**Abstract**

**Introduction**

The prevalence of peri-implant complications will increase as dental implant-retained prostheses become routine. Peri-implant diseases are present in two forms: peri-implant mucositis and peri-implantitis. Plaque-induced mucositis is a reversible inflammation of the peri-implant gingiva and responds satisfactorily to nonsurgical treatment. It is generally accepted that mucositis will eventually give rise to peri-implantitis, with inflammation encroaching on the alveolar support. Depending on the severity of the peri-implantitis lesion, surgical or nonsurgical procedures should be implemented. Based on the diagnosis, continuously made during recall visits, a maintenance system termed cumulative interceptive supportive therapy has been followed in this manuscript, further expanding the nonsurgical protocols, including the adjunctive use of the diode laser.

Long-term maintenance care for high-risk groups is essential to reduce the risk of peri-implantitis. Informed consents for patients receiving implant treatment must include the need for such maintenance therapy. When surgical treatment is contraindicated or not accepted by the patient, it is essential to implement nonsurgical therapy, well aware, however, of unpredictable results. The aim of this methodology was to discuss the nonsurgical approaches of the treatment of peri-implantitis.

**Methodology**

Since it is universally accepted that peri-implantitis has a bacterial aetiology, decontamination of the implant surface is crucial. Based on the diagnosis, made during recall visits, a maintenance system called CIST has been followed in this manuscript, with minor adjustments and further expanding the nonsurgical protocols, including the adjunctive use of the diode laser.

**Conclusion**

This article presents a protocol for nonsurgical treatment of peri-implant defects using antimicrobials combined with a nonsurgical mechanical treatment and the adjunctive use of the diode laser.

**Introduction**

Studies have shown that the placement of endosseous implants is a predictable procedure, although dental and biological complications arise. Peri-implant diseases are not an uncommon late outcome following implant therapy. Long-term maintenance care for high-risk groups is essential to reduce the risk of peri-implantitis. With the implant survival as the main criterion for success, the majority of clinical studies showed impressive success rates for dental implants, even in combination with cantilever extensions. There is evidence of chronic inflammation of peri-implant soft and hard tissues in the range of 8.6–9.7% after 5 years, and peri-implantitis is a frequent clinical finding 10 years after implantation. Peri-implant diseases, namely peri-implant mucositis and peri-implantitis, have been extensively studied in the literature and are considered the major complication in today’s dental implantology. Peri-implant mucositis is a gingival inflammation that resides in the soft tissues, with no signs of supporting bone loss (Figures 1 and 2), and it should be routinely treated with a nonsurgical mechanical therapy (Figures 2–4), as it has been proven to successfully reduce the inflammation. Moreover, peri-implant mucositis is the precursor of peri-implantitis and should therefore be promptly intercepted, as nonsurgical interventions have been demonstrated to give good predictable treatment outcomes. Peri-implant diseases have always been associated with the presence of a biofilm. Therefore, removal of the biofilm is essential to prevent, manage and control peri-implant infections. Patients should be on a regular recall schedule, and maintenance programs should be designed on an individual basis.

Little is known about the true magnitude of the pathology of peri-implantitis, mainly due to the lack of consistent and definite diagnostic criteria used to describe the condition. A diagnosed peri-implantitis should be treated without delay. Depending on the severity of the peri-implant lesion, surgical or nonsurgical procedures should be implemented (Figures 4–8). Moderate and severe peri-implantitis will require surgical consideration.

For the treatment of peri-implant infections, conventional nonsurgical periodontal maintenance therapy...
Methodology

Figure 1: Peri-implant mucositis. Presence of plaque and bleeding on probing (probing depth 2 mm) at the distal surface of the implant-supported crown in the mandibular second premolar site.

Figure 2: Peri-implant mucositis. No radiographically detectable bone loss around the implant.

Figure 3: Peri-implant mucositis. Following nonsurgical treatment, absence of bleeding on probing and 1 mm probing depth.

Figure 4: Peri-implant mucositis. Effective daily home care is also crucial and must be supplemented with the use of gauze.

has to be slightly adapted and proper methods of plaque and calculus removal and appropriate antimicrobial agents for maintenance around implants should be carefully selected.

Different maintenance regimens have been suggested, but little reliable evidence exists, suggesting which could be the most effective one for the long-term maintenance. Depending on the diagnosis made continuously during recall visits, a maintenance system called cumulative interceptive supportive therapy (CIST) has been proposed by Lang and co-workers. The indications for nonsurgical techniques, clearly delineated using the CIST algorithm, are followed in the present manuscript, with minor adjustments and further expanding the nonsurgical protocols, including the adjunctive use of the diode laser.

Besides mechanical debridement, combined with antiseptic/antibiotic therapy, the adjunctive use of the laser (Figures 9, 12 and 13) may be used for treating peri-implantitis. The clinical objectives of a nonsurgical approach are:

- To reduce the total amount of microorganisms on the titanium surface,
- To decrease probing pocket depth (PPD),
- To reduce and eliminate bleeding on probing (BOP),
- To enhance self-performed oral hygiene and peri-implant health,
Methodology

Figure 5: Radiographical view of the second quadrant. In 1991, the bicuspid were extracted because of severe periodontal lesions. In 1992, three implants were inserted. In 2004, presence of inflammation due to plaque accumulation required radiographic evaluation. No bone loss is detectable.

Figure 6: Follow-up radiograph. In 2012, no bone loss around the implants is present.

Figure 7: Peri-implant inflammation. In 2004, a moderate-to-severe plaque-induced inflammation presented in the second quadrant: 9 mm probing pocket depth and presence of bleeding on probing at the mesial aspect of the second premolar implant.

Figure 8: Diode laser therapy. Comparing the clinical picture with the radiograph (Figure 5), the presence of a pseudo-pocket is suspected.

• To prevent re-infection,
• To improve implant longevity.

The treatment of peri-implant diseases must always include anti-infective measures. As with chronic or aggressive periodontitis, the therapy has focused on two essential approaches: oral hygiene instructions for the supra-gingival plaque control and professional subgingival instrumentation for the reduction and/or elimination of the pathogenic microbiota. Since peri-implant mucositis usually responds to oral hygiene instructions and to a nonsurgical periodontal treatment, we will be describing guidelines for supportive implant therapy we use in our daily practice once our patients have received a treatment with implants or when they present problems around them.

Methodology
It is important to make the patient aware that the dental health care
habits, such as brushing and interdental cleaning, are crucial for long-term maintenance of their implants. Patients with a history of chronic periodontitis may present a higher incidence of biologic complications in the absence of proper dental hygiene compliance.

The roll technique with a soft manual or electric toothbrush is safe, although thoroughness and duration of the brushing is more important than the technique. It is essential not to traumatize the peri-implant soft tissues while brushing, but to eliminate plaque accumulation. The roll technique is especially indicated for thin periodontal biotypes or when implants are surrounded by alveolar mucosa, rather than keratinized tissue. This brushing technique is also adequate in case of thick tissue biotypes and keratinized peri-implant gingiva.

The use of disposable gauze embedded with chlorhexidine 0.12% (Digital Brush, Enacare, Micerium, Avegno, Ge, Italy) is recommended: the gauze is wrapped around the index finger of the dominant hand and used to clean the gingival mucosa, teeth and implants with a rolling motion in an apico-coronal direction.

Oral hygiene should be completed with an appropriate interproximal device that could be either an interdental brush or floss, depending on the interproximal width. The key parameter for diagnosing peri-implant mucositis is bleeding upon gentle probing. This technique is used to assess the status of the peri-implant mucosal health. A probing pressure of 0.15 N represents the threshold force to be applied to avoid false-positive BOP readings around oral implants. The probe is also used for calculus and plaque detection, prior to instrumentation. Since it is universally accepted that peri-implantitis has a bacterial etiology, decontamination of the implant surface is crucial. Based on the diagnosis, made during recall visits, a maintenance system called CIST has been followed in this manuscript, with minor adjustments and further expanding the nonsurgical protocols, including the adjunctive use of the diode laser. In case of PPD ≤ 5 mm, BOP and no bone loss, the essential therapeutic approach, based on strict home care reinforcement and professional mechanical and manual instrumentation, is usually sufficient to restore clinical health. However, when there is a PPD > 5 mm, BOP, no bone loss and presence of pus on probing, nonsurgical therapy is indicated, including highly recommended essential procedures as well as optional methods (Table 1). In case of PPDs > 5 mm, BOP, radiographic evidence of bone loss, with presence of pus on probing (Figures 10–15), surgical treatment is highly indicated.

However, systemic and general health impairments could make periodontal surgery contraindicated, or sometimes the patient does not want or cannot afford the ideal therapy. In such cases, nonsurgical periodontal therapy becomes the only alternative treatment option. It should be made clear to the patient that this is a supportive strategy with no predictable outcomes.

<table>
<thead>
<tr>
<th>Table 1 Nonsurgical procedures</th>
<th>Nonsurgical procedures</th>
<th>Therapy</th>
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<tbody>
<tr>
<td>Diagnosis</td>
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<tr>
<td>≤ 5 mm probing pocket depth</td>
<td>Bleeding on probing</td>
<td></td>
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<tr>
<td>No bone loss (Figures 1–4)</td>
<td></td>
<td></td>
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<tr>
<td>&gt; 5 mm probing pocket depth</td>
<td>Bleeding on probing</td>
<td></td>
</tr>
<tr>
<td>No bone loss Presence of pus on probing (Figures 5–9)</td>
<td>Essential:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Strict home care reinforcement</td>
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<tr>
<td></td>
<td></td>
<td>• Professional mechanical and manual instrumentation</td>
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<tr>
<td></td>
<td>Optional:</td>
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<tr>
<td></td>
<td></td>
<td>• Adjunctive use of diode laser</td>
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<tr>
<td></td>
<td></td>
<td>• Adjunctive use of antimicrobials</td>
</tr>
<tr>
<td></td>
<td>Highly recommended:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Adjunctive use of antimicrobials</td>
</tr>
</tbody>
</table>

These procedures are summarized, depending on the initial diagnosis and listed as essential, highly recommended, strongly recommended and optional. In the first two situations, nonsurgical therapy is always indicated, versus the third case where surgical treatment is the proper therapeutic option. However, if surgery is not possible, nonsurgical therapy becomes the only alternative. Nevertheless, this nonsurgical approach is a supportive strategy, with no predictable outcomes.
Table 2  Detailed description of the nonsurgical protocol

<table>
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<tr>
<th>Nonsurgical protocol summary</th>
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<tbody>
<tr>
<td>First appointment—day 0:</td>
</tr>
<tr>
<td>a. Circumferential probing to determine pocket depth.</td>
</tr>
<tr>
<td>b. Calculus detection.</td>
</tr>
<tr>
<td>c. Diode laser treatment: 2 W in pulsating mode (pw), for 20 s twice on each site, with a fluence of 124 J/cm², total energy 20,000 mJ and a frequency 10 Hz.</td>
</tr>
<tr>
<td>d. Power-driven instrumentation with dedicated inserts: ultrasonic piezoelectric (EMS Piezomaster 700) with PI insert (plastic fused to metal) or ultrasonic magnetostrictive (Dentsply Cavitron) insert capped with a plastic disposable tip and manual instrumentation with a titanium curette (Roncati Implant Care, by Martin, KLS).</td>
</tr>
<tr>
<td>e. Subgingival air polishing with glycine or erythritol (EMS).</td>
</tr>
<tr>
<td>f. Tetracycline for 3 min + physiologic solution for 30 s.</td>
</tr>
<tr>
<td>g. Application of chlorhexidine (CHX) gel with a disposable syringe and a blunt needle, three times.</td>
</tr>
<tr>
<td>h. Motivation and oral hygiene instructions: use of a medicated gauze soaked in 0.12% chlorhexidine gluconate (Digital Brush, Enacare Micerium, Italy) (four to five times daily between meals), rolling stroke brushing technique with an ultra soft toothbrush (three times a day), interdental brush bathed in CHX gel (three times a day).</td>
</tr>
<tr>
<td>i. Biostimulation by diode laser (LLLT): the same diode laser is used with a different 6.0 mm fiber and with a different power setting: 0.5 W in pulsating mode (pw), for 60 s twice on each site, for a total time of 360 s, with a fluence of 1 J/cm², total energy 6,000 mJ and a frequency 20 Hz.</td>
</tr>
<tr>
<td>j. Doxycycline 20 mg, oral dosage, twice daily, during 3 months.</td>
</tr>
</tbody>
</table>

Second appointment—day 1: (the next day if possible)

a. Diode laser treatment: 1 W in pulsating mode (pw), equivalent to 0.5 W in continuous mode (cw), for 30 s twice at each site, for a total time of 360 s, with a fluence of 62 J/cm², total energy 15,000 mJ and a frequency 10 Hz. |

b. Power-driven and manual instrumentation, as appropriate, with the same instrument described at day 0. |
c. Subgingival air polishing with glycine or erythritol (EMS), application of CHX gel with a disposable syringe and a blunt needle, three times. |
d. Motivation and reinforcement of home care instructions given on day 0. |
e. Biostimulation by diode laser (LLLT): diode laser treatment as described at day 0 (i). |

Third appointment—30 days later:

a. Plaque removal as needed. |
b. Application of CHX gel with a disposable syringe and a blunt needle, three times. |
c. Motivation and reinforcement of home care instructions given on day 0. |
d. Biostimulation by diode laser (LLLT): diode laser treatment as described at day 0 (i). |

e. Biostimulation by diode laser (LLLT): diode laser treatment as described at day 0 (i). |

Fourth appointment—at 3 months:

a. Diode laser treatment: 1 W in pulsating mode (pw), equivalent to 0.5 W in continuous mode (cw), for 30 s twice at each site, for a total time of 360 s, with a fluence of 62 J/cm², total energy 15,000 mJ and a frequency 10 Hz. |

b. Power-driven and manual instrumentation as needed, with the same instrument described at day 0. |
c. Subgingival air polishing with glycine or erythritol (EMS), application of CHX gel with a disposable syringe and a blunt needle, three times. |
d. Motivation and reinforcement of home care instructions given on day 0. |
e. Biostimulation by diode laser (LLLT): diode laser treatment as described at day 0 (i). |

5. Recall appointment every 3 months.

6. Once a year a peri-apical radiograph is needed.

Therefore, the proposed clinical protocol summarized in Table 2 includes a 810 nm diode laser therapy, power-driven instrumentation (ultrasonics with proper inserts), manual instrumentation using titanium curettes, polishing (air-flow with glycine or erythritol powder), locally delivered antimicrobials (tetracycline and chlorhexidine digluconate 0.2%), biostimulation/photodynamic therapy and/or systemic antibiotics (subantimicrobial dosage of doxycycline).

Laser treatment may serve as an adjunctive treatment to conventional mechanical therapy in periodontology, including supportive care of peri-implant inflammation. Recent studies show promising results in the treatment of...
per-implantitis. However, the laser is not a substitute for mechanical or manual instrumentation of the root/implant surfaces. The diode lasers (800–950 nm wavelength) are preferentially absorbed in pigmented tissues (with high percentage of endogenous chromophores: haemoglobin, melanin), such as inflamed peri-implant tissues. The diode and pulsed Nd:YAG lasers (Figures 8, 12 and 13), when used adjunctively with nonsurgical periodontal instrumentation, have been showing to have an additive effect in reducing subgingival bacterial populations in periodontal pockets of ≥ 4 mm. Both lasers seem to weaken the calculus chemical bond to roots and implant surfaces.

A temperature increase of more than 10°C can compromise the bone vitality. Within the appropriate parameters, the diode laser does not cause any visible surface alterations, as would an Er:YAG laser(s), which may produce a temperature increase above the critical threshold (10°C) after 10 s of continuous irradiation. Also a Neodymium YAG may produce some damage (melting and titanium surface cracking). The diode laser used within the correct

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Diode laser therapy. The day after the first diode laser treatment, a significant edema reduction is apparent.

Radiographic follow-up. In 2012, improved bone quality and density seem detectable on the radiograph.

The authors recommend the use of an air-flow system associated with glycine or erythritol powder (EMS, Nyon, Switzerland).

Finally, a 0.2% chlorhexidine gel is applied into the sulcus, with a disposable syringe and a blunt needle. Chlorhexidine shows a significant bactericidal effect against adhering bacteria on titanium surfaces.

Even if citric acid is the chemotherapeutic agent with the highest potential for the removal of the biofilm from contaminated titanium surfaces, tetracyclines are preferred since they have a less acid pH. The enzymatic inhibition and related anti-inflammatory properties of the tetracyclines are well documented.

At the end of the appointment, the same 810 nm diode laser is used with a different insert: 6.0 mm and with a different power (see description in Table 2). The use of antimicrobial photodynamic therapy adjunctive to conventional treatment provides short-term benefits: significant differences in clinical attachment level ($P=0.006$) and probing depth reduction ($P=0.02$).

A substantial dose of doxycycline (SDD) of 20 mg (Periostat® or a generic preparation) has been found to be a safe and effective adjunct when taken twice daily for at least 3 months and up to 24 months in randomized placebo-controlled clinical trials. The meta-analysis results seemed to support the long-term effectiveness of adjunctive SDD therapy. Doxycycline has a selective collagenase activity on polymorphonuclear cells, whose numbers are increased in peri-implant lesions, along with plasma cells and lymphocytes.

No evidence is available to suggest the frequency of recall intervals or specific hygiene treatments for peri-implant mucositis or peri-implantitis. Routine periodontal maintenance should be performed every 3 to 4 months reinforcing the patient’s own efforts in daily plaque control. Adjunctive use of the diode laser associated to conventional supportive periodontal therapy (SPT) can be applied, once or twice a year, during the follow-up period, only if needed.

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Discussion
The outcome of nonsurgical periodontal treatment of peri-implantitis is inconsistent and unpredictable. The decision as to whether a questionable implant should be treated and maintained nonsurgically or surgically is complicated due to variables related to patient behaviour. Nonsurgical periodontal treatment is indicated when a patient has medical or psychological contraindications. In peri-implant infections, 5 and 6 mm probing depths are frequently found and initially treated nonsurgically. Laser therapy is not only beneficial because of its bactericidal effect, but it can also reduce bacteremia and oedema. In some cases, implant removal is the only treatment option.

Conclusion
This article presents a protocol for nonsurgical treatment of peri-implant defects using antimicrobials combined with a nonsurgical mechanical treatment and the adjunctive use of the diode laser.

Abbreviations list
BOP, bleeding on probing; CIST, cumulative interceptive supportive therapy; PPD, probing pocket depth; SDD, substantial dose of doxycycline; SPT, supportive periodontal therapy

References
Methodology

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