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ORIGINAL ARTICLE

Trauma from instrumentation after non-surgical periodontal treatment with ultrasonic scalers and Nd:YAG laser

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Abstract

Objective. Periodontal therapies aimed at altering the progression of periodontal diseases must include meticulous mechanical debridement during both the non-surgical and the surgical phases of periodontal treatment. The aim of this study was to evaluate and compare the immediate effect of trauma from instrumentation on clinical attachment level after non-surgical periodontal treatment with ultrasonic scalers and a Nd:YAG laser. ***Materials and methods.*** Twenty-four patients with untreated chronic periodontitis, presenting probing depths of 4–6 mm on anterior teeth, upper and lower, were entered into the study. The selected teeth were probed with a pressure-controlled probe, guided by stents. Each quadrant was randomly allocated in a split-mouth design either to treatment with Nd:YAG laser using an energy of 1W, 100mj, 1064nm (test group) or to periodontal treatment using ultrasonic scalers (control group). Clinical parameters, including plaque index (PI), bleeding on probing (BOP), probing pocket depth (PPD) and probing attachment level (PAL) were acquired prior to and immediately after treatment. ***Results.*** Statistical analysis demonstrated no differences between groups at baseline for all parameters ($p > 0.05$). Immediately after treatment, the control group showed a greater PAL loss than the test group ($p < 0.05$). For the control group, there were statistically significant differences between PAL immediately before and after treatment ($p < 0.05$), but not test group ($p > 0.05$). ***Conclusions.*** Within the limits of the present study, it may be concluded that non-surgical periodontal treatment with ultrasonic scalers causes a mean immediate attachment loss of 0.68 mm and that a Nd:YAG laser seems to reduce significantly the trauma the instrumentation produced.

Key Words: *periodontal debridement, periodontal attachment loss, chronic periodontitis, laser therapy, lasers and Nd-YAG laser*

Introduction

The presence of periodonto-pathogen-containing biofilms on the teeth or root surfaces is the major cause of periodontal diseases (i.e. gingivitis and periodontitis) [1,2]. The main goal of the therapeutic approach is to eliminate biofilm and hard deposits on the root surfaces. Mechanical biofilm removal (SRP), using curettes and ultrasonic scalers, has become a well-documented and effective periodontal treatment modality [3–6]. The previous studies have reported that substantial improvements of periodontal condition measured by a reduction in the probing pocket depth and gains in the clinical attachment level, were a common outcome of SRP [7–9]. However, a few previous studies indicated that clinical attachment loss seems to occur in some cases where SRP is performed in pockets with curettes and ultrasonic scalers [10–13].

In addition to these conventional tools, in recent years, the use of lasers has been reported as an alternative device for periodontal therapy. Lasers shown to be useful include the Nd:YAG (neodymium-doped: yttrium, aluminium and garnet), the Er:YAG (erbium-doped: yttrium, aluminium and garnet), the CO_2 (carbon dioxide), the He-Ne (Helium/neon), the KTP (potassium-titanyl-phosphate) and diode laser [14–27]. Various advantageous characteristics of lasers, such as sterilization effects, accelerate wound healing, a positive effect on inflammatory process, hemostatic effects and enhanced visual control, selective calculus ablation or bactericidal effects against periodontopathic pathogens might lead to improved treatment outcomes [14–16]. Among these

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lasers, the Nd:YAG laser has most commonly been used in the treatment of periodontal disease.

Data concerning trauma from instrumentation are available considering ultrasonic scalers [10,13] or curettes [11,12], but not lasers. Therefore, the aim of this study was to evaluate and compare the immediate effect of trauma from instrumentation on clinical attachment level after non-surgical periodontal treatment with ultrasonic scalers and Nd:YAG laser.

Materials and methods

The study protocol was approved by the local ethical committee and conducted according to the principles outlined in the Declaration of Helsinki on experimentation involving human subjects. All participants provided written informed consent.

Selection of patients

The study population consisted of 24 patients with chronic periodontitis who visited the periodontology department of Atatürk University, Erzurum, Turkey. Criteria for subject selection were: (1) no systemic diseases; (2) not using any medication; (3) no use of smoking; (4) no receive periodontal therapy in the last 6 months; and (5) the selected anterior teeth had to exhibit a PPD ranging from 4–6 mm.

Sample size

The sample size was calculated using $\alpha = 0.05$ and the power $(1 - \beta) = 80\%$. For the variability (σ = SD), the value of 0.5 mm was used considering clinical attachment gain as a variable outcome. The minimum clinically significant value (δ) considered was 0.5 mm. On the basis of these data, the number of patients required to be enrolled to conduct this study has been calculated as 24 [28].

Study design

For each patient, six non-adjacent sites with PPD from 4–6 mm were selected (total = 144 sites). Alginate molds of dental arches were made to prepare individual acrylic occlusal stents for standardizing the relative probing attachment level (PAL) measurements during the clinical trial. The SRP and laser therapies were performed by one researcher (SS) and the clinical measurements were assessed by another researcher (AD).

The study was performed according to a split-mouth design and all anterior teeth in the mouth were treated randomly using either the left or right side of the maxilla and mandible for control and the opposite side for the therapy. Each patient was entered into a clinical protocol consisting of two different modalities: Nd:YAG laser (test group) and ultrasonic scalers (control group). The assignment of the test or control sides for the respective treatments was randomly determined by a coin toss prior to initiating treatment.

On the first visit, each patient received initial periodontal therapy consisting of thorough oral hygiene instructions and full-mouth supra- and sub-gingival SRP with ultrasonic instruments (EMS Mini-Piezon, Nyon, Switzerland). SRP with ultrasonic instruments was performed until the researcher considered the teeth surfaces to be appropriately debrided and planed. Following SRP, all supra-gingival teeth surfaces were polished with a rubber cup and point in combination with a dental paste (Detartrine, Septodont, Cedex, France).

Examiner calibration

The researcher charged with clinical assessments was calibrated for intra-examinar repeatability prior to the start of the trial. Ten patients with a total of 34 periodontal pockets were enrolled for this purpose. Duplicate measurements of PPD were collected with an interval of 48 h between the first and the second recording. Calibration was accepted if measurements at baseline and at 48 h were within a millimeter (mm) at ≥99% of the time.

Clinical parameters

The following clinical periodontal parameters were assessed before and 7 days after treatment: Plaque index (PI) [29] and bleeding on probing (BOP) and probing pocket depth (PPD). In addition, on the second visit, probing attachment level (PAL) was acquired prior to and immediately after treatment and calibrated blind by the same researcher.

Bleeding on probing (BOP). On the selected teeth, BOP (see below PPD) to the bottom of the pocket was determined and the percentage of BOP positive sites bled upon within 30 s after probing with a controlled-force probe (Florida Probe, Gainesville, FL) was recorded.

Probing pocket depth (PPD) and probing attachment level (PAL). PPDs and PALs were measured with the use of a controlled-force probe (0.25 N, 127 N/cm^2). PPD measurements were performed in duplicate, according to the guidelines of the Florida Probe software (FP 32 Software version 4), and subsequently the mean of the two values was calculated. PAL measurements were obtained from a groove at the occlusal stent to the bottom of the pocket by the Florida stent probe.

Treatment

All therapy procedures for both test and control groups were performed during the same treatment

session and by the same researcher and with the same technique. For the control group, a piezoelectric ultrasonic scaler device (EMS Mini-Piezon, Nyon, Switzerland) with specific metal tip (PS tip, medium intensity) was used with water coolant according to the manufacturer's instructions. The tip of the scaler was applied parallel to the tooth surface to remove the sub-gingival debris in the periodontal pocket and there was no intention to traumatize the soft tissues.

For the test group, the laser application was performed using a Nd:YAG laser device (Smarty A10, DEKA, Florence, Italy; short-pulsed wave laser with a wavelength of 1064 nm) with a flexible fiber-optic tip with a diameter of 300 μm. The laser was used for laser-assisted sub-gingival curettage and disinfection of the periodontal pockets. The periodontal pockets were radiated by a laser beam of 1 W, 10 Hz, 100 mj, 100-μs pulsewidth, energy density of 141.54 J/cm^2 with sweeping motion (5 mm/s) and with air cooling. Two 60-s applications were made in each direction by inserting the contact optic fiber into the periodontal pocket, for a total irradiation time of 120 s for each tooth. An interval of 20 s between irradiations was used for thermal relaxation of the tissue. Before activating the laser, the fiber-optic tip was placed at the base of the periodontal pocket parallel to the tooth surface. Then the laser was activated and the tip moved horizontally (back and forth) and coronally (up and down) until it reached the gingival margin. When the lasers were in use, protective eyewear of appropriate optical density was worn by the investigator and patients.

Participants with deep pocket sites when the study was completed were scheduled for surgical periodontal therapy.

Statistical analysis

The means and standard deviations were calculated for all clinical parameters of both groups. The data thus collected were assessed using SPSS 16.0 - statistical software (SPSS Inc., Chicago, IL). The Wilcoxon's signed ranks test was chosen to compare test and control group differences in mean PI, BOP, PPD and PAL. In addition, the differences in mean PI, BOP, PPD and PAL values between at baseline and after treatment were evaluated using Wilcoxon's signed ranks test.

Results

The present study included anterior 144 sites selected from 24 chronic periodontitis patients throughout the study period. The mean age of the patients was 39.1 ± 4.7 years and 14 out of 24 were females.

All participants completed the study and reported 100% compliance. None of the patients revealed any major periodontal inflammatory symptoms after instrumentation during the entire study. Post-operative complications such as infections, suppuration or abscesses were not observed.

Table I. Mean ± SD values of the clinical parameters before and after therapy for both groups.

Parameters	Control group	Test group
PI		
Before therapy	1.06 ± 0.24	1.12 ± 0.33
After therapy	0.71 ± 0.47[a]	0.82 ± 0.53[a]
BOP (%)		
Before therapy	94 ± 0.24	100 ± 0.00
After therapy	88 ± 0.33	94 ± 0.24
PPD (mm)		
Before therapy	5.20 ± 0.67	5.38 ± 0.62
After therapy	4.32 ± 0.64[a]	4.52 ± 0.64[a]
Difference (before–after therapy)	0.88 ± 0.63	0.87 ± 0.61

[a]Statistically significant difference from before therapy ($p < 0.05$), Wilcoxon signed-rank non-parametric test.
PI, plaque index; BOP, bleeding on probing; PPD, probing pocket depth.

The statistical analyses for the clinical parameters at baseline and 7 days after the therapy are presented in Table I. According to Table I, no statistically significant differences between groups were observed for any of the clinical parameters at baseline and 7 days ($p > 0.05$). At 7-day examination, there was, compared to the baseline value, statistically significant reduction of the PI scores (from 1.06 ± 0.24 to 0.71 ± 0.47 for the control group; from 1.12 ± 0.33 to 0.82 ± 0.53 for the test group; $p < 0.05$), a corresponding statistically significant reduction of the PPD values (from 5.20 ± 0.67 mm to 4.32 ± 0.64 mm for the control group; from 5.38 ± 0.62 mm to 4.52 ± 0.64 mm for the test group, $p < 0.05$).

Table II shows the distribution of PAL values immediately before and after therapy. There was a statistically significant increase of the PAL values (from 6.24 ± 0.58 mm to 6.92 ± 0.54 mm) in the control group ($p < 0.05$). In comparison, immediately

Table II. Mean ± SD values of the PAL before and immediately after treatment for both groups.

Parameters	Control group	Test group
PAL (mm)		
Before therapy	6.24 ± 0.58	6.31 ± 0.48
Immediately after therapy	6.92 ± 0.54[b]	6.38 ± 0.69[a]
Difference (before–after therapy)	0.68 ± 0.57	0.04 ± 0.58

[a]Statistically significant difference between the groups ($p < 0.05$), Wilcoxon signed-rank non-parametric test.
[b]Statistically significant difference from before therapy ($p < 0.05$), Wilcoxon signed-rank non-parametric test.
PAL, probing attachment level.

after the therapy, statistically significant differences were found between the test and control groups for PAL values ($p < 0.05$).

The mean attachment loss calculated immediately after therapy considering ultrasonic scaling was 0.68 ± 0.57 mm.

Discussion

The aim of this randomized-controlled, split-mouth, double-blind designed clinical trial was to evaluate and compare the immediate effect of trauma from instrumentation on clinical attachment level after non-surgical periodontal treatment with ultrasonic scalers and Nd:YAG laser. Immediate PAL loss during periodontal treatment with the ultrasonic scaler and Nd:YAG laser differed statistically significantly: PAL loss occurred during non-surgical periodontal treatment with an ultrasonic scaler. This result compares well with those of others. Alves et al. [10] and Claffey et al. [13] have reported an average mean immediate attachment loss of 0.50–0.75 mm in the studies when a ultrasonic scaler was used to perform SRP. To the best of our knowledge, the effect of laser therapy on the immediate attachment loss has not been investigated before; therefore a direct comparison with the literature is not possible.

Pathogen-containing biofilms plays a key role in the etiology and pathogenesis of periodontitis. The aim of the periodontal therapy is to create a biologically acceptable root surface by eliminating the putative periodontal pathogens and the metabolic products. Conventional mechanical debridement in conjunction with supra-gingival plaque control has proven to be effective in periodontal therapy [3–6]. SRP is performed using a number of dental tools, including hand and ultrasonic instruments, and can result in significant clinical improvement in the great majority of cases [3–7]. Ultrasonic scalers seem to be similarly effective as manual debridement regarding clinical attachment gain, PPD reduction and BOP reduction [3,4]. In addition, a detailed systematic review of the clinical use of powered instruments compared with hand instruments reported that there were similar clinical outcomes in the efficacy in the sub-gingival debridement of single rooted teeth [5]. In the present study, therefore, ultrasonic scaler was chosen for the SRP.

The current study, the reason for choosing a split-mouth design, was to facilitate the comparison of both treatment methods under very similar and optimally standardized healing and evaluation conditions by eliminating patient-specific conditions [30]. The number of affected sites should have been equally distributed in the two groups, as the treatment time was set to 120 s per site. Furthermore, none of the clinical parameters revealed any statistically significant differences.

Since the vast majority of clinical studies relating to periodontitis therapy have been conducted using manuel instruments, hand instrumentation is generally regarded as the gold standard [6]. Clinically, there is evidence that SRP with manuel and ultrasonic instruments provides the best results for the treatment of periodontal disease [3–6]. However, several anatomic variations may limit the success of conventional SRP such as deep pockets, root concavities, furcations, multi-rooted teeth, grooves and dental crowding, which may hinder the access of instruments into the periodontal pocket [6]. In periodontal pockets ≥3.73 mm in depth, hand instruments cannot eliminate subgingival dental plaque and calculus effectively and no instruments are effective for periodontal pockets with 5.7–8.3 mm [4]. For this reason, in the past decades, several treatment alternatives have been presented. Thus, Nd:YAG laser therapy has been proposed as an alternative or adjunct to conventional SRP, due to bactericidal and detoxification effects against periodontal species in deep pockets [14–16]. With respect to clinical outcome measures, there are several studies reporting the inconsistency of the efficacy of Nd:YAG laser therapy as an alternative or adjunct to non-surgical periodontal treatment. A few previous studies reported that no additional benefit was found when Nd:YAG laser therapy was used secondary to traditional SRP [19–22]. On the contrary, several previous studies have demonstrated that Nd:YAG laser therapy is superior to SRP therapy alone [24–27].

Despite so many studies, at the moment it is not possible for a meaningful comparison to be achieved between various clinical studies or between Nd:YAG laser and conventional SRP therapy, because of the wide variations in laser parameters such as power level (W), exposure time (s), pulsed vs continuous wave energy, energy density (J/cm^2), distance from the surface and the angle between the target tissue and the fiber tip, the insufficient reporting of parameters that, in turn, do not allow calculation of energy density, the differences in the experimental design, the lack of proper controls and the differences in severity of disease and in treatment protocols [15,16]. The laser parameters used in the present study (1 W, 10 Hz, 100 mj) were based on some literature studies [25,31,32], which demonstrated that the Nd:YAG laser, when used with mean power up to 2 W, promoted minimal root surface hazard effects. Therefore, the most important issue in laser therapy is to determine the correct parameters to use to achieve satisfactory results, without inducing detrimental thermal effects in the pulp or causing fracturing or carbonization.

As can be seen in Table I, the finding that non-surgical periodontal treatment with an ultrasonic scaler can result in statistically significant

improvements in PI and PPD compared to baseline is in agreement with previously reported data [33–40].

Using an ultrasonic scaler for subgingival debridement, Obeid et al. [7] reported a mean PPD reduction of 1.1 mm in deep pockets. In the present study, a mean PPD reduction of 0.88 mm was observed in 4–6 mm-pockets. These results are in accordance with data reported in different recent meta-analyses [3,5].

One important aspect to assess the success of subgingival debridement is the effective reduction of periodontal inflammatory symptoms like BOP [5]. In the present study, supra- and sub-gingival debridement and oral hygiene instructions were conducted, in order to reduce gingival inflammation. BOP differences between baseline and 7-days were very little and not statistically significant. One possible explanation may be the short evaluation period.

So far, there has been no report in the literature about the immediate effect of trauma from instrumentation on clinical attachment level after non-surgical periodontal treatment with lasers. In the present study, Nd:YAG laser therapy did not cause immediate PAL loss, whereas, an ultrasonic scaler for sub-gingival debridement of root surfaces caused immediate PAL loss of 0.68 mm. This finding is in accordance with data from other studies [10,13]. Alves et al. [10] have reported an average attachment loss of 0.77 mm immediately after a single episode of ultrasonic instrumentation. Similarly, Claffey et al. [13] found an average attachment loss of 0.60 mm immediately after SRP with an ultrasonic instrument. This was mainly because of harmful effects of excessive penetration into the bottom of the pocket of periodontal instruments. In addition, perhaps this was because the junctional epithelium might be ruptured, as ultrasonic instruments provide less tactile sensitivity when the tip of the ultrasonic scaler is inserted between the tooth and gingiva and over instrumentation of the root surfaces.

In conclusion, within the limits of the present study, it may be concluded that non-surgical periodontal treatment with ultrasonic scalers causes a mean immediate attachment loss of 0.68 mm and that the Nd:YAG laser seems to reduce significantly the trauma from instrumentation produced. Further comparative studies are needed to evaluate long-term influences of different degrees of immediate attachment loss on probing attachment levels and various properties such as power, frequency, energy and time in the application of the Nd:YAG laser to immediate attachment loss.

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