Efficacy of Nonsurgical Mechanical Debridement With and Without Adjunct Low-Level Laser Therapy in the Treatment of Peri-Implantitis: A Randomized Controlled Trial

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We hypothesized that in the long term (6-month follow-up), nonsurgical mechanical debridement (NSMD) with adjunct low-level laser therapy (LLLT) is more effective for the treatment of peri-implantitis than NSMD alone. The aim of the present 6-month follow-up convenience-sample cohort study was to assess the efficacy of LLLT as an adjunct to NSMD in the treatment of peri-implantitis. A questionnaire was used to collect demographic information. Patients with peri-implantitis in the test and control groups underwent NSMD with and without adjunct LLLT, respectively. Randomization was done by tossing a coin. In the test group, the laser was applied perpendicular to the periodontal pocket for 20 seconds at a constant distance of 15 mm and with a continuous wavelength (3.41 J/cm^2 delivery with a 1.76 cm^2 spot and average output of 0.3 W). In both groups, peri-implant probing depth, bleeding upon probing, and crestal bone resorption were assessed at baseline and at the 3-month and 6-month follow-up. Group comparisons were performed, and $P < .05$ was considered statistically significant. Sixty-seven individuals with peri-implantitis were included. The mean age of participants who underwent NSMD with adjunct LLLT and NSMD alone was 46.5 $\pm$ 3.4 and 45.3 $\pm$ 1.1 years, respectively. At the 3- and 6-month follow-up, peri-implant ($P < .05$), bleeding upon probing ($P < .05$), and probing depth ($P < .05$) were significantly higher among patients who underwent NSMD alone compared with patients who underwent NSMD with adjunct LLLT. There was no significant difference in crestal bone resorption in all patients up to the 6-month follow-up. In the short term, NSMD with adjunct LLLT was a useful treatment protocol for the treatment of peri-implant soft-tissue inflammation.

Key Words: alveolar bone loss, peri-implant diseases, inflammation, low-level laser therapy, nonsurgical mechanical debridement

INTRODUCTION

Peri-implant diseases are characterized by inflammation of the soft tissues surrounding the dental implant (peri-implant mucositis), which, if left untreated, may progress to loss of supporting alveolar bone (peri-implantitis) and ultimately implant failure.[1,2] Traditionally, nonsurgical mechanical debridement (NSMD) is performed for the treatment of periodontal and peri-implant diseases.[3,4] The ultimate goal of this form of therapy is to debride the teeth and peri-implant surfaces from dental plaque/calculus and granulation tissues. This in turn reduces the pathogenic microbial load in the gingival sulcus and facilitates healing.[5]

Adjunct therapies, such as use of antibiotics (eg, azithromycin) are often prescribed for patients undergoing NSMD for the treatment of peri-implantitis because although NSMD significantly removes plaque and calculus from implant surfaces, pathogenic bacteria may persist in the sulci, and these are eliminated via the adjunct antibiotic therapy.[5] Low-level laser therapy (LLLT) positively influences biological tissues by improving cell proliferation, nerve conduction, and microcirculation.[6] Pamuk et al[3] reported that NSMD, when performed with adjunct LLLT, significantly reduced the expression of tissue plasminogen activator (a serine protease associated with the breakdown of blood clots) in the gingival crevicular fluid compared with NSMD performed as the sole treatment for oral inflammatory conditions such as chronic periodontitis. Other positive effects may include stimulation of the host immune system, increased enzyme activity and DNA synthesis, and enhancement of cell membrane structure. Results presented by Khadra[7] showed that LLLT stimulates mechanical strength at the implant-bone interface and promotes cellular proliferation in the peri-implant tissues.

In a randomized controlled trial (RCT), Abduljabbar et al[8] assessed the efficacy of neodymium-doped yttrium aluminum

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garnet laser-assisted NSMD in the treatment of peri-implant diseases. The 6-month follow-up results showed that diode laser therapy was effective in the short term (3-months follow-up) but not in the long term (6-month follow-up) in the treatment of peri-implant diseases. However, after a vigilant review of pertinent indexed literature, the authors observed that no RCTs have assessed the efficacy of NSMD with adjunct LLLT in the treatment of peri-implant diseases. It is hypothesized that in the long term (6-month follow-up), NSMD with adjunct LLLT is more effective than NMSD alone for treating peri-implantitis.

The aim of the present 6-month follow-up convenience-sample cohort study was to assess the efficacy of LLLT as an adjunct to NSMD in the treatment of peri-implantitis.

Methods

Subjects

Patients with the following characteristics were included: (1) presence of dental implants; (2) diagnosis of peri-implantitis (peri-implant probing depth [PrD] $\geq$4 mm, bleeding upon probing [BUP] at $\geq$30% of sites, and crestal bone resorption [CBR; mesial and/or distal] of at least 3 mm); and (3) signed informed consent form. Tobacco smokers and persons using electronic nicotine-delivery systems or smokeless tobacco; patients with systemic diseases, including but not limited to, cardiovascular disorders, diabetes mellitus, human immunodeficiency virus infection/acquired immune deficiency syndrome, renal disorders, and/or arthritis; patients who had consumed anti-inflammatory medicines, steroids, probiotics, bisphosphonates, and/or antibiotics within the previous 3 months; pregnant and/or lactating women; and patients who had received surgical/nonsurgical periodontal/peri-implant mechanical debridement within the previous 90 days were excluded. A flow chart was made in accordance with the CONSORT guidelines that described the study outline and allocation of patients in the test and control groups (Figure). The patients were randomly divided into the test and control groups. Patients in the test group underwent NSMD with adjunct LLLT, and those in the control group underwent NSMD alone. Randomization was done by 1 examiner via coin toss.

Measurements

An experienced and qualified investigator (Kappa score = 0.90) used a standardized questionnaire for data collection (age, gender, duration of implants in function, and daily toothbrushing and flossing regimens). Clinical and radiographic examinations were performed at baseline and at the 3- and 6-month follow-up by a trained and calibrated investigator (Kappa = 0.88). In all patients, peri-implant PrD was measured in millimeters using a graded plastic probe (Hu-Friedy Mfg Co LLC, Chicago, Ill). Probing was measured to the nearest millimeter. The BUP was measured on 3 buccal (mesial, mid, and distal) and 3 palatal (mesial, mid, and distal) surfaces per implant. Mesial and distal CBR was measured on digital bitewing radiographs (NOMAD Pro 2 Intraoral X-Ray Systems, Gendex, Hatfield, Pa) using the long-cone paralleling technique.[9,10]

Procedure

Peri-implant NSMD was performed using plastic scalers (Titanium implant scalars, IMPM11-14T, Hu-Friedy Mfg). In all remaining teeth, scaling and root planning (SRP) was done using sterile Gracey's curettes (EverEdge 2.0 scalers, Hu-Friedy Mfg). The NSMD and SRP procedures were performed by a trained and calibrated investigator (B.S.; Kappa score = 0.92). The LLLT was performed in accordance with the protocol used in the study by Pamuk et al.[3] In summary, LLLT was done using a 940-nm indium gallium arsenide phosphorous diode laser (Epic Biolase, Irvine, Calif). The LLLT was done on the day of SRP and peri-implant NSMD and then on the second and seventh days after treatment. The laser was applied perpendicularly to the periodontal pocket for 20 seconds at a constant distance of 15 mm and with a continuous wavelength (3.41 J/cm^2 delivery with a 1.76 cm^2 spot and average output of 0.3 W).

Statistical analysis

The statistical assessment was done by a trained and independent statistician. Group comparisons were done using the 1-way analysis of variance, and percentages were compared using the Fisher exact test using a software program (SPSS version 20, SPSS Inc, Chicago, Ill). For multiple comparisons, a Bonferroni post hoc adjustment test was done. Level of significance was set at $P < .05$. Sample-size estimation was performed on a patient-based analysis of PrD (primary outcome variable) using a computer-based software (G*Power, version 3.1.9.2, Heinrich-Heine-Universität Düsseldorf, Dusseldorf, Germany).[11] In order to detect a difference of 1 $\pm$ 0.75 mm in PrD between the test (NSMD +LLLT) and control (NSMD alone) groups at a significance level of $\alpha = 0.05$ with power of $\gamma = 0.9$, the minimum number of participants in each group was estimated to be 33. Moreover, in order to detect a difference in PrD of 1 $\pm$ 1 mm between the follow-up periods (3 and 6 months) within each group at a significance level of $\alpha = 0.05$ with a power of $\gamma = 0.9$, the minimum number of participants in each group was also estimated to be 33 (with a Pearson correlation of $r = 0.5$ between the measurements over time).

Ethical approval

The study protocol was reviewed and approved by the research ethical committee of the the Dental Health Department, CAMS, King Saud University, Riyadh, KSA. Guidelines recognized by the Helsinki Declaration for experimentation involving humans were followed. All participants had to read and sign a consent form. All participants reserved the right to withdraw at any phase without penalty. All participants were given written information sheets about oral hygiene maintenance.

Results

General characteristics

In total, 67 individuals with peri-implantitis were included: 33 who underwent NSMD with adjunct LLLT and 34 who underwent NSMD alone. Among patients who underwent

TABLE

General characteristics of the study groups*

Parameters	MD+LLLT	MD Alone
No. of participants	34	33
Men:women	31:3	30:3
Age in years, mean ± SD	46.5 ± 3.4 years	45.3 ± 1.1 years
Men, mean ± SD	47.5 ± 2.5 years	46.3 ± 1.9 years
Women, mean ± SD	44.1 ± 1.3 years	43.6 ± 2.1 years
No. of implants	34	33
Duration of implants in function in years, mean ± SD	5.6 ± 0.2 years	5.4 ± 0.4 years
Jaw location		
Maxilla, n	4	5
Mandible, n	30	28
Tooth brushing		
Once daily, n (%)	28 (82.4%)	29 (87.9%)
Twice daily, n (%)	6 (17.6%)	4 (12.1%)
Flossing	0	0

*LLLT indicates low-level laser therapy; MD, mechanical debridement.

NSMD with adjunct LLLT, 31 were men and 3 were women. In patients who received NSMD alone, 30 and were men and 3 were women. Mean age was 46.5 ± 3.4 for those who underwent NSMD with adjunct LLLT and 45.3 ± 1.1 years for those who underwent NSMD alone. There was no statistically significant difference in age among male and female patients in both groups. The mean duration of implants in function was 5.6 ± 0.2 for those who underwent NSMD with adjunct LLLT and 5.4 ± 0.4 years for those who underwent NSMD alone. Among patients who underwent NSMD with adjunct LLLT, 30 and 4 implants were placed in the mandible and maxilla, respectively. Among patients who underwent NSMD alone, 28 and 5 implants were placed in the mandible and maxilla, respectively. In patients who underwent NSMD with and without adjunct LLLT, 82.4% and 87.9%, respectively, reported brushing their teeth once daily. No patients had ever used dental floss (Table).

Comparison of peri-implant inflammatory parameters at baseline and at the 3- and 6-month follow-ups

NSMD Alone

The percentage of sites that exhibited plaque ($P < .05$) and BUP ($P < .05$) were significantly higher at baseline than at the 3-month follow-up. At the 6-month follow-up, PI and BUP were comparable with their respective baseline values (Figure 2). The peri-implant PrD was significantly higher at baseline than at the 3-month follow-up. There was no statistically significant difference in CBR at any time interval (Figure 3).

NSMD With Adjunct LLLT

The percentage of sites that exhibited plaque and BUP were significantly higher at baseline than at the 3-month ($P < .05$) and 6-month ($P < .05$) follow-ups (Figure 1). The peri-implant PrD was significantly higher at baseline than at the 3-month ($P < .05$) and 6-month ($P < .05$) follow-ups (Figure 3).

NSMD Alone Compared With NSMD With Adjunct LLLT

At baseline, there was no statistically significant difference in PI, BUP, PrD, and CBR among patients who underwent NSMD with or without adjunct LLLT. At the 3- and 6-month follow-ups, peri-implant PI ($P < .05$), BUP ($P < .05$), and PrD ($P < .05$) were significantly higher among patients who underwent NSMD alone compared with those who underwent NSMD with adjunct LLLT. There was no significant difference in CBR in all patients up to the 6-month follow-up (Figures 2 and 3).

DISCUSSION

In the present study, all implants were placed at bone level and had a platform-switched design with moderately rough surfaces. Implant diameter ranged between 4.1 and 4.8 mm and implant length ranged between 11 and 14 mm. All implants were placed at insertion torque ranging between 30 and 35 Ncm and were restored with cement-retained prostheses. The present cohort study was based on the hypothesis that in the long term (6-month follow-up), NSMD with adjunct LLLT is more effective for treating peri-implantitis than NSMD alone. The reported results are in accordance with the proposed hypothesis to an extent since at the 6-month follow-up, peri-implant PrD and BUP were significantly lower in patients who had undergone NSMD with adjunct LLLT than those who had undergone NSMD alone. It is important to note that the beneficial effects of LLLT as an adjunct to NSMD were limited to reduction in peri-implant soft-tissue–related inflammatory parameters. One explanation for this is that photobiomodulation using LLLT stimulates receptors on the mitochondria and cellular membranes, which in turn increases the rate of cellular proliferation without causing any cytotoxic effects.[12] Moreover, LLLT induces a broader cell-light response as its wavelengths (600–1100 nm) increases RNA and DNA synthesis.[13–15] Furthermore, LLLT is known to be effective when delivered in a dose-dependent manner.[16] In other words, LLLT with a low stimulus increases, a moderate stimulus inhibits, and a strong stimuli eliminate physiologic activity. According to Raghavendra et al[15] an optimal biological response of LLLT is achieved with an energy fluence ranging between 1 and 10 J/cm^2. It is pertinent to mention that in the present study, the energy fluence of

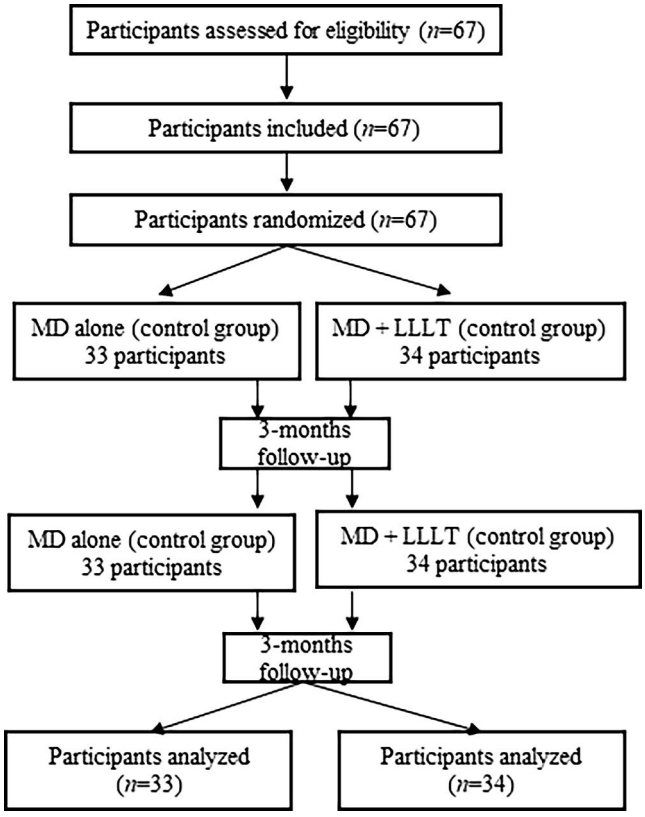

Figure 1. Patient allocation according to the CONSORT guidelines. MD indicates mechanical debridement; LLLT, low-level laser therapy.

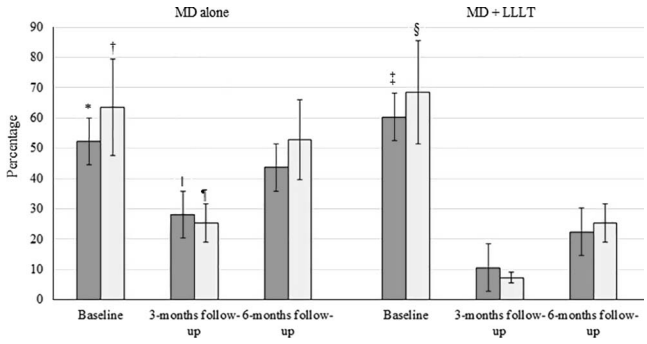

Figure 2. Comparison of peri-implant plaque index (dark grey bars) and bleeding upon probing (light grey bars) among patients with peri-implantitis who underwent mechanical debridement with and without adjunct low-level laser therapy. *Compared with plaque index at the 3-month follow-up ($P < .05$); †Compared with bleeding upon probing at the 3-month follow-up ($P < .05$). ‡Compared with plaque index at the 3-month ($P < .05$) and 6-month ($P < .05$) follow-ups. §Compared with bleeding upon probing at the 3-month ($P < .05$) and 6-month ($P < .05$) follow-ups. ||Compared with patients who underwent mechanical debridement with adjunct low-level laser therapy at the 3-month follow-up ($P < .05$). ¶Compared with patients who underwent mechanical debridement with adjunct low-level laser therapy at the 6-month follow-up ($P < .05$). MD indicates mechanical debridement; LLLT, low-level laser therapy.

LLLT was 3.4 J/cm^2. This aspect seems to have significantly contributed to achieving photobiomodulatory effects of LLLT in reducing peri-implant soft tissue inflammation. The present results, however, contradict those reported in the study by Abduljabbar et al,[8] in which the authors claimed that LLLT with adjunct NSMD was effective in treating peri-implant diseases in the short term (up to the6-months follow-up) but not in the long term (6-month follow-up). It is noteworthy that in the study by Abduljabbar and coworkers,[8] laser therapy was performed only once throughout the study period; however, in our study, LLLT was done 3 time points after NSMD. This factor may have contributed to the optimal beneficial effect of LLLT after NSMD. Although LLLT has been shown to increase the proliferation of osteoblasts,[17] the present results showed no statistically significant effect of NSMD with or without adjunct LLLT in new bone formation on the mesial and distal surfaces of the implants. It is postulated that the maximum follow-up duration of 6 months was insufficient to have induced new bone formation. It is therefore hypothesized that studies of longer durations (at least 12 months) with additional sessions of LLLT may demonstrate new bone formation around peri-implant osseous defects. Further clinical trials are warranted to test the therapeutic usefulness of LLLT in osseous tissue regeneration and to define a treatment protocol in this regard.

In the present study, there was no statistically significant difference in peri-implant clinical and radiographic inflammatory parameters among male and female participants (data not shown). However, these results should be interpreted with caution as nearly 90% of the patients who underwent NSMD with or without adjunct LLLT were men. In the present study, strict eligibility criteria were adopted in terms of patient selection. For instance, tobacco smokers, smokeless-tobacco users, and patients with systemic diseases such as diabetes mellitus were excluded. It is well known that a state of persistent hyperglycemia such as among patients with poorly controlled diabetes mellitus is a risk factor of peri-implant diseases (peri-implant mucositis and peri-implantitis).[18] More-

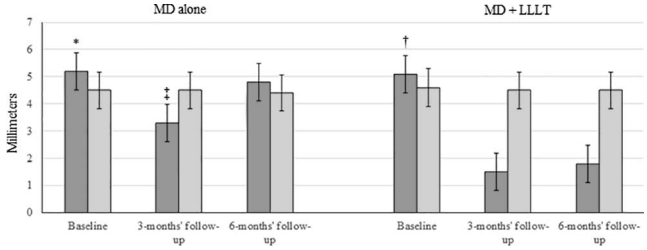

Figure 3. Comparison of peri-implant probing depth (dark grey bars) and crestal bone resorption (light grey bars) among patients with peri-implantitis who underwent mechanical debridement with and without adjunct low-level laser therapy. *Compared with probing depth at the 3-months follow-up ($P < .05$). †Compared with probing depth at the 3-month ($P < .05$) and 6-month ($P < .05$) follow-ups. ‡Compared with patients who underwent mechanical debridement with adjunct low-level laser therapy at the 3-month follow-up ($P < .05$). MD indicates mechanical debridement; LLLT, low-level laser therapy.

over, the outcomes of periodontal therapy have also been reported to be compromised in tobacco smokers compared with nonsmokers.[19–21] It is therefore speculated that the outcomes of NSMD with or without LLLT are compromised in tobacco-product users and immunocompromised patients compared with individuals not using any form of tobacco product and systemically healthy individuals. Further well-designed randomized controlled trials are needed in this regard.

A number of limitations are associated with the present study. First, the authors used stringent eligibility criteria for participation. This was primarily done to eliminate the risk of bias among the reported results. Tobacco smoking is a classic risk factor of periodontal and peri-implant diseases.[19] Similarly, a state of chronic hyperglycemia, which is manifested in patients with poorly controlled diabetes mellitus is known to enhance peri-implant soft tissue inflammation and cause loss of supporting alveolar bone.[18,22] Furthermore, tobacco smoking and chronic hyperglycemia retard healing after oral therapeutic interventions.[23,24] It is therefore hypothesized that the outcomes of NSMD with or without adjunct LLLT are compromised in tobacco smokers and immunosuppressed patients in contrast to systemically healthy nonsmoking individuals. Moreover, it is also speculated that the outcomes of NSMD with LLLT in patients with diabetes and optimal glycemic control are comparable to those observed in systemically healthy individuals. Further studies are needed to test these hypotheses.

Conclusion

In the short term, NSMD with adjunct LLLT was a useful treatment protocol for treating peri-implant soft-tissue inflammation.

Abbreviations

BUP: bleeding upon probing
CBR: crestal bone resorption
LLLT: low-level laser therapy
NSMD: nonsurgical mechanical debridement
PrD: peri-implant probing depth
RCT: randomized controlled trial
SRP: scaling and root planning

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Note

All authors report no potential conflicts of interest.

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