Summary

Peri-implantitis, or inflammation of the tissues surrounding an implant, is an irreversible process characterized by progressive bone loss, with concomitant symptoms of inflammation with the formation of pathological pockets, fistulas, or gingival recession. According to epidemiological data, this disease affects more than 20% of implants.

The primary goal of the *peri-implantitis* treatment is to clean the surface of the implant and the tissues surrounding the implant in order to eliminate the inflammation and bone resorption. However, the treatment of peri-implantitis is very difficult due to the fact that the surface of the implant is porous, which favors bacterial colonization and prevents effective removal of the bacterial biofilm. Currently, no predictable treatment methods for *peri-implantitis* have been defined. Various types of instruments, antiseptics, and antibiotics are used, both in nonsurgical procedures through the pocket around the implant and in surgical procedures after the mucoperiosteal flap has been debrided. The non-surgical procedures are minimally invasive and therefore produce only minor postoperative discomfort. Surgical procedures, on the other hand, allow a better view of the surgical field, thus potentially increasing the effectiveness of the decontamination procedure. In recent years, attention has been drawn to the potential use of lasers, particularly the erbium:yttrium-aluminium-garnet (Er:YAG) and neodymium:yttrium aluminium garnet (Nd:YAG) lasers, to increase the effectiveness of tissue treatment around implants. The Er:YAG laser is used for granulation tissue removal, implant surface decontamination and superficial bone ablation. The Nd:YAG laser, on the other hand, is used for bone disinfection and photobiomodulation.

The purpose of this study was to compare the effectiveness of non-surgical and surgical treatment of *peri-implantitis* using erbium:yttrium-aluminium-garnet (Er:YAG) and neodymium:yttrium aluminium garnet (Nd:YAG) lasers.

We enrolled 40 generally healthy patients aged 35-78 years, including 22 women and 18 men, who were diagnosed with peri-implantitis. The surgical method was used to treat 13 women and 7 men, while the non-surgical method was used to treat 9 women and 11 men. Approval was obtained from the Bioethics Committee No. R-I-002/131/2018 to conduct the study.

The inclusion criteria for the study were the finding of:

- bleeding on probing at least one probing point in the pocket around the implant (Bleeding on Probing (BOP) - BOP+
- probing Depth (PD) not less than 4 mm - PD ≥4 mm
- the presence of a vertical bone defect visible on X-ray with a height of ≥2 mm.

Exclusion criteria for the study were:

- peri-implantitis treatment within the last six months
- chronic diseases affecting bone healing or metabolism
- medications affecting bone healing or metabolism
- anticoagulants

- pregnancy and breast-feeding.

The clinical study consisted of the evaluation of the following parameters:

- Plaque Index (PI) - dichotomously+/-; the result was given as a percentage of bleeding sites
- BOP - dichotomously+/-; score given as percentage of bleeding sites
- PD (in mm)
- presence of pus exudate (PUS) - dichotomously+/-.

Radiographic evaluation was based on intraoral radiographs taken with the long-cone parallel technique. To obtain reproducible projections, the sensor (RVG 6500 Carestream, USA) was mounted in a positioner (Rinn, Dentsply Sirona, Germany), which was individually prepared for each patient using O-Bite material (DMG, Germany). Measurements were taken on the mesial and distal surfaces of the implant. The segment between the implant flange and the edge of the bone immediately adjacent to the implant surface was measured.

Clinical and radiographic examination were performed before treatment and 3 and 6 months after treatment. Data were statistically analyzed using the statistical package STATISTICA version 12.0 (StatSoft. Inc., USA) and an Excel spreadsheet.

Depending on the treatment used, patients were divided into two groups of 20 patients each. In the first group, the procedure of cleaning the implant surface and surrounding tissues was performed after preparation of the muco-periosteal flap to gain better access to the treatment area. The laser sequence included 5 steps: removal of granulation tissue with the Er:YAG laser (H14 tip, cylindrical tip, LP mode 160 mJ, 10 Hz, 1.6 Watts, 6 water, 4 air); decontamination of the implant surface (Er:YAG, H14 tip, cylindrical tip, MSP mode 80 mJ, 10 Hz, 0.8 Watts, 6 water, 4 air); superficial ablation of infected bone (Er: YAG, H14 tip, cylindrical tip, QSP mode 200 mJ, 10 Hz, 2 Watts, 4 water, 2 air); reduction of bacteria in bone using Nd:YAG laser (300 um fiber, MSP mode 1.5 Watts, 15 Hz); photobiomodulation after flap repositioning (Nd:YAG fiber 300 um, VLP mode 0.5 Watts, 10 Hz).

In the second group, treatment consisted of cleaning the implant surface and surrounding tissues with Er:YAG and Nd:YAG lasers through a pocket around the implant (non-surgical treatment). The laser work included the following sequence of 4 steps: removal of granulation tissue with the Er:YAG laser (H14 tip, VARIAN tip, LP mode 160 mJ, 10 Hz, 1.6 Watts, 6 water, 4 air); decontamination of the implant surface (Er: YAG, H14 tip, VARIAN tip, MSP mode 80 mJ, 10 Hz, 0.8 Watts, 6 water, 4 air); surface ablation of infected bone (Er:YAG, H14 tip, VARIAN tip, QSP mode 200 mJ, 10 Hz, 2 Watts, 4 water, 2 air); Nd:YAG laser photobiomodulation (300 um fiber, VLP mode 0.5 Watts, 10 Hz).

In the flapless procedure, due to limited access to the treatment field, a 400 um diameter VARIAN tip was used during Er:YAG laser work. In addition, Nd:YAG laser bacterial reduction was not performed in this procedure due to the risk of implant damage. Laser-assisted implant cleaning has been shown to lead to a clinical improvement in soft tissue status during *peri-implantitis* treatment, that is, a reduction in probing depth and a reduction in inflammatory symptoms. However, there is no effect

on the position of the bone edge around the implant schoulder. Based on the analysis of the data, there was no correlation between the amount of bone loss and hygiene status or the presence of inflammation. There was also no correlation between probing depth and hygiene status or bone loss size. It was only noted that regardless of the treatment used, an increase in probing depth over time was accompanied by an increase in the number of bleeding sites on probing.

Based on the results, the following conclusions were drawn:

1. Laser-assisted implant cleaning leads to a clinical improvement in soft tissue status during *peri-implantitis* treatment.

2. *Peri-implantitis* treatment using laser therapy has no effect on bone status around the implant in short-term observations.

3. Surgical increase of access to the treated area by preparation of a muco-periosteal flap does not provide additional benefits in the treatment of *peri-implantitis* with laser therapy.

4. The efficacy of the methods studied is similar and therefore a less traumatic, non-surgical method of *peri-implantitis* treatment should be chosen.