo TheraLite Laser, bredent medical).

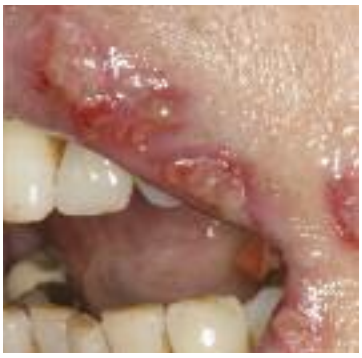


Fig. 19 Postoperative herpes infection one week after the bone graft; first administration of MTX.

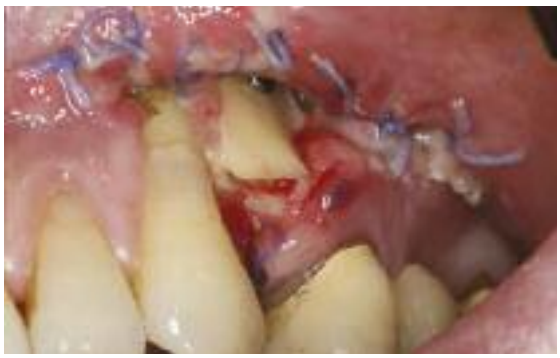


Fig. 20 Complete necrosis of the flap at the time the sutures were to have been removed.

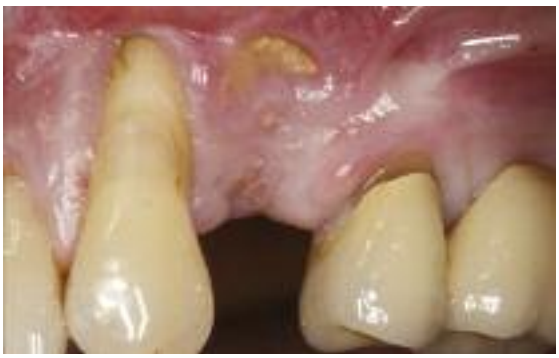


Fig. 21 Almost complete granulation after three months with multiple aPDT applications.

beyond the soft-tissue contour. As the wound is generally critically colonized by bacteria, inflammatory reactions will be found in these cases and no revascularization will take place, so systemic antibiotic therapy will not be very helpful. A better solution would appear to be decontamination by way of photodynamic therapy. This treatment is repeated at intervals of between three and eight days to support both effects of the treatment, namely disinfection and stimulation of wound healing for secondary granulation (Figs. 18 to 21).

Once the graft consolidation phase is completed, any osteosynthesis screws are removed and the implants are placed as part of a new surgical intervention. If the regenerated tissue is found to be unstable, the infected bone tissue may have to be removed. Depending on how much augmented tissue is left, it must be decided individually whether implantation is possible or whether additional augmentation is required, either in a single-stage or in a two-stage procedure. In these cases, the thin mono-

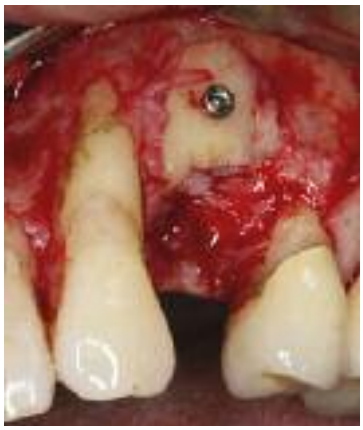


Fig. 22 Accessing the augmented area to investigate implant placement options.

Fig. 23 Inserting the implant after removing the non-integrated vestibular plate.

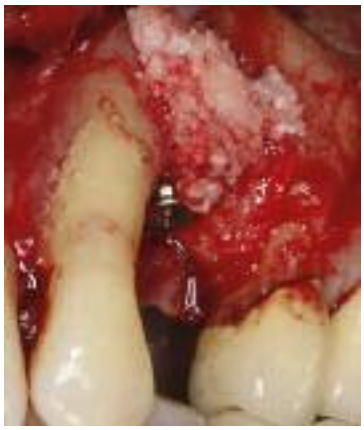


Fig. 24 Lateral augmentation with a mixture of bone substitute and collected autologous bone chips.

Fig. 25 Placement of a collagen matrix to support the soft-tissue regeneration process (Mucograft, Geistlich Biomaterials).

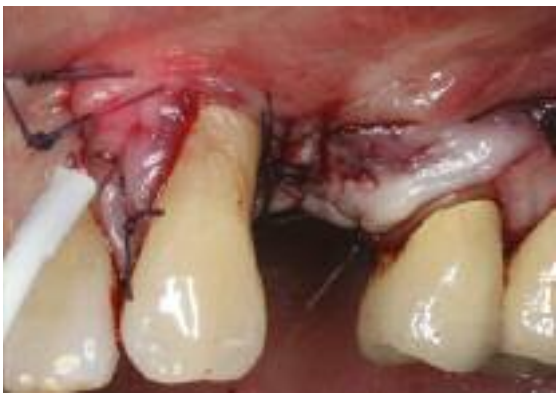


Fig. 26 LLLT to support wound healing (Helbo Blue, bredent medical).

Fig. 27 Partial flap necrosis eight days after implant placement.

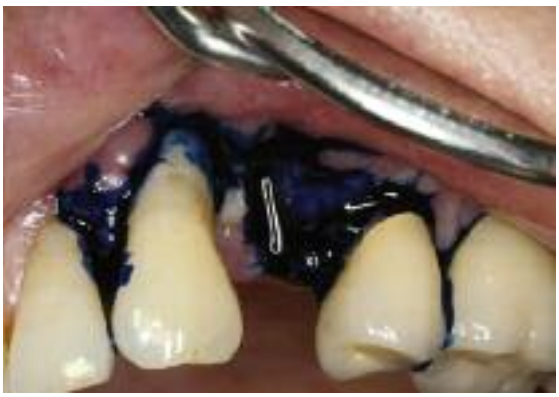


Fig. 28 Applying the photosensitizer for wound disinfection aPDT.

cortical plates will often lack bony attachment, as the formation of new capillary blood vessels could not take place owing to the wound dehiscence leading to infection and bone exposure; the plates will therefore have to be removed. The soft-tissue coverage will also frequently be reduced, as there is only secondary soft-tissue granulation. This requires re-mobilization, for example by periosteal separation. To support and stabilize the soft tissues, a xenogeneic collagen graft may be introduced. Depending on the regenerative capacity of the soft tissues, wound healing problems may occasionally return. These are treated topically using aPDT until complete secondary granulation is achieved (Figs. 22 to 31).

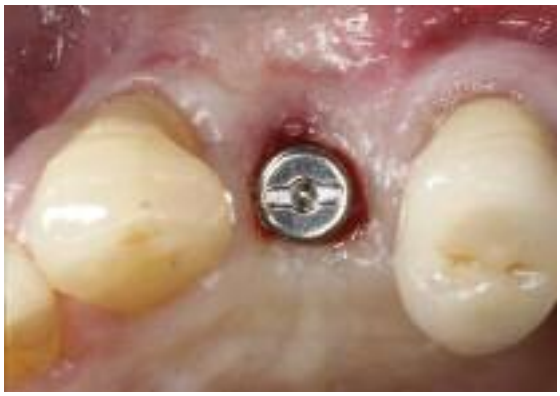
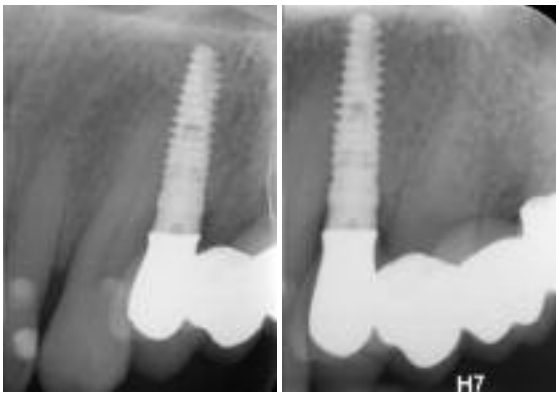


Fig. 29 Stable implant position at re-entry.



Figs. 30a and b Radiological control at delivery of the implant-supported crown and at the one-year recall.

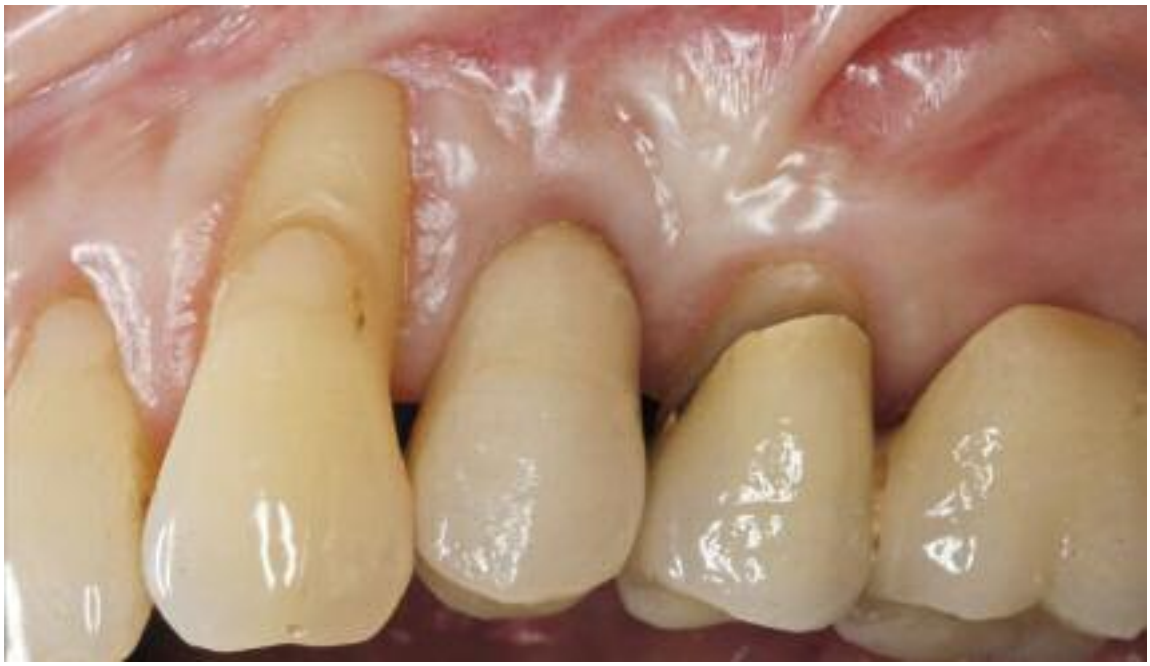


Fig. 31 Complete gingival healing one year after delivery of the restoration.

Practical conclusions

Wound healing problems will always be associated with an increased need for postoperative care. It is therefore important to diagnose these problems early and to control their extent and progression by an appropriate course of therapy. Once the right surgical technique has been chosen and correctly implemented, it is recommended to support it by concomitant local and possibly preventive decontamination using aPDT. The clinician must then decide whether the graft can be preserved completely or at least partially and whether additional augmentation is required to recontour the incompletely restored hard tissues and for soft-tissue regeneration. Obtaining an acceptable clinical treatment result and a positive patient response even in the presence of complications requires individual treatment decisions and close patient monitoring. ■

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