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# Two-year clinical outcomes following non-surgical mechanical therapy of peri-implantitis with adjunctive diode laser application

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**Abstract**

**Background:** Non-surgical mechanical therapy of peri-implantitis (PI) with/without adjunctive measures yields limited clinical improvements.

**Aim:** To evaluate the clinical outcomes following non-surgical mechanical therapy of PI with adjunctive application of a diode laser after an observation period ≥2 years.

**Material and methods:** At baseline (BL), 15 patients with 23 implants with a sandblasted and acid-etched (SLA) surface diagnosed with PI were enrolled and treated. PI was defined as presence of probing pocket depths (PPD) ≥5 mm with bleeding on probing (BoP) and/or suppuration and ≥2 threads with bone loss after delivery of the restoration. Implant sites were treated with carbon fiber and metal curettes followed by repeated application of a diode laser 3x for 30 s (settings: 810 nm, 2.5 W, 50 Hz, 10 ms). This procedure was performed at Day 0 (i.e., baseline), 7 and 14. Adjunctive antiseptics or adjunctive systemic antibiotics were not prescribed.

**Results:** All implants were in function after 2 years. The deepest PPD decreased from 7.5 ± 2.6 mm to 3.6 ± 0.7 mm at buccal ($P < 0.0001$) and from 7.7 ± 2.1 mm to 3.8 ± 0.9 mm at oral sites ($P < 0.0001$), respectively. The % of implants with ≥1 site with BoP decreased from 100% at BL to 43% after 2 years ($P = 0.0002$). The % of implants with suppuration decreased from 87% at BL to 0% after 2 years ($P < 0.0001$).

**Conclusion:** Non-surgical mechanical therapy of PI with adjunctive repeated application of a diode laser yielded significant clinical improvements after an observation period of at least 2 years.

While peri-implant mucositis is defined as an inflammatory process initiated by bacterial biofilms, peri-implantitis is characterized by further loss of supporting bone (Lang & Berglundh 2011). Peri-implantitis is a disease with growing incidence (Derks & Tomasi 2015) that, if left untreated, leads to implant loss. The etiological factors of peri-implant infections are similar to those involved in periodontal diseases. Consequently, the goals of peri-implantitis treatment must be the resolution of peri-implant soft tissue inflammation and stabilization of the bony attachment (e.g., the level of osseointegration). This can only be achieved under the condition that the majority of bacterial biofilms and hard deposits are eliminated on the implant surface to create a biologically acceptable surface conducive to wound healing.

Conventional non-surgical treatment procedures of peri-implant lesions showed limited predictability (Karring et al. 2005; Renvert et al. 2008, 2009; Heitz-Mayfield & Mombelli 2014). Open flap procedures of peri-implantitis, on the other hand, show more promising outcomes (Lindhe & Meyle 2008). To achieve resolution of inflammation and arrest crestal bone loss, decontamination of the implant surface is mandatory. Decontamination of the implant surface, however, is much more challenging when compared to the decontamination of natural root surfaces. The concept of the classical periodontal treatment integrates the debridement of the root surface by means of mechanical instruments, surgical access, if required, and optimal self-performed plaque control and regular supportive periodontal therapy (SPT). Based on the fact that both periodontitis and peri-implantitis share similar etiological factors, this concept may theoretically work in the treatment of peri-implantitis as well.

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The outcomes of a randomized clinical trial demonstrated that mechanical debridement with adjunctive delivery of photodynamic therapy (PDT) in conjunction with optimal self-performed plaque control yielded improvements in clinical, microbiological and host-derived parameters of initial peri-implantitis lesions up to 12 months (Bassetti et al. 2014). Complete resolution of mucosal inflammation, however, was not routinely achieved with adjunctive PDT therapy.

Based on the characteristics of absorption of different laser wavelengths, it is known that $CO_2$ and erbium lasers absorb highly in water, diode lasers in pigments and erbium laser additionally in hydroxyapatite. These three laser systems coupled with small instruments tips fulfill the clinical requirements to decontaminate the implant surface. Results from studies using diode, $CO_2$ or erbium lasers demonstrated their antibacterial efficacy *in vitro* as well as *in vivo* (Deppe et al. 2007). The efficacy of decontamination methods of implant and tooth surfaces was investigated under several settings *in vitro* (Coffelt et al. 1997; Kato et al. 1998; Hauser-Gerspach et al. 2010; Stübinger et al. 2010). Successful clinical treatment outcomes of peri-implantitis were reported after $CO_2$ laser (Deppe et al. 2001; Romanos et al. 2006; Romanos et al. 2008) and diode laser decontamination (Bach et al. 2000), respectively. Implant surfaces with calculus deposits could also be decontaminated with an erbium laser exhibiting ideal absorption properties in hydroxyapatite and water (Schwarz et al. 2003, 2006; Sculean et al. 2005).

In a recent case report, a diode laser with an 810 nm wavelength was used in addition to non-surgical therapy around an implant with 7 mm PPD, bleeding on probing, suppuration and five threads with bone loss (Roncati et al. 2013). Treatment was completed in two consecutive 1-hour appointments within 24 h. Following active therapy, the patient was scheduled for regular supportive care every 3 months. At the 1-year examination, probing pocket depths around the implant were significantly reduced and did not bleed upon probing. After 5 years, radiographic bone fill of the peri-implant defect could be observed. Although the 5-year results of this case report look promising, evidence on the adjunctive use of a diode laser in the treatment of peri-implantitis is preliminary (Roncati et al. 2013).

Hence, the aim of this study was to evaluate the clinical outcomes following non-surgical mechanical therapy of peri-implantitis with adjunctive repeated application of a diode laser after an observation period of at least 2 years.

## Material and methods

### Study design

This was a retrospective case series study with an observation period ≥2 years. Fifteen partially edentulous patients with 23 implants diagnosed with peri-implantitis were referred by private dentists and included in this study. All patients were examined and treated by one experienced periodontist (G.R.M.) in a private practice setting in Bern, Switzerland.

### Inclusion criteria

Implants were diagnosed with peri-implantitis based on the following criteria:

-Tissue level (TL) titanium implants with a sandblasted and acid-etched (SLA) surface (Straumann® Dental Implant System, Institut Straumann AG, Basel, Switzerland)
-Implants with ≥1 site with probing pocket depth (PPD) ≥5 mm
-Presence of bleeding on probing (BoP) and/or
-Presence of suppuration
-Presence of crestal bone loss of ≥2 threads (e.g., 2.5 mm) based on periapical radiographs after delivery of the final restoration

### Assessment of clinical parameters

One examiner (G.R.M.) assessed the clinical parameters at 6 sites per implant (e.g., distobuccal, buccal, mesiobuccal, disto-oral, oral, mesio-oral) with a periodontal probe. The applied probing force ranged from 0.15 to 0.25 N. The implant shoulder was used as landmark for the calculation of the mucosal recession and probing attachment level (PAL).

The following clinical parameters were assessed at baseline (i.e., Day 0) and at the 2-year follow-up:

Probing pocket depth (PPD) expressed in mm

Probing attachment level (PAL) expressed in mm

***Table 1.*** **Demographic characteristics of the study sample at baseline**

| | |
|---|---|
| Number of patients | 15 |
| Gender (males/females) | 7 males/8 females |
| Mean age (years) (range) | 67 (56–93) |
| Current smokers | 1 |
| Non-smokers | 14 |
| Total number of treated implants | 23 |
| Implant position (maxilla/mandible) | 19/4 |
| Number of patients with 1 treated implant | 12 |
| Number of patients with 2 treated implants | 0 |
| Number of patients with 3 treated implants | 1 |
| Number of patients with 4 treated implants | 2 |

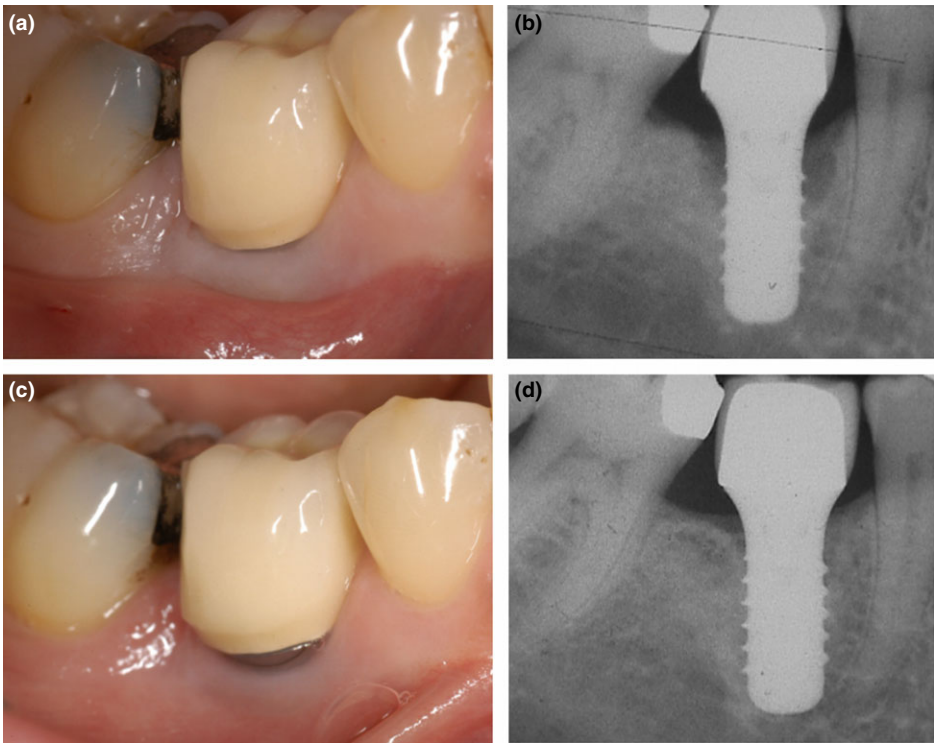


*Fig. 1.* Baseline buccal view of implant 45 with PPD ≤9 mm, bleeding on probing (BoP) and suppuration (a); baseline radiographic bone defect at implant 45 (b); buccal view of implant 45 at the 2-year follow-up with PPD ≤5 mm (c); radiographic hard tissue fill at the 2-year follow-up at implant 45 (d).

Bleeding on probing (BoP) (Lang et al. 1986) expressed in %

Presence/absence of suppuration expressed in %

The implant-supported restorations were not removed prior to the assessment of the clinical parameters and for delivery of treatment.

#### Non-surgical treatment of peri-implantitis

Case presentation and oral hygiene instructions by means of interdental brushes were performed during the first session. The implant surfaces were debrided under local anesthesia using carbon fiber curettes, and the inflamed peri-implant soft tissue wall was curetted with sharp metal curettes. After mechanical debridement, the pockets around the implants were rinsed with sterile saline solution. Adjunctive diode laser (settings: 810 nm, 2.5 W, 50 Hz, 10 ms) was applied 3x for 30 s (i.e., 90 s per appointment) using a 400-μm thick fiber (WhiteStar, Orcos Medical AG, Küsnacht, Switzerland). The entire treatment procedure, including mechanical debridement, was performed at Day 0 (= baseline), 7 and 14. The laser decontamination procedure occurred by systematically moving the laser tip along the subgingival implant surface in a vertical and horizontal scanning way. The laser tip was checked after 4–5 s for coagulation to prevent hotspots in the soft tissues. Consequently, the laser was activated for 4–5 s followed by 2–3 s of standby mode. In case of a hotspot, the fiber tip was cut-off with a scissor to avoid heat development. Adjunctive antiseptics or adjunctive systemic antibiotics were not prescribed.

#### Supportive care and clinical follow-up

Evaluation of the clinical parameters was performed 6–8 weeks after completion of active therapy. Supportive care consisted of oral hygiene monitoring and supramucosal prophylaxis by means of carbon fiber curettes and rubber cup with polishing paste. The interval was gradually increased from 1 to 6 months depending of the clinical parameters. In the cases of recurrent BoP or increase in PPD without suppuration, rescue treatment was performed. This consisted of submucosal debridement with carbon fiber curettes and adjunctive diode laser application 3x for 30 s (settings: 810 nm, 2.5 W, 50 Hz, 10 ms) (Mettraux, 2011).

#### Data analysis

The patient was the unit of analysis. Descriptive statistics present an overview of the study sample. Mean values and standard deviations (SD) were calculated for every variable at baseline and at the 2-year follow-up.

Intra-individual comparisons between baseline and the 2-year follow-up were tested using the Wilcoxon signed rank test.

The level of statistical significance was set at $\alpha = 0.05$. All statistical analyses were performed using the SAS system (SAS Institute Inc., Cary, NC, USA).

## Results

Fifteen patients with at least one implant each diagnosed with peri-implantitis were included and treated. The mean age of the patients was 67 years ranging from 56 to 93 years. Of the 15 patients, only 1 patient was a current smoker at baseline. No adverse events related to the treatment were reported. The baseline demographic characteristics of the subject sample are summarized in Table 1. Three clinical cases and their corresponding radiographs at baseline and at the 2-year follow-up are presented in Figs 1–3.

#### Pocket probing depth (PPD)

Mean PPD values ± SD at the deepest buccal and oral sites at baseline and after 2 years are presented in Table 2. At baseline, the mean PPD amounted to 7.5 ± 2.6 mm at the deepest buccal and to 7.7 ± 2.1 mm at the deepest oral sites, respectively. At the 2-year follow-up a mean PPD of 3.6 ± 0.7 mm was

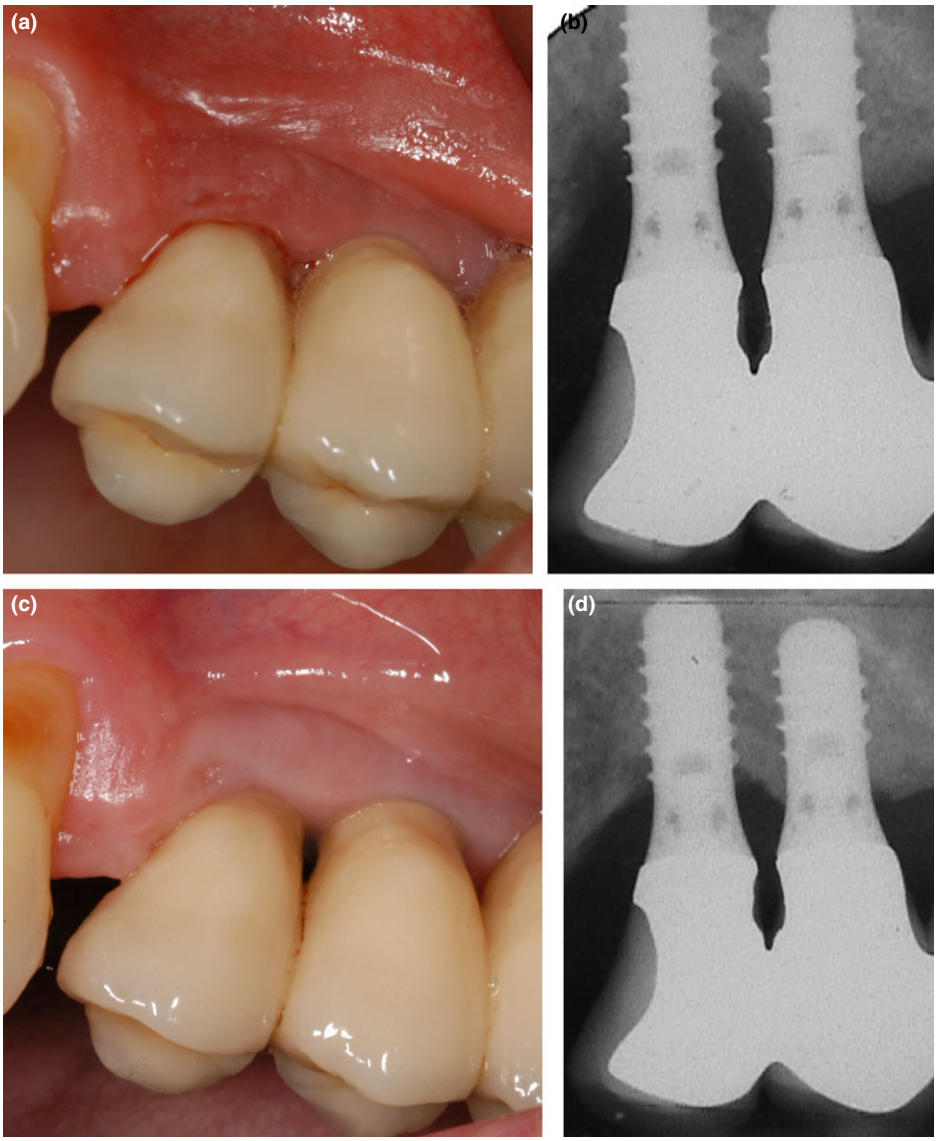


*Fig. 2.* Baseline view of implants 24 and 25 with PPD ≤8 mm, bleeding on probing (BoP) and suppuration (a); baseline radiographic bone defect at implant 24 and at the mesial aspect of implant 25 (b); buccal view of implants 24 and 25 at the 2-year follow-up with PPD ≤4 mm (c); radiographic hard tissue fill at the 2-year follow-up at implant 24 and at the mesial aspect of implant 25 (d).

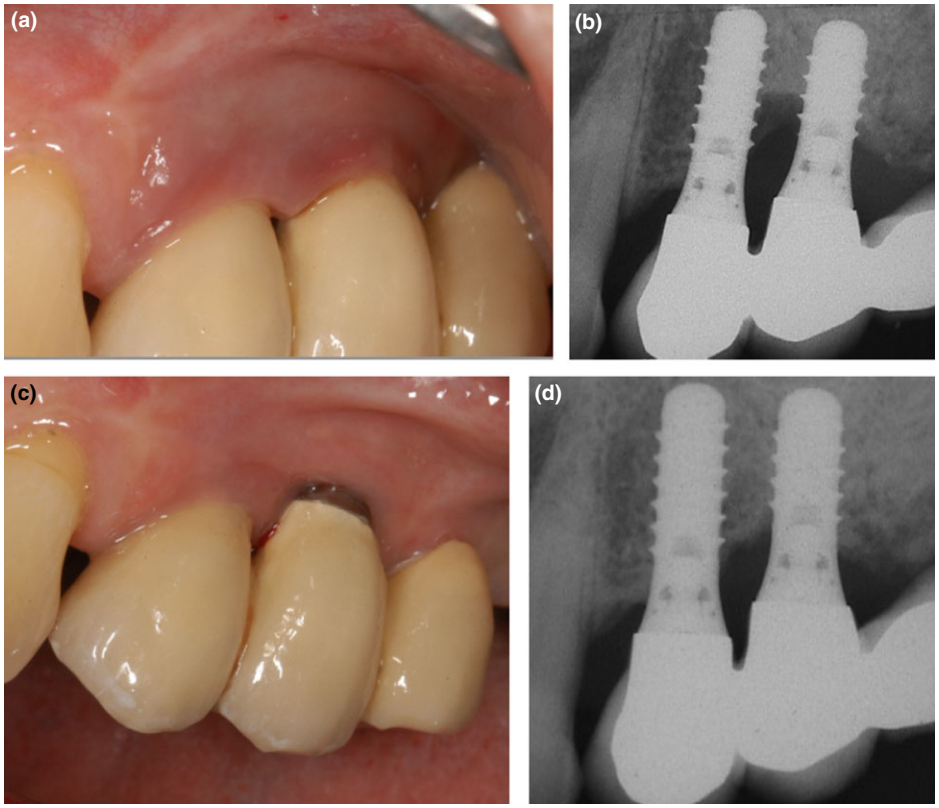


*Fig. 3.* Baseline view of implants 24 and 25 with PPD ≤7 mm, bleeding on probing (BoP) and suppuration (a); baseline radiographic peri-implant bone defect at implant 25 and at the distal aspect of implant 24 (b); buccal view of implants 24 and 25 at the 2-year follow-up with PPD ≤4 mm (c); radiographic hard tissue fill at the 2-year follow-up between implants 24 and 25 and at the distal aspect of implant 25 (d).

***Table 2.* Clinical parameters at baseline and at the 2-year follow-up**

| | Baseline | 2-year follow-up |
|---|---|---|
| Deepest PPD buccal: mean ± SD (mm) | 7.5 ± 2.6 | 3.6 ± 0.7 |
| Deepest PPD oral: mean ± SD (mm) | 7.7 ± 2.1 | 3.8 ± 0.9 |
| PAL at deepest PPD buccal: mean ± SD (mm) | 6.2 ± 2.3 | 3.4 ± 1.4 |
| PAL at deepest PPD oral: mean ± SD (mm) | 6.1 ± 1.9 | 3.5 ± 1.4 |
| % of implants with ≥1 site with BoP | 100% | 43% |
| % of implants with suppuration | 87% | 0% |

SD, Standard Deviation; PPD, Probing Pocket Depth; PAL, Probing Attachment Level; BoP, Bleeding on Probing.

observed at the deepest buccal and of 3.9 ± 0.9 mm at the deepest oral sites, respectively. At both deepest buccal and oral sites, a statistically significant reduction in mean PPD was observed ($P < 0.0001$).

#### Probing attachment level (PAL)

Mean PAL values ± SD at the deepest buccal and oral sites at baseline and after 2 years are presented in Table 2. At baseline, the mean PAL amounted to 6.2 ± 2.3 mm at the deepest buccal and to 6.1 ± 1.9 mm at the deepest oral sites, respectively. At the 2-year follow-up, a mean PAL of 3.4 ± 1.4 mm was observed at the deepest buccal and of 3.5 ± 1.4 mm at the deepest oral sites, respectively. At both deepest buccal and oral sites, a statistically significant reduction in mean PAL was observed ($P < 0.0001$).

#### Bleeding on probing (BoP) and suppuration

The % of implants with ≥1 site with BoP decreased statistically significantly from 100% at baseline to 43% at the 2-year follow-up ($P = 0.0002$). A complete resolution of BoP was detected in 57% of implants after 2 years. The % of implants with suppuration decreased statistically significantly from 87% at baseline to 0% at the 2-year follow-up ($P < 0.0001$).

## Discussion

The outcomes of the present study indicated that non-surgical mechanical debridement of the implant surface and of the soft tissue wall in conjunction with diode laser application 3 times within 2 weeks resulted in significant clinical improvements after 2 years. These results were obtained without adjunctive delivery of antiseptics or systemic antibiotics. No adverse events such as pain or swelling were reported after adjunctive diode laser application indicating that development of hotspots in the peri-implant tissues could be avoided. Although standardized radiographs were not taken, a continuous fill of the peri-implant bony defects was observed, reaching in some cases the borderline between the microrough surface and the smooth neck of the implant.

The repeated adjunctive application of the diode laser 3 times within 2 weeks resulted to be an important step of this non-surgical protocol. In conjunction with optimal self-performed mechanical plaque control, repeated diode laser application allowed to control bacterial recolonization of the pockets from the soft tissue wall and to modulate wound healing. From a biological point of view, a dual mode of action of diode laser irradiation with a wavelength of 810 nm in conjunction with non-surgical mechanical debridement may be postulated for the treatment of peri-implantitis. Firstly, as summarized in a recent review by Aoki et al. (2015), various laser types including diode lasers are able to kill bacteria through photo-thermal effects. The bactericidal effect of diode lasers due to localized increase in temperature was shown using DNA probes for the detection of periodontal pathogens (Cobb 2006).

Furthermore, low-level lasers are able to inactivate bacterial endotoxins such as lipopolysaccharides of Gram-negative bacteria involved in peri-implantitis. The diode laser with a wavelength of 810 nm used in the present study was able to decontaminate on both the implant surface and the soft tissue sides, respectively. Thus, the combination of photo-thermal and detoxification effects of diode laser application may provide additional beneficial effects in conjunction with non-surgical mechanical debridement in the treatment of peri-implantitis lesions.

Secondly, the biostimulatory property of laser therapy on hard and soft tissues is

unique and different from that of mechanical therapy (Mester et al. 1971, 1985). Although the biostimulatory effects may be associated with photochemical reactions within hard and soft tissue cells rather than with thermal effects, their underlying mechanisms are not yet fully understood. Nevertheless, biostimulation after low-level laser irradiation was shown to promote wound healing (Mester et al. 1971; Enwemeka et al. 2004), reduce inflammation (Albertini et al. 2004) and relieve pain (Björdal et al. 2006).

Thirdly, the entire treatment procedure (e.g., mechanical debridement, decontamination and biostimulation with diode laser) was performed 3 times within 2 weeks. This proved to be a crucial step, as it allowed to control bacterial recolonization of the peri-implant pockets and to promote wound healing.

In conclusion, the results of the present study indicated that non-surgical treatment of peri-implantitis lesions including mechanical debridement of the implant surface and soft tissue wall followed by repeated diode laser application with a wavelength of 810 nm resulted in significant clinical improvements for at least 2 years. These results highlight the clinical benefits of diode laser application in conjunction with non-surgical mechanical therapy.

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## Conflict of interest

The authors do not report any conflict of interest related to this study.

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