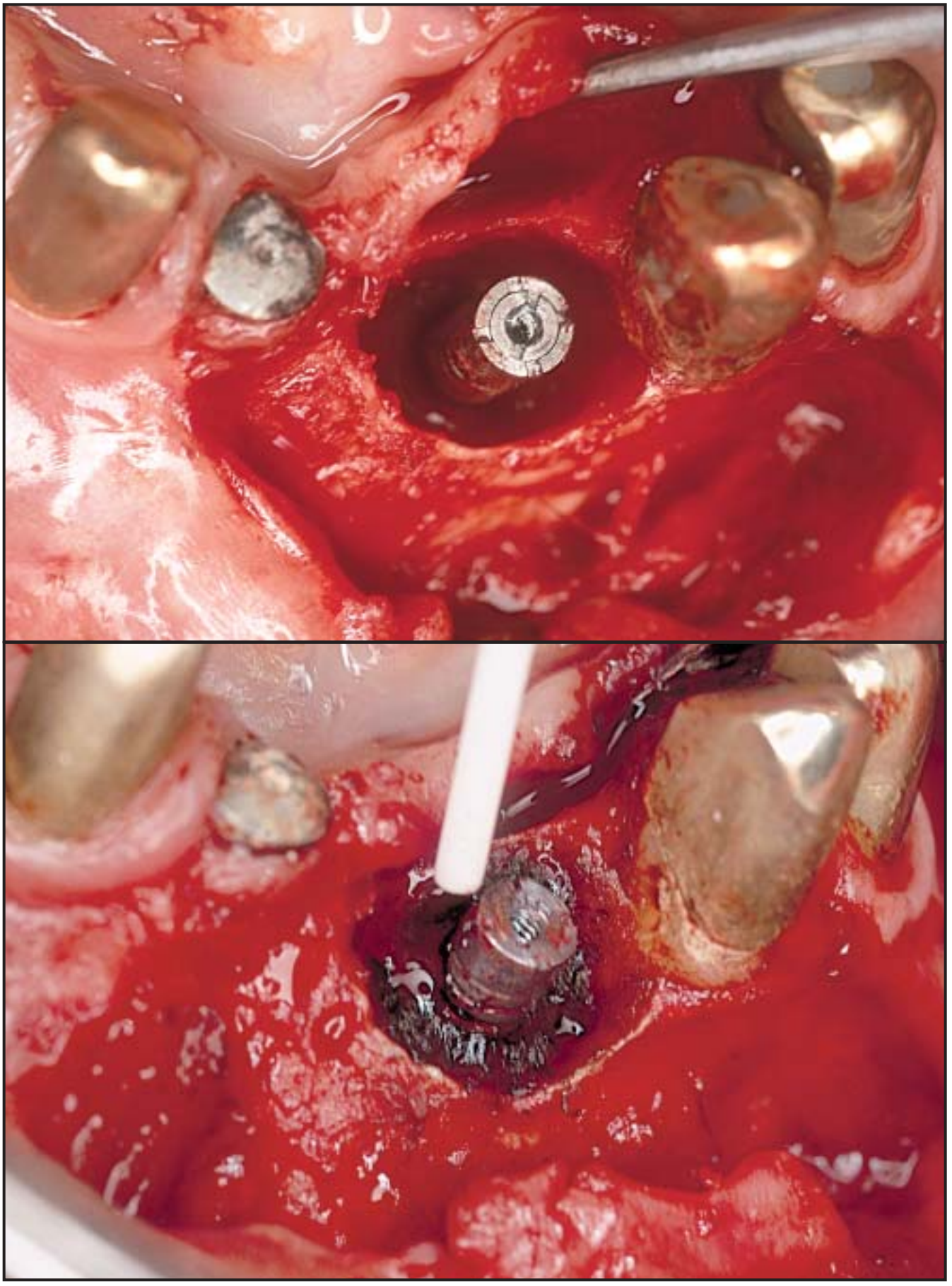
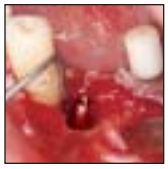


Regenerative Therapy of Deep Peri-implant Infrabony Defects After CO_2 Laser Implant Surface Decontamination



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*Georg H. Nentwig, DMD, Dr Med Dent, PhD***

The treatment of a peri-implant infrabony defect is difficult because of contamination of the implant surface and adjacent tissues. This case series addresses the ability of a carbon dioxide (CO_2) laser to decontaminate failing implants in 15 patients. Clinical and radiologic data are presented with regard to using the laser in combination with bone grafting and a barrier. Augmentation with autogenous bone grafting material (n = 10) or a xenogenic bone grafting material (BioOss) (n = 9) was used, and bone grafts were covered with a collagen membrane. Clinical and radiologic parameters were evaluated postoperatively. After an observation period of 27 months (± 17.83), almost complete bone fill in the peri-implant defect was accomplished. These preliminary clinical and radiologic findings suggest that decontamination of the implant surfaces with the CO_2 laser in combination with augmentative techniques can be an effective treatment method for peri-implantitis. (Int J Periodontics Restorative Dent 2008;28:245–255.)

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Today, a large number of endosseous implants are being placed, usually with a high survival rate.[1] However, over a 5-year period, 0% to 14.4% of dental implants demonstrate peri-implant inflammatory reactions associated with crestal bone loss.[2] In general, there is a dearth of data regarding how to manage peri-implantitis.[3]

To cease bone loss caused by peri-implantitis and attain regeneration around implants, decontamination of the implant surface is necessary.[4–6] Ideally, bone-to-implant contacts should be increased, and implants should become reosseointegrated. At present, there is no evidence regarding the utility of anti-infective treatment to prolong the longevity of an implant. There is also insufficient evidence to support any specific treatment strategy for peri-implantitis.[7,8]

Numerous treatments have been recommended, and various methods of implant decontamination have been reported.[9] Guided bone regeneration has been used for the treatment of peri-implant bony defects[5,10,11]; however, this procedure has limited predictability.[12] In general, peri-implant bony defects are characterized by poor

bone regenerative capacity adjacent to contaminated implant surfaces.[13] Currently, there are no clinical studies or case series documenting successful regenerative procedures in peri-implant bony lesions. Some cases series have demonstrated limited bone fill after guided bone regeneration procedures.[4] To enhance these results, investigators suggested that it would be necessary to decontaminate ailing implant surfaces.[4,14] Subgingival irrigation with local disinfectants was used,[14–16] and local antibiotic therapy with tetracycline fibers was employed, but neither treatment provided a conclusive therapeutic effect.[17] Systemic antimicrobial administration of antibiotics was used in the treatment of peri-implantitis; however, the results were limited because of resistant strains of bacteria and ineffective drug dosages.[18,19] In contrast, encouraging results were reported using a carbon dioxide (CO_2) laser in dogs as a decontamination device to improve reosseointegration.[20] This animal study suggested that the laser may be an effective therapeutic modality in the treatment of peri-implantitis. Thus, in humans, it was decided to evaluate clinically and radiologically the prognosis of failing implants with deep infrabony defects that were decontaminated with the CO_2 laser, augmented with grafting material, and covered with a membrane.

Method and materials

Fifteen patients (five men, ten women; mean age: 57.21 ± 12.14 years) manifesting 19 deep peri-implant infrabony defects were treated in the Department of Oral Surgery and Implantology of the University of Frankfurt, Frankfurt, Germany. The implants were not mobile and showed bone loss over two thirds of their length. Four implants that were originally submerged, uncovered, and restored were included in the study. These implants developed peri-implantitis after the final prosthetic restoration was placed. The other 15 implants were submerged, and developed peri-implantitis before being uncovered and restored. These implants were considered early failures. Clinical and radiologic parameters were evaluated before surgical intervention to determine the need for defect augmentation. The Plaque Index and Sulcus Bleeding Index were recorded before surgery. The mean probing depth was 6.0 ± 2.03 mm. The width of the keratinized mucosa was 2.30 ± 1.45 mm before surgery. Bone loss was recorded as horizontal or vertical loss.

Surgical technique

A full-thickness mucoperiosteal flap was elevated after local anesthesia to facilitate implant exposure and gain access to peri-implant bony defects. Granulomatous tissue was removed using titanium curettes. Intraosseous defects had a mean probing depth of 6.95 ± 1.84 mm. A CO_2 laser (SC 20, Weil Dental or Smart US-20D, DEKA) was used to irradiate the exposed implant surfaces for a total period of 1 minute. The power setting was 2.84 ± 0.83 watts, which promoted blood coagulation in the bony defect. The coagulum formed as a result of the laser irradiation and remained as a clot

Table 1 Peri-implant defects according to treatment

Patient	Age (y)	Site (FDI)	Implant	Defect (mm)	Defect morphology	Graft material	Power setting (W)
1	5	34	Ankylos	7.0	1-wall	BioOss	2
2	24	35	Ankylos	8.0	1-wall	Autogenous bone	3
3	50	36,37	ITI	6.6	1-wall	Autogenous bone	2
4	73	34	Ankylos	10.0	3-wall	BioOss	4
5	53	36, 37	IMZ	8.8	2-wall	BioOss	4
6	77	46	Ankylos	7.0	1-wall	Autogenous bone	3
7	57	34	Ankylos	7.0	1-wall	Autogenous bone	2
8	45	23	Ankylos	8.0	2-wall	BioOss	2
9	63	11	Ankylos	12.0	2-wall	BioOss	2
10	58	36,37	Ankylos	9.4	2-wall	BioOss	3
11	72	45	ITI	4.0	3-wall	Autogenous bone	2
12	49	15	Ankylos	6.0	2-wall	Autogenous bone	2
13	58	34	Ankylos	11.0	2-wall	BioOss	2
14	58	46,47	Ankylos	8.8	1-wall	Autogenous bone	3
15	65	32	Ankylos	12.0	3-wall	Autogenous bone	4

in the defect. Ten bony lesions were augmented with autogenous bone. Bone was taken from the chin, ramus, or tuberosities. The harvested bone was milled with a bone mill. Nine defects were augmented with a cancellous bone grafting material (BioOss, Osteohealth) (Table 1). The augmented sites were covered with collagen membranes (BioGide, Osteohealth), and the membranes were fixed in place with titanium pins (Frios, Friadent). Mucoperiosteal flaps were closed with 4-0 silk sutures (Resorba). No systemic antibiotic therapy was used preoperatively or postoperatively.

Four implants were loaded with the final restorations immediately after the augmentation procedure, while the remaining 12 implants were submerged after bone augmentation. Sutures were removed 1 week after surgery. Reexamination of the implants was performed at 1 month and 3, 6, and 9 months and then once a year for the entire observation period. Clinical and radiologic parameters were evaluated at each recall visit over the entire observation period using conventional radiographs (panoramic or periapical) (Figs 1 to 3).

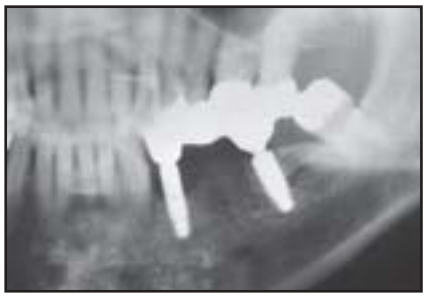
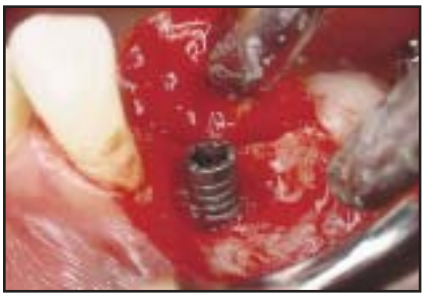


Fig 1a (left) *Radiologic bone loss extending to the middle third of the implant.*

Fig 1b (right) *Peri-implant bony destruction.*



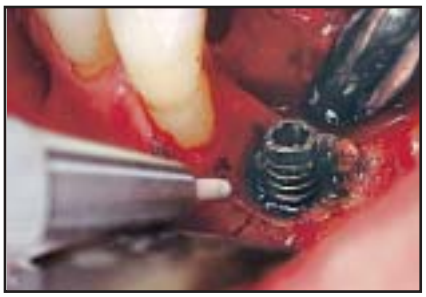


Fig 1c (left) *Irradiation of the implant surface with a CO_2 laser (noncontact).*

Fig 1d (right) *Radiograph 35 months postoperatively showing no bone loss.*

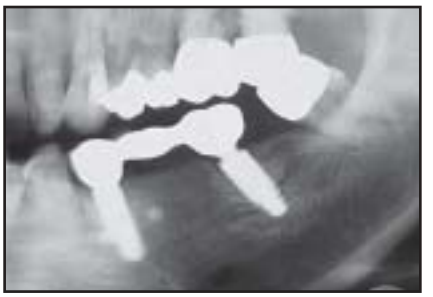


Fig 2a *Infrabony defect (12 mm).*

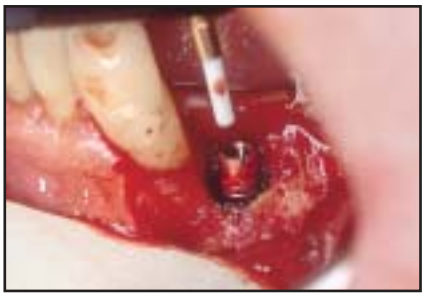


Fig 2b *CO_2 laser irradiation of the infrabony defect (noncontact).*

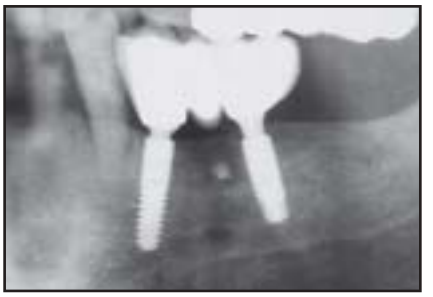


Fig 2c *Complete bone fill after 1 year of implant loading (1.5 years after surgery).*

Results

After an observation period of 27.10 ± 17.83 months, all implants were examined clinically and radiologically. No peri-implant inflammatory reaction (eg, bleeding or suppuration) was noted during the observation period (Table 2). Clinical parameters such as Sulcus Bleeding Index and probing depth presented a significant reduction during the examination period ($P < .01$) (Table 2). No significant difference was found in terms of Plaque Index or width of keratinized mucosa during the total observation period (Table 2). Complete bone fill was radiologically observed in all defects (Table 3) after the use of the xenogenic bone grafting material (BioOss). In all sites treated

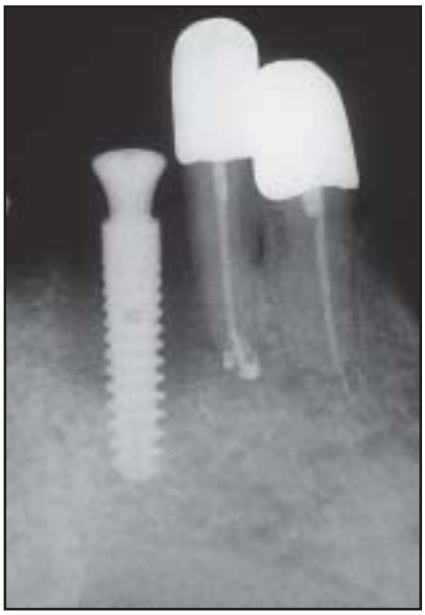
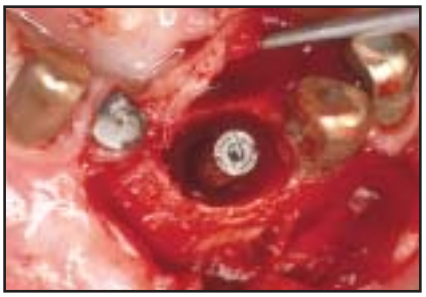


Fig 3a (left) *Radiolucency during the implant healing period.*

Fig 3b (right) *Circumferential infrabony defect immediately before decontamination.*



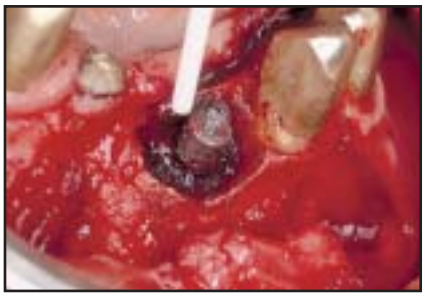


Fig 3c *CO_2 laser irradiation of the defect for sufficient decontamination.*

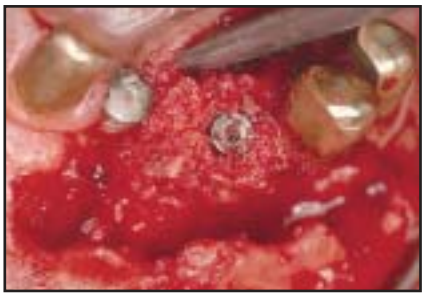


Fig 3d *Augmentation of the defect with autogenous bone.*

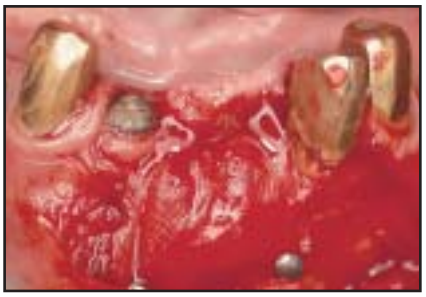


Fig 3e *Coverage of the augmented area with a collagen membrane (Biogide) and fixation with titanium pins.*

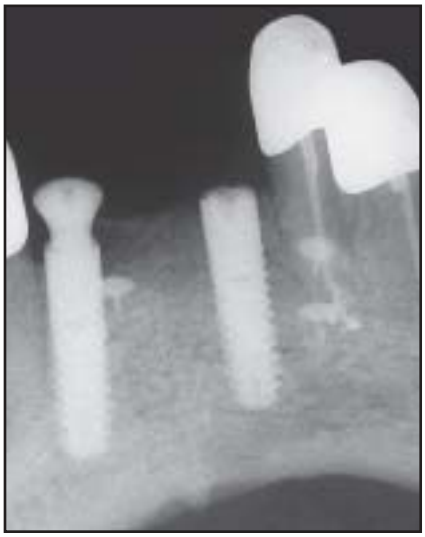


Fig 3f (left) *Complete bone fill 2 months after surgery.*

Fig 3g (right) *Bone fill after 2 years of loading (observe the resorption of the autogenous bone grafting material at the top of the machined-surfaced implant.*

Table 2 Clinical indices before and after laser irradiation and augmentation

	Preoperative	Postoperative	*P*
PI	1.01 ± 1.37	0.98 ± 1.20	NS
SBI	2.76 ± 0.35	1.03 ± 0.85	< .01
PD (mm)	6.00 ± 2.03	2.48 ± 0.63 mm	< .01
KM (mm)	2.30 ± 1.45	2.41 ± 1.39 mm	NS

PI = Plaque Index; SBI = Sulcus Bleeding Index; PD = probing depth; KM = width of keratinized mucosa; NS = no significance.

Table 3 Vertical bone loss in the peri-implant bony defects*

	No. of defects	
Bone loss	Preoperative	Postoperative
0–2 mm	0	13
1/3 of implant length	8	6
2/3 of implant length	7	0
To the apical area	4	0

*Follow up: 27.10 ± 17.83 months.

Table 4 Studies on the treatment of peri-implantitis

Study	Type	No. of implants	Decontamination	Bone fill	Reosseointegration
Grunder et al (1993)	Animal (dog)	20 (Screw-vent)	Air flow + membrane	—	—
Jovanovic et al (1993)	Animal (dog)	30 (Brånemark, IMZ, Integral)	Air flow + citric acid	+	Not stated
Ericsson et al (1996)	Animal (dog)	30 (Brånemark)	Amoxicillin + metronidazole (systemic) for 3 wk	—	—
Wetzel et al (1999)	Animal (dog)	41 machined and TPS or SLA (ITI)	Systemic antibiotic (Metronidazole) + cleaning + CHX	60%–80%	0.1 mm (smooth)/ 0.6 mm (rough)
Bach et al (2000)	Clinical	Not stated (20 patients)	Cleaning, CHX, 810 nm Diode laser	11%/30% recurrence (test/control)	Not stated
Behneke et al (2000)	Clinical	25 (ITI)	Air flow + bone graft + systemic Antibiotics	86% in 3 mo 100% in 3 years	Not stated
Haas et al (2000)	Clinical	24 (IMZ)	Systemic antibiotics, soft laser + membrane + bone graft	+	—
Deppe et al (2001)	Animal (dog)	35 (PVS) 32 (LAS) 34 (LAS + PVS)	CO_2-laser vs PVS and LAS + PVS	PVS: + LAS: +++ PVS+LAS: ++	Not stated
Persson et al (2001)	Animal (dog)	24 ITI (Turned/SLA)	Systemic antibiotics + irrigation with NaCl	Turned: 72% SLA: 76%	Turned: 22% SLA: 84%

with only autogenous bone graft, at least two thirds of the bony defect was filled with bone because of some bone graft resorption over time.

Discussion

Nonsurgical methods to treat peri-implantitis include mechanical instrumentation and use of a variety of antibacterial agents. The use of curettes or ultrasonic instruments in the treatment of peri-implantitis has been criticized because such tools may damage the implant surface.[21–23] Alternative treatment protocols with antibiotics for the treatment of peri-implantitis do not lead to sufficient bone fill or reosseointegration (Table 4).

Animal studies,[5,10,13,24–27] clinical case reports,[6,28] and two clinical studies with larger groups of patients[29,30] have addressed the surgical treatment of peri-implant bony defects. However, no treatment method attained excellent results. Other studies recommended apically positioning the flaps for better plaque control and polishing the threads of implants, especially when wide bony defects are present.[11,31,32] However, such treatment methods are associated with cosmetic problems in the esthetic zone. Citric acid and sandblasting,[11,25] sandblasting alone,[24,30,33] or chlorhexidine irrigations[27] have also been recommended. These methods seem to be as effective as using curettes or ultrasonic instruments for the treatment of peri-implant lesions, although implant decontamination using sandblasting units may be associated with risks such as emphysema.[34]

In a clinical study by Khoury and Buchmann,[35] no differences were found when citric acid and systemic antibiotic therapy were used for implant decontamination prior to bone grafting with or without membrane coverage. Persson et al[36] treated peri-implant bony defects in animals with local irrigation of sodium chloride (NaCl) solution in combination with systemic administration of amoxicillin and metronidazole. Turned (polished) surfaced implants showed 22% reosseointegration, while sand-blasted, large grit, acid-etched implants demonstrated 84% reosseointegration.

The present series of clinical cases with deep peri-implant infrabony defects showed extensive bone fill 27 months after laser decontamination and bone augmentation. Using the described protocol, the authors were able to decontaminate the implant surface efficiently and augment infrabony defects with either autogenous bone or bone grafting materials. The good coagulation properties of the laser allow for excellent stabilization of the clot in combination with the graft in close contact with the implant surface, which is necessary to promote reosseointegration. The defects treated had a mean depth of approximately 7 mm. Treatment was accomplished without inducing recession. Furthermore, both osseous fill and reosseointegration were achieved. This conclusion is supported by the histologic observations by Deppe et al[20] and Stübinger et al,[37] who note that reosseointegration occurred when bone fill was induced around peri-implant defects.

The ability of lasers to reduce the bacterial challenge around implants has been previously documented. Several studies demonstrated a significant reduction of periodontopathogens in vitro after use of CO_2 lasers.[38,39] A 810-nm diode laser,[40,41] an erbium-doped yttrium aluminum garnet (Er:YAG) laser,[42] and a 905-nm soft laser combined with photodynamic therapy[43] also decreased bacterial levels after laser therapy. The physical properties of laser light and its interactions with the tissues—such as reflection, scattering, transmission, and absorption—explain why the implant surface may be decontaminated in all areas as well as within the threads. The light, along with its antibacterial effects, may be absorbed by the implant and adjacent surrounding tissues or may be reflected by the metal

surface, causing a slight rise of tissue temperature.

The CO_2 laser does not damage the implant surface[38,44] during irradiation compared to other laser systems, such as the neodymium (Nd):YAG,[44] Er:YAG,[45] or diode 810-nm (unpublished data) if the correct power and frequency are used. The CO_2 laser (continuous or pulsed mode) does not modify the implant surface in the power range of 2.0 to 6.0 watts. Melting or loss of porosity was not found in titanium implants.[44] Currently, the only alternative to the CO_2 laser seems to be a diode laser with 980-nm wavelength, which also does not cause dramatic changes during laser irradiation.[46] Data regarding other laser systems are lacking.

It has also been noted that irradiation of the implant does not significantly increase the temperature of the implant body[47–50]; therefore, osteoblastic activity and soft tissue attachment may not be compromised.[51] Kato et al[38] noted a slight temperature increase, which did not negatively influence attachment of fibroblasts or osteoblastic cells on the implant surface. With regard to the impact of the laser on the surrounding tissue of the implant, there is decreased penetration depth due to absorption of the CO_2 radiation by the high water content of the mucosa.

Several authors indicated that low-intensity lasers[43,52,53] and high-intensity lasers[20,42,54,55] are useful for treating peri-implant defects. The application of toluidine blue and irradiation with a diode soft laser and a wavelength of 905 nm for 1 minute caused a significant reduction of the periodontopathogens in the peri-implant bony defects.[43] However, there are no histomorphometric data showing new bone formation and osseointegration after the use of this laser wavelength.

Conclusion

This case series confirms that the use of a CO_2 laser in the treatment of peri-implantitis deserves consideration as an efficacious treatment modality. There appears to be little risk to the patient; however, special training of the surgeon is necessary regarding safety procedures and laser-tissue interactions. In addition, the costs of the laser unit and the wavelength must be considered. Along with decontamination of implant surfaces, the CO_2 laser has been used for soft tissue surgery,[56] surgery in the periodontal tissues,[40] or endodontic treatment,[57] and thus has various clinical applications in a private clinic.

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