Peri-implant bone regeneration through laser decontamination

Endoscopic paracrestal tunnel technique

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Introduction

The recently published S3 guidelines of the German Association of Oral Implantology (DGI) and the German Society of Dentistry and Oral Medicine (DGZMK) state that peri-implant infections can be categorised into peri-implant mucositis and peri-implantitis.[1] In peri-implant mucositis, only the supracrestal soft-tissue interface is involved; in peri-implantitis, the bony implant site is also involved.[2] Smoking is the main risk factor for peri-implant mucositis, but it is likely that there are further contributing factors, such as cement residue, diabetes mellitus and sex.[2] The development of peri-implantitis is particularly favoured by a history of periodontal disease, smoking and interleukin-1 polymorphism.[4,5] The main diagnostic criterion for distinguishing peri-implantitis from peri-implant mucositis is the lack of reversibility of the condition. Peri-implantitis can be characterised by putrid secretion, increasing probing depth, pain and radiographic bone resorption. Implant loosening requires a high degree of bone resorption in the case of peri-implantitis. Microbiological tests are rather unspecific regarding peri-implant mucositis and peri-implantitis.

The goal of non-surgical peri-implantitis therapy is to eliminate the clinical signs of the infection. In addition to a partial or complete reduction in bleeding on probing (BOP), an effective therapy should lead to a reduction in the depth of periodontal pockets.[6] To date, deep peri-implant pockets have not been clearly defined, but in most cases, a probing depth of less than 6 mm is considered a treatment success.[7] There are various treatment protocols used for non-surgical therapy: procedures for biofilm removal, antiseptic therapy and adjuvant antibiotic therapy. Surgical peri-implantitis treatment includes surface decontamination, adjuvant resectional therapy and, if necessary,

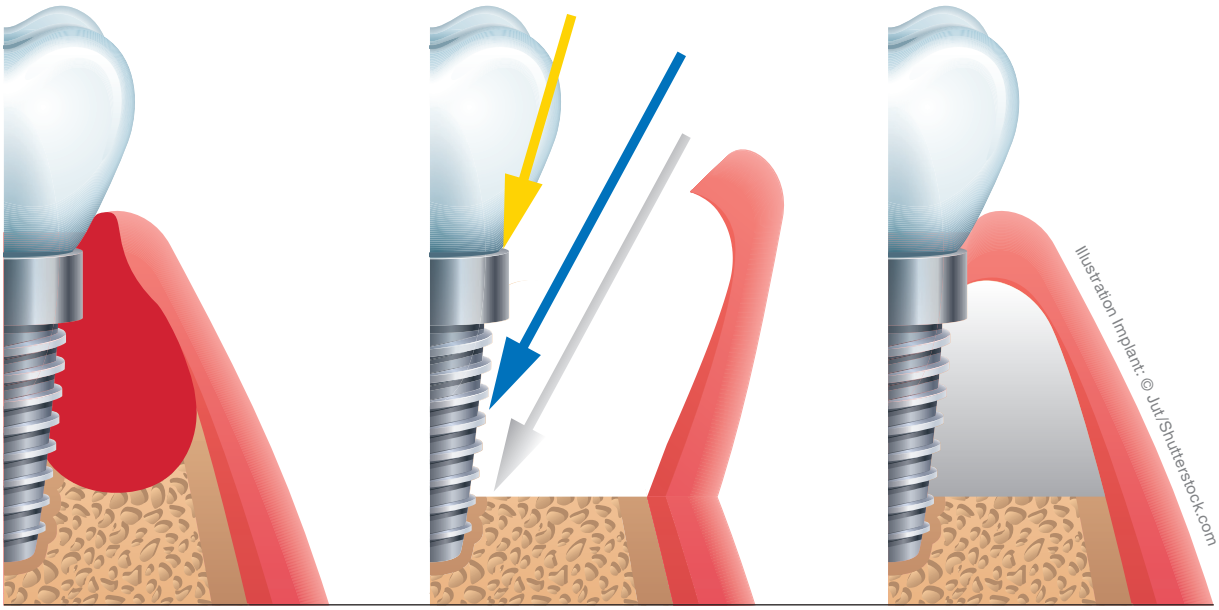

Fig. 1a: Open surgical peri-implantitis therapy with basal stemmed flap: application and operating direction of the laser for sulcular decontamination (yellow), implant surface decontamination (blue) and bone decontamination (white).

adjuvant augmentative therapy. Surface decontamination by means of a modified ultrasonic system (hydroxyapatite suspension) led to a comparable reduction in mucosal bleeding and probing depth after six months to mechanical debridement using carbon fibre or titanium curettes.[8] After an observation period of 12 months, BOP values increased again, especially in initially deep pockets.[9] In conventional flap surgery for surface decontamination, the use of special decontamination methods (e.g. 980 nm diode laser, carbon dioxide laser, chlorhexidine digluconate and cetylpyridinium chloride) did not lead to significantly better clinical or radiographic results than in the respective control groups, in which air polishing, chlorhexidine solutions and placebo solutions were used.[10, 11]

The clinical effectiveness of an adjuvant augmentative measure for flap surgery alone (titanium curettes and surface conditioning with 24 % ethylenediaminetetraacetic acid and covered wound healing for six months) was investigated in a prospective clinical study using a porous titanium granulate for treating intraosseous defect components.[12] After the primarily covered wound healing, a very high exposure rate was observed in both groups (control group: 12/16; test group: 13/16). After 12 months, both procedures showed a comparable reduction in probing depth and only minor improvements in peri-implant bleeding values. However, in the test group, a significantly higher decrease in radiographic translucency in the intraosseous defect area, as well as an increase in implant stability, was observed.[12] For advanced, complex defect configurations, surgical augmentative and resectional procedures were combined as part of an implantoplasty procedure. An implantoplasty was aimed at smoothing the macro- and microstructure of the implant body in areas outside the physiological barrier of current augmentation procedures. Augmentation (xenogeneic bone substitute material of bovine origin and a barrier membrane) was carried out only in the area of intraosseous defects, whereby the adjacent implant surfaces were preserved in their original structure, and these surfaces were decontaminated before augmentation. Over an observation period of four years, combination therapy after open wound healing led to a clinically relevant reduction in BOP and ST values. A difference between the two investigated decontamination methods was not observed.[13]

In summary, it is not possible at this point to clearly determine which protocol should be preferred, based on current literature. In the case of surgical therapy, granulation tissue should first be entirely removed. The decontamination of exposed implant surfaces should be of central importance. Mechanical procedures (for reducing biofilm) and chemical procedures (for reducing and inactivating biofilm) are often combined. At this point in time, the additional benefit of peri- and/or post-operative antibiotic therapy cannot be assessed. Analogous to the guideline for perioperative antibiotic prophylaxis, a supportive once-off administration can be done as part of surgical peri-implantitis therapy. After decontamination, augmentative measures can lead to a radiographically detectable filling of intraosseous defect components. It should be noted that all surgical therapy approaches involve a high risk of post-operative mucosal recession. Soft-tissue augmentation can be performed to stabilise the peri-implant mucosa.[14]

In addition to these general explanations based on the guidelines, a number of techniques have been described

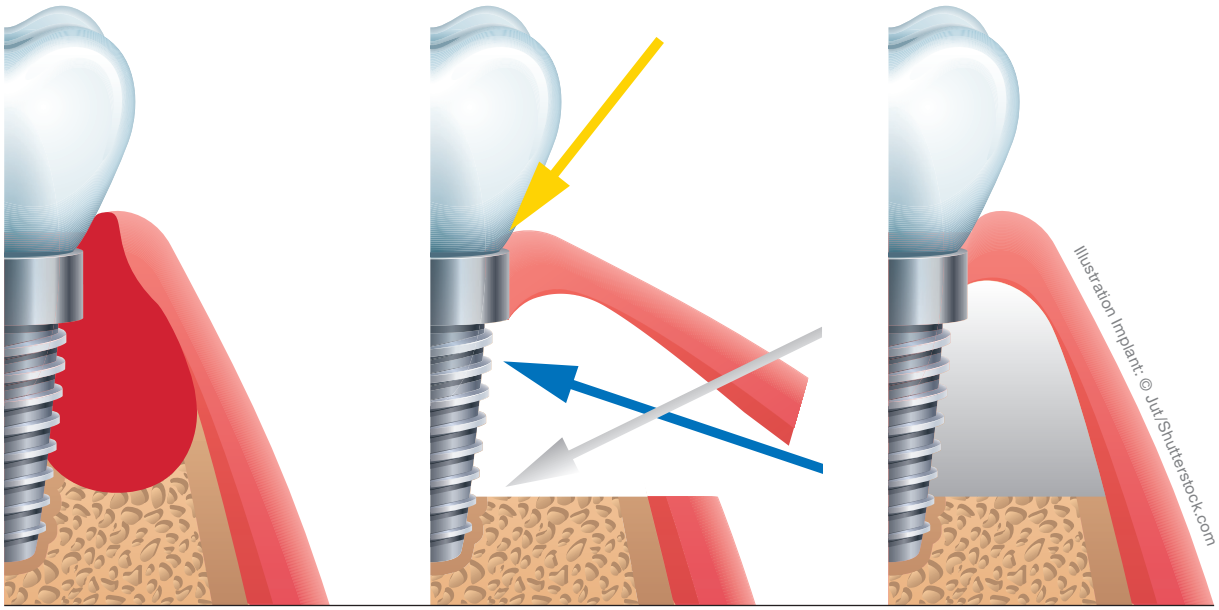

Fig. 1b: Surgical peri-implantitis therapy with closed endoscopic paracrestal tunnel technique: application and operating direction of the laser for sulcular decontamination (yellow), implant surface decontamination (blue) and bone decontamination (white).

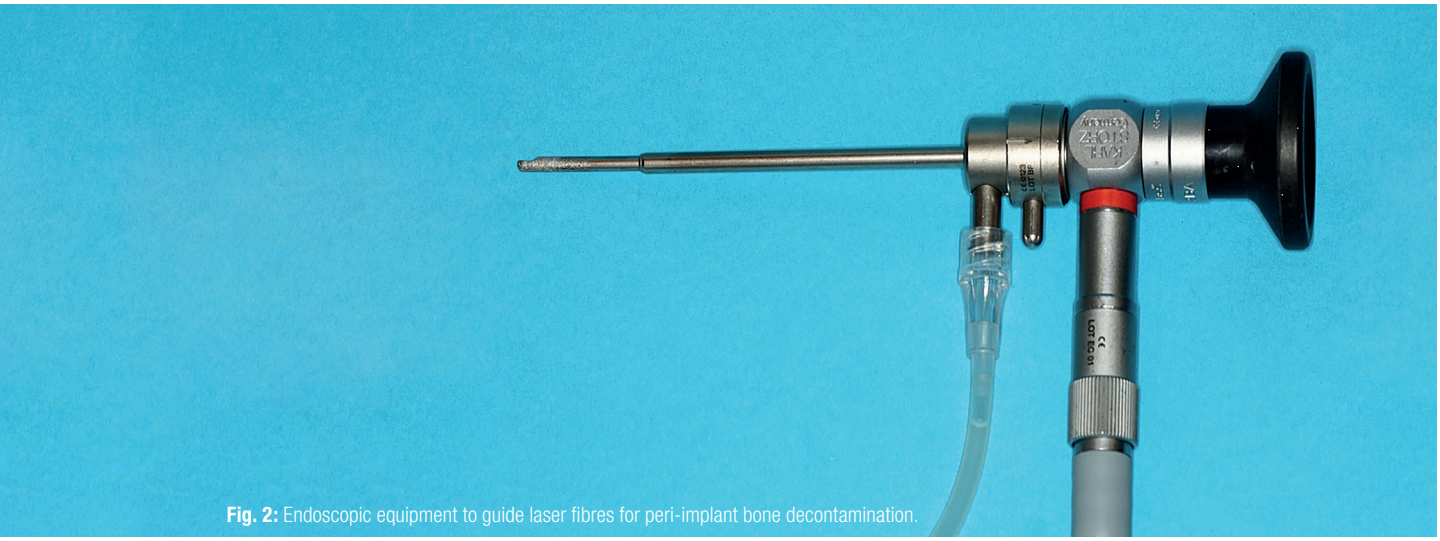

Fig. 2: Endoscopic equipment to guide laser fibres for peri-implant bone decontamination.

that could support modern peri-implantitis treatment based on a minimally invasive therapy concept, given that their concepts can be combined in order to safely decontaminate the implant surface. Kim et al. made a small labial incision with subperiosteal tunnelling for horizontal ridge augmentation.[15] They used bone grafts, which were placed in the soft-tissue pocket created by tunnelling and subsequently fixed by conventional means so that they could successfully integrate implants into the alveolar ridge in the context of a two-stage procedure.[15] Montevecchi et al. reported cases of peri-implantitis in which fibres of dental floss attached themselves to the implant superstructure and, as a result, gave rise to peri-implantitis.[16] They were able to remove these fibres using a periodontal endoscopic technique and, in doing so, promote healing. The healing was confirmed over a six-year period. An endoscopically supported therapy in implant dentistry was described by our working group for implant cavities and for sinus floor augmentation in a closed procedure.[17,18] In this context, a tunnel technique was carried out laterally for the augmentation of the sinus floor, in which the entire basal maxillary sinus mucosa was detached and tunnelled through without having to cut a bony window, which made the procedure less invasive.

In 2003, Sennhenn-Kirchner and Engelke reported on a procedure in which peri-implantitis can be successfully treated by endoscopic tunnelling and the use of a diode laser.[19] The laser is used for decontaminating the exposed implant surfaces, followed by augmentation of the peri-implant bone defects.[19] The authors found that radiographic defect filling and a reduction in probing depths can be achieved, with no post-operative infections and no augmentation losses observed in five patients with eight implants.[19] Prior to the operation which their research is based on, the probing depths were deeper than 6 mm and, afterwards, between 3 and 4 mm.[19] Sennhenn-Kirchner and Engelke emphasised the satisfaction of the patients owing to the minimally invasive nature of the procedure.[19] However, there has not been a good solution, thus, far to the problem of accessing contaminated and infected implants, since most endoscopes do not feature working shafts particularly designed for this kind of application. This paper presents a concept that allows for targeted and visually controlled implant decontamination, removal of granulation tissue and simultaneous augmentation without the need for open-flap reflection.

Case report

A 48-year-old female patient presented with an in alio loco placed exposed titanium screw-retained implant. Upon examination, a triangular bony defect situation was noted, extending into the middle third of the implant. In addition, there was secretion of pus. Upon pressure, the patient experienced a feeling of tension and local pain. Explantation of the implant and bone regeneration measures for the purpose of a new restoration were discussed. Various possible treatment protocols were explained to the patient, and minimally invasive microsurgical treatment using the tunnel technique was proposed. The patient was thoroughly informed about possible risks and the overall problematic prognosis. In the tunnel technique, the implant surface is reached through an entrance fashioned away from the implant, without interrupting the continuity of the peri-implant tissue cuff. In order to gain an optimal view in the tunnelled area throughout the procedure, support immersion endoscopy is used (Fig. 1b).

The operation was performed via a mesial tunnel entrance outside the surgical field and under local anaesthesia. After access away from the implant through a vertical mucosal periosteal incision, subperiosteal tunnelling was performed up to the affected implant. The surface of the implant was visualised by advancing the endoscope

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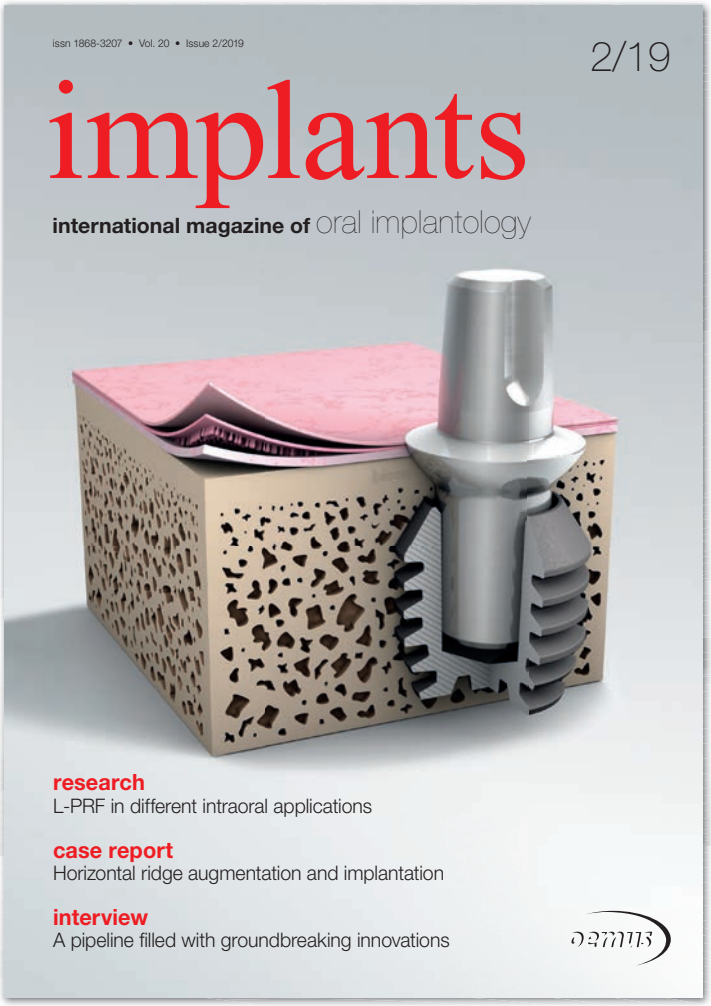

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while perfusing the tunnel with a sterile sodium chloride solution. The gingival cuff could be mobilised towards the occlusal plane via a high vestibular periosteal slit. Granulation tissue was removed and the implant surface decontaminated under direct endoscopic vision without irrigation. Decontamination was done with a GaAlAs laser set at 1 W and at a wavelength of 809 nm (Fig. 3). The exposure time was 20 seconds. Four repetitions in contact mode were enough to produce sterile conditions.[20] After filling the defect with tricalcium phosphate ceramic and locally obtained autogenous bone particles, the minimally invasive access was closed with two button sutures. The post-operative medication consisted of an analgesic (paracetamol, 500 mg, if necessary) and a single dose of antibiotic (clindamycin, 600 mg). The post-operative course was inconspicuous, and the augmentation height showed that the defect had been completely regenerated. In the re-entry to expose the implant after four months, a complete bony covering of the implant could be observed vestibularly (Fig. 4). The prosthetic restoration was performed by the family dentist.

Discussion

The concept of microsurgical peri-implant bone regeneration using the tunnel technique complies with the DGI/DGZMK guidelines and has two significant advantages: firstly, the cervical gingival cuff around the implant is preserved, and secondly, augmentation material can be securely positioned in a zone of optimal perfusion through the local periosteum. This significantly reduces the risk of post-operative recession and promotes bone regeneration. Support immersion endoscopy allows a minimally invasive approach away from the implant. The different types of support and irrigation shafts allow preparation under immersion. Blood and secretion are immediately removed by the irrigation flow and do not interfere with the preparation of the operation site. After exposure of the infected part of the implant surface inside the tunnel, laser decontamination should be done in an aerobic environment, reducing heat generation and, thus, allowing for targeted decontamination. Using intermittent irrigation, the operating field can be freed from detritus and secretion at any time. Finally, surface decontamination is done in the open operation area. The size of the tunnel entrance and its localisation can be reduced to such an extent that large-area detachment of the flap and basal flap extension by periosteal slitting can be avoided without compromising visualisation of the contaminated implant surface.

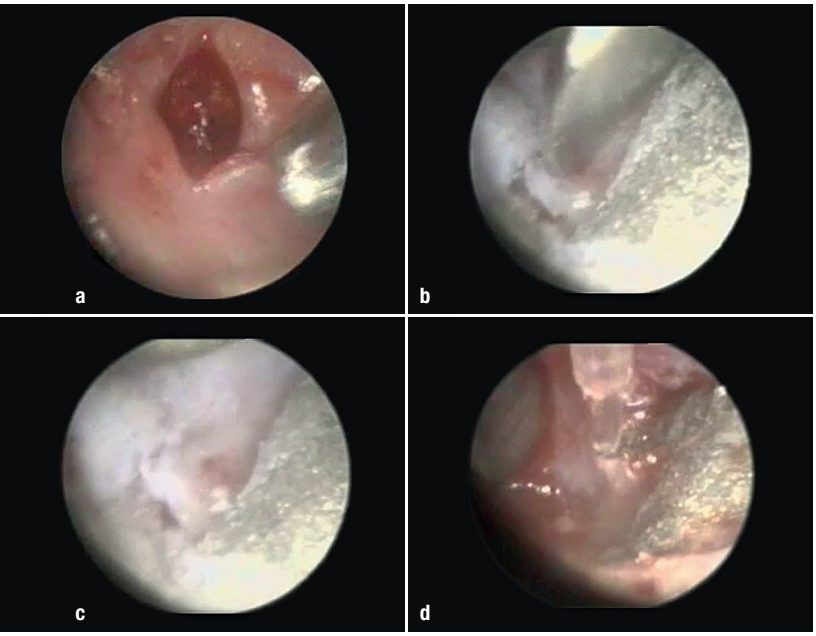

Fig. 3: Intra-op situation: **(a)** mucosal incision away from implant, **(b)** vestibular mucosa, **(c)** laser fibre in the fundus of the bone pocket (immersion), **(d)** decontamination of the bone pocket (without immersion).

Bleeding in the tunnel can be stopped by means of vasoconstrictors or direct laser coagulation so that an optically perfect assessment of the critical parts of the bone pockets is possible using support immersion endoscopy. Removal of granulation tissue with a laser has the advantage that a low-bleeding preparation technique facilitates the precision of the subsequent steps significantly. This advantage of the endoscopic technique can also be used for tunnel procedures in primary bone augmentation, allowing reliable intraoperative quality control of the microsurgical measures even without flap reflection. If dealing with fixed implants, it is not advantageous to remove the superstructure before the operation, since the operating direction is apical. Removal should only be carried out in pathological situations, for example inaccuracies in fit. In the case of extensive interdental or oral defects, multiple tunnelling sessions might be necessary. Their indication should be clarified beforehand by means of 3D imaging. In the case that is described in this article, 3D diagnosis was not desired by the patient. Based on the extensive experience of the authors with the described procedure, it can be stated that the tunnelling of apicoapproximal peri-implantitis is advantageous for the majority of referred peri-implantitis cases and that the frequency of dehiscence may be significantly reduced by modifying the approach.

The recommended treatment sequence for the peri-implantitis therapy described in this article is as follows:

- Granulation tissue is first removed completely.
- The implant surfaces exposed in the tunnel are safely decontaminated.
- After decontamination, suitable augmentative procedures are performed for radiographically detectable filling of intraosseous defects. The choice of suitable procedures depends on the clinician's experience. The use of bone block grafts can also be considered if the tunnel entrance is wide enough.

In all surgical therapy approaches without preservation of the cervical peri-implant gingival cuff, there is a high risk of post-operative mucosal recession. Only through systematic comparative investigations of the influence of soft-tissue surgery with and without preservation of the cervical gingival cuff can solid data be obtained in order to adequately evaluate the influencing parameters. The microbial analysis of implant surfaces shows a significant relation between peri-implant infections and the number of microorganisms on the surface. Therefore, laser treatment units should be considered for treating such cases owing to their inherent and well-documented disinfection potential. The visually controlled implant surface decontamination with a laser has a clear advantage over the closed application of a laser in the periodontal pocket, since clinically problematic areas can be treated with better visualisation. In addition, carbonised tissue and necroses can be easily and safely ablated during surgery. Up to this point, surface smoothing of the implant was usually not necessary owing to the augmentation in the closed tunnel procedure, as regeneration was aimed for. The re-entry image shows that regenerate had formed on the initially exposed and visibly contaminated rough implant surface, effectively preventing recession.

Guiding the laser fibre via an apical tunnel entrance allows for the cervical gingival cuff on the implant to be altered as little as possible. The procedure described in this article can also be used on implants prior to their definite exposure if it becomes apparent that the cervical vestibular bone lamella is insufficiently dimensioned and requires secondary augmentation. In addition, apical tunnel access can be gained in all stages of a prosthetic restoration without changing the soft-tissue situation in contact with the superstructure. The tunnel boundaries should be fashioned in such a way that outflow of the augmentation material is prevented and the placement of the augmentation material is gradually controlled endoscopically. In this context, form stability of the augmentation material, as recommended by manufacturers of biomaterials such as GUIDOR easy-graft (Sunstar Suisse), is very important. If followed, a certain overcontouring in the crestal area can be achieved. The relocation of tissue required for this is determined by the particular type of defect. With concave alveolar ridges, the restoration up to overcontouring of the original ridge volume can mostly be easily achieved. In some cases, however, the coronal relocation of the soft-tissue cover should be supported by a basal periosteal slit.

Conclusion

Practitioners who consider using the described technique can safely assume that the minimal invasiveness of the procedure is highly appreciated by patients. Furthermore, the number of post-operative complaints is considerably lower compared with those with open procedures.

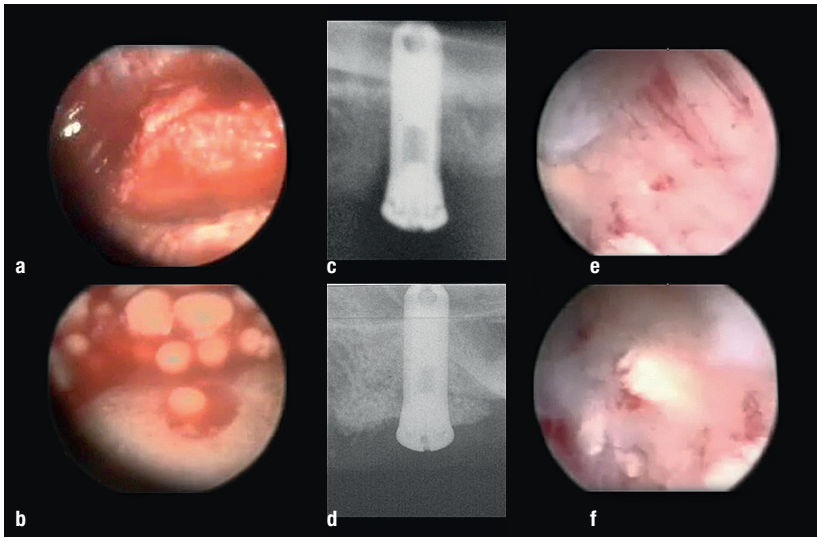

Fig. 4: Intra-op situation: augmentation with autologous bone material **(a)** and tricalcium phosphate augmentation material **(b)**. Radiographic findings: pre-op **(c)** and post-op site **(d)** on the tooth film, clear filling of the defect. Re-entry after four months: implant surface covered by bone **(e)** with residue of bone replacement material **(f)**.

In order to finally assess the clinical value of this procedure with regard to compliance and the post-operative healing period, however, extensive, preferably prospective, randomised studies are required.

Literature

about the author

Prof. Wilfried Engelke works as a private practitioner in a joint practice in Göttingen in Germany. He is specialised in oral surgery and implantology. In addition, he is head of the DZOI "Curriculum Implantologie". In 1996, he was appointed Professor and since then, he has been giving lectures not only at the Medical Faculty of the University of Göttingen, but at Universities all around the globe.

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