Efficacy of non-surgical periodontal therapy with adjunct Nd:YAG laser therapy in the treatment of periodontal inflammation among patients with and without type 2 diabetes mellitus: A short-term pilot study

Fawad Javed a,⇑, Mohammad D. Al Amri b, Abdulaziz A. Al-Kheraif c, Talat Qadri d, Asma Ahmed e, Alexis Ghanem a, José Luis Calvo-Guirado f, Georgios E. Romanos g

a Division of General Dentistry, Eastman Institute for Oral Health, University of Rochester, NY, USA
b Department of Prosthetic Dental Sciences, College of Dentistry, King Saud University, Riyadh, Saudi Arabia
c Dental Biomaterials Research Chair, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia
d Division of Periodontology, Department of Dental Medicine, Karolinska Institutet, Huddinge, Sweden
e Department of Laser and Cosmetic Dentistry, Burjeel Hospital, Abu Dhabi, United Arab Emirates
f Chairman of International Dentistry Research Cathedra, Faculty of Medicine and Dentistry, San Antonio Catholic University of Murcia (UCAM), Murcia, Spain
g Department of Periodontology, School of Dental Medicine, Stony Brook University, NY, USA

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Abstract

Background and aim: Effect of non-surgical periodontal therapy (NSPT) with and without adjunct neodymium-doped:yttrium, aluminum and garnet (Nd:YAG) laser therapy in the treatment of periodontal inflammation in patients with type 2 diabetes mellitus (T2DM) remains uninvestigated. The aim of the present short-term pilot study was to assess efficacy of NSPT with adjunct Nd:YAG laser therapy in the treatment of periodontal inflammation in patients with and without T2DM.

Methods: Twenty-two patients with T2DM (Group-1) and 22 controls (Group-2) were included. Teeth on test- and control-sites underwent NSPT with and without Nd:YAG laser therapy, respectively. Periodontal parameters (plaque index [PI], bleeding on probing [BOP] and probing pocket depth [≥ 4 mm [PPD]]) were measured at baseline and after 1 and 3 months. Hemoglobin A1c (HbA1c) levels were measured at baseline and after 3 months.

Results: In Group-1, PI, BOP and PPD ≥ 4 mm were higher at the control-sites (6.4% [P < 0.05], 5.5% [P < 0.05] and 3.5% [P < 0.05], respectively) than test-sites (1.5%, 2.1% and 1.1%, respectively) at 1-month follow-up. In Group-2, PI, BOP and PPD ≥ 4 mm were higher at the control-sites (4.2% [P < 0.05], 2.2% [P < 0.05] and 2.2% [P < 0.05], respectively) than test-sites (1.2%, 1.3% and 1.1%, respectively) at 3-months follow-up. There was no difference in PI, BOP and PPD ≥ 4 mm among test- and control-sites in both groups at 3-month follow-up. Mean HbA1c levels were comparable among patients in groups 1 and 2 (5 ± 0.2% and 4.6 ± 0.1%, respectively).

Conclusion: These short-term pilot results support our hypothesis that NSPT + Nd:YAG laser therapy is more effective in reducing periodontal inflammation in patients with and without T2DM when NSPT is used alone. Further long-term randomized controlled clinical trials are needed in this regard.

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1. Introduction

Non-surgical periodontal therapy (NSPT) (or scaling and root planing) using ultrasonic scalers or hand instruments (such as curettes) is commonly performed for the management of periodontal inflammation [1–3]; however, studies [1,4,5] have shown that NSPT alone is often inefficient in completely eliminating pathogenic microbes and their products from periodontal pockets. Studies [5–7] have shown that NSPT when performed with adjunct therapeutic regimes (such as use of antibiotics therapy, ozonated olive oil therapy and photodynamic therapy) reduces periodontal inflammation to a significantly greater extent as compared to when NSPT is used alone; yet, controversial results have also been reported in this regard [4,8].

The neodymium-doped:yttrium, aluminum and garnet (Nd:YAG) laser has a wavelength of 1064 nm and operates in a free
running pulsed mode. Since the past nearly 20 years, Nd:YAG laser is being used in clinical dentistry, mainly for minor surgery and endodontic procedures [9–12]. The exact mechanism through which Nd:YAG laser reduce inflammation remains unclear; however it has been proposed that these lasers (even in the absence of water cooling) only affect the soft tissues such as the pocket epithelial linings without causing any damage to hard tissues such as cementum or dentin [13]. Results from a short-term split-mouth, single-masked, randomized controlled clinical trial (RCT) showed that a single application of a water-cooled Nd:YAG laser as an adjunct to NSPT significantly reduced clinical signs of periodontal inflammation as compared to when NSPT was performed alone [1]. Similar results were reported in a long-term split-mouth single blind RCT [14]. It is well known that periodontal inflammation is worse among patients with chronic hyperglycemia (such as those with poorly-controlled type 2 diabetes mellitus [T2DM]) as compared to non-diabetic individuals (controls) [15–18]. Moreover, it has also been reported that the outcomes of periodontal therapy are compromised among patients with poorly-controlled T2DM than controls [19,20]. Loss of fibroblasts and osteoblasts through apoptosis is also higher among diabetic patients than control thereby contributing to limited repair of injured tissue, particularly when combined with other known deficits in diabetic wound-healing [19]. Furthermore, high levels of tumor necrosis factor-alpha (a proinflammatory cytokine that stimulate tissue loss) in the gingival crevicular have been associated with a chronic hyperglycemic state [5]. This may in turn lead to a limited capacity to repair periodontal tissue following inflammatory insults. In the present study we hypothesized that NSPT with adjunct Nd:YAG laser therapy is more effective in reducing periodontal inflammation in patients with and without T2DM as compared to when NSPT is used alone.

The aim of the present short term split mouth pilot study was to assess the efficacy of NSPT with adjunct Nd:YAG laser therapy in the treatment of periodontal inflammation among patients with and without T2DM.

2. Material and methods

2.1. Ethical approval

The study was approved between March 2013 and August 2014 at the College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. The study was approved by the research ethics review committee of the College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. Consent were presented a consent form. It was mandatory for consent participants to have read and signed the consent form before being included in the present study.

2.2. Eligibility criteria

The following eligibility criteria were entailed: (a) patients with medically diagnosed T2DM; (b) systemically healthy controls; (c) and patients with periodontal inflammation (presence of at least 6 periodontal pockets ≥4 mm in depth [1]). Patients were excluded from the present study if they were edentulous, smokers, had dental malocclusions, had a self-reported history of systemic disorders other than T2DM (such as patients with acquired immune deficiency syndrome/HIV, cardiovascular disorders, hepatitis B, hepatitis C, prediabetes, renal disorders and type 1 diabetes) and had used antibiotics, non-steroidal anti-inflammatory drugs and/or steroids within the past 3 months.

2.3. Study participants and groups

In total, 44 patients (22 patient with T2DM [Group-1] and 22 systemically healthy controls [Group-2]) were included. Patients with T2DM were recruited from the Diabetes Care Unit of King Saud University Hospital, Riyadh, Saudi Arabia and were requested to present their medical records to verify the diagnosis of T2DM. Non-diabetic individuals were recruited from the Department of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. In groups 1 and 2, the patients were divided into two sub-groups depending upon the protocol adopted for the treatment of periodontal inflammation in the mandible. Teeth on test-sites underwent NSPT with adjunct laser therapy (subgroup-1); whereas on the control-sites (sub-group-2) only NSPT was performed. Selection of the treatment protocols (whether SRP + laser or SRP alone) and determination of the test-and control-sites was done by tossing a coin.

2.4. Periodontal parameters

One calibrated investigator blinded to the study groups (Group-1 and Group-2) and test and control sites (sub-groups) performed the clinical periodontal examination. The overall kappa value for intra-examiner reliability was 0.85. A full-mouth plaque index (PI) [15]; bleeding on probing (BOP) [15] and probing depth (PD) (≥4 mm) [15] were measured at six sites per tooth (mesiobuccal, midbuccal, distobuccal, distolingual/distopalatal, midlingual/midpalatal and mesiolingual/mesiolapalatal) on all maxillary and mandibular teeth (excluding bilateral maxillary and mandibular third molars). PD was measured to the nearest mm with a graded probe (Hu Friedy, IL, Chicago, USA) [15,16]. Fractured teeth with embedded root remnants were also excluded.

2.5. Laser parameters

In the present study, an Nd:YAG laser system (Genius Dental, Tureby, Denmark) was used which emitted pulsed light at 1064 nm. To circumvent thermal effect and maintain the optimal therapeutic effect, the instrument was set at level five using the following parameters: average output: 4 W; energy per pulse: 80 mJ; pulse width: 350 ms, pulse-repetition rate: 50 Hz; peak power: 240 W; average power density at the fiber end: 1430 Watts per square centimeters (W/cm²); and peak power density: 85,800 W/cm² [1]. The laser treatment was accompanied by air and water-cooling. Irradiation parameters were governed through the fiber diameter, treatment time, power of the laser at the tip of the fiber, and surface area of the irradiation site. The fiber diameter was 600 μm. Water-cooling and air-cooling were always used during irradiation. The time spent on each tooth varied between 60 and 120 s, depending on accessibility. The laser energy per treated site was 240–480 J. The power density and peak-power density were calculated by a hypothetical 100% emission through the small fiber tip. However, the energy was not emitted solely from the tip of the fiber; there was also considerable lateral emission. Because of the high uncertainty about the total area of irradiated tissue, the energy density (joules per square centimeter) was not calculated.

Laser therapy was performed by inserting the fiber into the periodontal pocket almost parallel to the tooth and moving from mesial to distal directions continuously on the buccal and the lingual aspect of the tooth. The fiber was held in a constant motion in contact with the pocket epithelial lining almost parallel to the long axis of the root. Laser therapy was performed by one trained and calibrated investigator.
2.6. Measurement of hemoglobin A1c levels

To determine the HbA1c levels among patients in groups 1 and 2, venous blood samples were drawn in the morning. HbA1c levels were determined using the high-performance liquid chromatography method (Bio-Rad Laboratories, Inc., D-10® Hemoglobin Systems, Hercules, CA, USA).

2.7. Statistical analysis

Statistical analysis was performed using a software program (SPSS Version 18, Chicago, IL, USA). Changes in periodontal inflammatory parameters from baseline to 1- and 3-months of follow-up and between treatment modalities were assessed using the paired t-test. The primary outcome was change in periodontal parameters (PI, BOP ad PPD > 4 mm) and HbA1c levels. For multiple comparisons (patients in test- and control-groups among patients with T2DM [Group-1] compared to patients in test- and control-groups among controls [Group-2]), the Bonferroni post hoc test was used. With inclusion of 22 patients per group (assuming a standard deviation of 1.0%), the study power was estimated to be 85% to detect a difference in PI, BOP and PD > 4 mm between control-sites and test-sites after 3-months of treatment (Table 3). The study was powered to detect a difference in HbA1c levels between patients in Group-1 as compared to those in Group-2 with an 85% power.

3. Results

3.1. General characteristics of the study population

Twenty-two patients with T2DM (Group-1) and 22 controls (Group-2) were included. Mean ages of patients in groups 1 and 2 were comparable. In both groups, most of the participants were male. Fifty percent individuals in Group-2 and 54.6% individuals in Group-1 had attained graduate level education. Among patients in Group-1, the mean duration of T2DM was 7.1 ± 3.3 years.

Regarding daily oral hygiene maintenance, 68.2% and 77.3% individuals in Group 1 and Group-2, respectively reported to brush their teeth once daily; and 31.8% and 22.7% individuals in Group 1 and Group-2, correspondingly reported to brush their teeth twice daily. Concerning dental checkups, 27.3% and 40.9% individuals in groups 1 and 2, respectively reported to have visited a dentist within the past 12 months; and 72.7% and 59.1% individuals in groups 1 and 2, respectively reported to have visited a dentist more than 1 year ago (Table 1).

3.2. Periodontal inflammatory conditions among individuals in groups 1 and 2 treated with NSPT with and without adjunct Nd:YAG laser therapy

3.2.1. Periodontal inflammatory parameters at baseline

At baseline, periodontal inflammatory parameters (PI [P < 0.01], BOP [P < 0.01] and PD ≥ 4 mm [P < 0.01]) were worse among patients in Group-1 as compared to those in Group-2.

3.2.2. At 1-month follow-up

In Group-1, periodontal inflammatory parameters at all sites were significantly higher at baseline as compared to control-sites (P < 0.01) and test-sites (P < 0.01). Periodontal inflammatory parameters were significantly higher at the control-sites as compared to test-sites (P < 0.05) (Table 2).

In Group-2, periodontal inflammatory parameters at all sites were significantly higher at baseline as compared to control-sites (P < 0.05) and test-sites (P < 0.05) after 1-month of treatment. Periodontal inflammatory parameters were significantly higher at the control-sites as compared to test-sites (P < 0.05) (Table 2).

3.2.3. At 3-month follow-up

In Group-1, all periodontal inflammatory parameters were significantly higher at all sites at baseline as compared to control-sites (P < 0.01) and test-sites (P < 0.01). There was no statistically significant difference in PI, BOP and PD ≥ 4 mm between control-sites and test-sites after 3-months of treatment (Table 3).

In Group-2, all periodontal inflammatory parameters were significantly higher at all sites at baseline as compared to control-sites (P < 0.01) and test-sites (P < 0.01). There was no statistically significant difference in PI, BOP and PD ≥ 4 mm between control-sites and test-sites after 3-months of treatment (Table 3).

Table 1

<table>
<thead>
<tr>
<th>Characteristics of the study population.</th>
</tr>
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<tbody>
<tr>
<td>Group-1 (patients with T2DM)</td>
</tr>
<tr>
<td>Number of patients (n)</td>
</tr>
<tr>
<td>Mean age (±SD)</td>
</tr>
<tr>
<td>Gender (Male:Female)</td>
</tr>
<tr>
<td>Graduate level education (%)</td>
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<tr>
<td>Mean duration of T2DM (years ± SD)</td>
</tr>
<tr>
<td>Mean Hemoglobin A1c (% ± SD)</td>
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* Compared to individuals in Group-2 (P < 0.01).

Table 2

<table>
<thead>
<tr>
<th>Periodontal parameters</th>
<th>Group-1</th>
<th>Group-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periodontal inflammatory parameters</td>
<td>Baseline</td>
<td>Control sites</td>
</tr>
<tr>
<td>PI</td>
<td>68.4 (52.2–73.1) *</td>
<td>6.4 (5.2–6.8) #</td>
</tr>
<tr>
<td>BOP</td>
<td>73.1 (63.6–79.8) §</td>
<td>5.5 (4.3–6.1)</td>
</tr>
<tr>
<td>PPD &gt; 4 mm</td>
<td>48.1 (43.6–51.1) #</td>
<td>3.5 (2.8–4)</td>
</tr>
</tbody>
</table>

* Compared to baseline among individuals in Group-2 (P < 0.01).
# Compared to control-sites in Group-1 (P < 0.01).
§ Compared to test-sites in Group-1 (P < 0.01).
* Compared to test-sites in Group-2 (P < 0.05).
# Compared to control-sites in Group-2 (P < 0.05).
* Compared to test-sites in Group-2 (P < 0.05).
3.3. Comparison of periodontal conditions among patients in groups 1 and 2 between 1- and 3-months following (a) NSPT and (b) NSPT + Nd:YAG laser therapy

Periodontal parameters (PI, BOP, and PD ≥ 4 mm) were comparable at the test-sites and control-sites among patients in groups 1 and 2 between 1-month and 3-months of follow-up (Table 4).

3.4. Hemoglobin A1c levels

At baseline, mean HbA1c levels were significantly higher among patients in Group-1 as compared to individuals in Group-2 (P < 0.01) (Table 1). Among patients in Group-1, mean HbA1c levels were significantly higher (6.3 ± 0.4%) as compared to those in Group-2 (4.6 ± 0.2) (P < 0.05) at 1-month follow-up. Among patients in Group-1, baseline mean HbA1c levels (7.6 ± 0.4%) were significantly higher as compared to those measured at 3-months follow-up (5 ± 0.2%) (P < 0.05). At 3-month follow-up, mean HbA1c levels were comparable among patients in Group-1 (5.0 ± 0.2%) and Group-2 (4.6 ± 0.1%).

4. Discussion

The present convenient sample pilot study was based on the hypothesis that outcomes of NSPT with or without adjunct Nd:YAG laser therapy in the treatment of periodontal inflammation is compromised among patients with T2DM as compared to controls. This outcome was speculated since host resistance (such as defective migration of polymorphonuclear leukocytes, impaired phagocytosis and an exaggerated inflammatory response to microbial products) is altered in patients with chronic hyperglycemia due to enhanced formation and accumulation of advanced glycation endproducts and increased oxidative stress in periodontal tissues as compared to a normoglycemic state [21,22]. The present pilot study supports these results [21,22] since baseline periodontal inflammatory parameters (PI, BOP, and PD ≥ 4 mm) were significantly higher among patients in Group-1 (patients with T2DM) as compared to those in Group-2 (controls).

One-month follow-up results showed that periodontal inflammatory parameters (PI, BOP, and PD ≥ 4 mm) were significantly higher at control-sites (NSPT alone) as compared to the test-sites (NSPT + Nd:YAG laser therapy) among patients in groups 1 and 2. This reflects that adjunct use of Nd:YAG laser with NSPT augments periodontal healing by demonstrating significant reduction PI, BOP and PD ≥ 4 mm as compared to the control-sites. Although it is exigent to provide a precise justification for the improvement of periodontal status on the test-sites compared to control sites; however, the partial removal of the pocket epithelial lining may be an essential contributing factor. In vivo study, Ting et al. [23] investigated morphologic alterations in the periodontal pocket epithelium (with or without clinical inflammation) following the use of Nd:YAG laser therapy. Scanning electron microscopic results showed that in sites with PD ≥ 4 mm, complete removal of the epithelium occurred whereas epithelium persisted in the unflamed sites following whose extent and degree were increasing, was observed in the inflamed portion following Nd:YAG laser therapy [23]. In the present study, periodontal parameters were comparable among the test-sites and control-sites among patients in groups 1 and 2 after 3-months of treatment. It may therefore be claimed that Nd:YAG laser when used as an adjunct to conventional NSPT enhances periodontal tissue healing response and is more efficient in reducing periodontal inflammation among patients with and without T2DM as compared to when NSPT is performed as the sole treatment strategy.

An interesting finding in the present study was that at 3-months follow-up there was a significant improvement in HbA1c levels among patients in Group-1 (patients with T2DM) as compared to their baseline glycemic levels. It is speculated that NSPT reduces the severity of periodontal infection and decreases the systemic burden of proinflammatory mediators thereby reducing the hyperglycemic state in patients with T2DM [24,25]. However, 6 month follow-up results by Engbring et al. [26] showed no significant improvement glycemic control in patients with T2DM and moderate to advanced periodontal inflammation. A possible explanation for this difference in outcomes could be associated with the small sample size and split mouth design of the present study. Further long-term randomized controlled trials focusing using a larger patient population are needed in this regard. It is highly recommended that future studies should focus on a specific periodontal treatment (either NSPT + laser or NSPT alone) in patients with T2DM in order to assess whether or not...
NSPT + laser treatment or NSPT alone when performed in these patients influence glycemic levels differently.

A limitation of the present pilot study is that the sample size was small. Another limitation of the present study is that smokers were excluded from the present investigation. It is well-acknowledged that habitual smoking jeopardizes the outcomes of periodontal treatment [27,28]. It has also been suggested that nicotine exposure reduces insulin release, and negatively affect insulin action thereby proposing smoking as a possible cause for development of insulin resistance [29]. It is therefore hypothesized that outcomes of NSPT (with or without adjunct Nd:YAG laser therapy) are compromised in smokers with and without T2DM. Hence, further large-scale studies adjusted for confounders with longer follow-up durations (at last 6-months) are needed to assess the influence of NSPT with and without adjunct Nd:YAG laser therapy in the treatment of periodontal inflammation in patients with and without T2DM.

5. Conclusion

The present short-term pilot results support our hypothesis that NSPT + Nd:YAG laser therapy is more effective in reducing periodontal inflammation in patients with and without T2DM than when NSPT is used alone. Further long-term randomized controlled clinical trials are needed in this regard.

Conflict of interest statement

None declared.

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