applied sciences

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Long-Term Stability of Er:YAG Laser Non-Surgical Periodontal Treatment

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Abstract: Background: Nonsurgical periodontal therapy is the first step of periodontal diseases treatment. It could be performed with various instruments and in recent years lasers have been tested too. The aim of the present study is to evaluate the long-term clinical effectiveness of Er:YAG laser monotherapy in the treatment of moderate chronic periodontitis. Methods: 451 teeth (1099 periodontal pockets) from 30 patients with moderate chronic periodontitis are allocated for subgingival scaling and root planing into two groups—hand instrumentation (control) and Er:YAG laser instrumentation with 100 mJ/15 Hz (test). Patients are examined for probing pocket depth, gingival recession, clinical attachment level, bleeding on probing, plaque presence at baseline, 1, 3, 6 and 12 months after instrumentation. Results: One year after therapy significant reduction of all clinical parameters examined is observed. The pocket depth decreases with 1.55 mm for the control group and 1.70 mm in the test group. The attachment level gain reveals 1.09 mm for hand instrumentation and 0.59 for laser instrumentation. The bleeding on probing reduces more significantly in the test group, where one year after treatment the index is 19.1%, whereas in the control group, it is 33.8%. Conclusions: The Er:YAG laser demonstrates similar clinical effectiveness to hand instrumentation in the non-surgical periodontal treatment. Better long-term stability is observed in the test group.

Keywords: periodontitis; Er:YAG laser; periodontal pocket; subgingival scaling; treatment efficacy

Citation: Yaneva, B.; Tomov, G.; Karaslavova, E.; Romanos, G.E. Long-Term Stability of Er:YAG Laser Non-Surgical Periodontal Treatment. *Appl. Sci.* **2023**, *13*, 12065. https://doi.org/10.3390/app132112065

Academic Editor: Oleh Andrukhov

Received: 2 October 2023
Revised: 31 October 2023
Accepted: 31 October 2023
Published: 6 November 2023

1. Introduction

The evaluation of the clinical effectiveness of mechanical periodontal therapy is based on the evaluation of the elimination of the inflammatory process, which consists of the reduction of periodontal pocket bleeding, reduction of pocket depth and gain of clinical attachment [1]. The main goal of periodontal therapy is to preserve natural dentition by achieving and maintaining a healthy periodontium. That is why the first step in the treatment of periodontitis, as a result of polymicrobial infection, is the removal of dental biofilm and calculus deposits, aiming at reducing periodontal pathogens to levels compatible with periodontal health [2]. Various tools have been developed for professional mechanical plaque removal. Hand and ultrasonic instrumentation have proven efficacy in non-surgical periodontal treatment [3]. Different types of lasers have also been used in the treatment of periodontitis, with only the Erbium family having the ability to ablate hard and soft tissues and thus remove calculus as well [4,5]. The Er:YAG laser has also proved its antibacterial effectiveness [6,7].

Despite the use of lasers in the last 25 years, the results in terms of their clinical effectiveness are quite contradictory [8,9].

For the first time, the clinical efficacy of the Er:YAG laser was studied by Watanabe et al. in 1996 [10]. They instrument the root surfaces of 60 teeth in 60 patients with 40 mJ energy

and 10 Hz pulse frequency using a 600 µm diameter tip. The authors report successful removal of supra- and subgingival calculus in 95% of cases. Although the surfaces appear rough after treatment, the researchers report a decrease in pocket depth. As no side effects or complications are identified during the study, the authors conclude that the Er:YAG laser is safe and effective in clinical application. Later, a number of studies regarding the monotherapy or additional use of the Er:YAG laser in the treatment of periodontitis are conducted. Most of them are short-term and do not give clear information about the long-term clinical effectiveness of the Er:YAG laser in non-surgical periodontal treatment [11–13].

Several studies examining the results of Er:YAG laser treatment over a longer period of time report promising data. Schwarz et al. demonstrate that the Er:YAG laser is a suitable alternative to conventional mechanical cleaning, as its application in patients with chronic periodontitis demonstrates a significantly greater reduction in bleeding on probing and in gain of clinical attachment compared to manual instrumentation [14]. The authors confirm this result up to 2 years after the initial instrumentation [15]. Other authors who have observed treatment outcomes over a longer period also report a significant reduction in clinical data after instrumentation [16,17].

The aim of the present study is to determine the long-term clinical efficacy of Er:YAG laser monotherapy in the treatment of moderate chronic periodontitis and to compare it with conventional instrumentation with Gracey curettes.

2. Materials and Methods

The study is approved by the Ethics Committee of the Medical University of Plovdiv with protocol No. 3/05.07.2012.

The study includes 30 patients with generalised moderate chronic periodontitis (which corresponds to Stage II and partially Stage III periodontitis according to the last classification) who visited the Department of Periodontology and Oral Mucosal Diseases of Medical University—Plovdiv, Bulgaria, in the period July 2012–February 2014 [18,19]. Inclusion criteria are at least 2 teeth per quadrant with a probing depth between 3.6 mm and 6.4 mm (measured with periodontal probe); loss of clinical attachment up to 4 mm; bleeding on probing; no periodontal treatment in the last 12 months; no antibiotic intake in the last 6 months; and no systemic diseases or systemic intake of drugs that could affect the course of the disease or pregnancy. Included in the study are 451 teeth (1099 periodontal pockets). Patients are examined using Florida probe (Florida Probe Corporation, Gainesville, FL, USA) and probing pocket depth (PPD, as distance between the gingival margin and the depth of the pocket), gingival recession (GR, as distance between the cemento-enamel junction and gingival margin), clinical attachment level (CAL, as distance between cemento-enamel junction and depth of the pocket), bleeding on probing (BOP in %) and full mouth plaque score (FMPS in %) are included in the periodontal chart. After removing the supragingival calculus with the ultrasonic device Piezon Master 400 (EMS Electro Medical Systems SA, Nyon, Switzerland) and supragingival tip—A, patients are treated subgingivally on the principle of split mouth design where 217 teeth (527 periodontal pockets) are allocated in the control manual instrumentation group (control group) and 234 teeth (572 periodontal pockets) in the test Er:YAG laser instrumentation group (laser group). Supra- and subgingival instrumentation was performed within 24 h on the principle of full mouth disinfection [20]. In the control group—C, subgingival scaling and root planing is performed with hand instruments—Gracey-curettes (Hu-Friedy Co., Chicago, IL, USA)—until clean and smooth root surfaces are achieved. In the test group—laser group, subgingival instrumentation is performed with an Er:YAG laser (Lite Touch, Light Instruments Ltd., Yokneam, Israel) with chisel type × 17 mm/hard tissue mode/contact mode/energy 100 mJ/pulse frequency 15 Hz/water cooling level 6; and pocket debridement—with tip with diameter × length—0.6 × 17mm/soft tissue mode/non-contact/energy 50 mJ/pulse frequency 30 Hz/water cooling level 6. Follow-up examination to register PPD, GR, CAL, BOP and FMPS is performed at 1, 3, 6 and 12 months after treatment.

The statistical analysis is performed with SPSS for Windows, version 17 (SPSS Inc., Chicago, IL, USA). Data are presented as mean ± Sx (SD). Independent samples *t* tests are used for comparison of the clinical variables (PPD, GR, CAL). Chi-square test is used for analysis bleeding on probing and plaque presence. Differences are considered statistically significant when the *p* value is <0.05.

The null hypothesis is that the Er:YAG laser does not have better effectiveness in nonsurgical periodontal therapy neither immediately after treatment nor in long-term observations in comparison to the conventional treatment.

3. Results

The participants of the present study are between 30 and 62 years old (46.87 ± 8.49 years); 23.1% are male and 76.9% are female. Table 1 presents the data on changes in PPD and the comparison between both treatment groups from the initial examination up to one year after the therapy. After hand instrumentation, a statistically significant reduction in PPD is obtained in the first and third months ($p < 0.05$) (Table 1). Between the third and sixth month, there is a slight increase in the PPD (0.36 mm), and between the sixth and twelfth month the deepening of the pockets averaged 0.91 mm, which is statistically significant ($p = 0.04$). The overall mean reduction in this clinical indicator for the control group one year after therapy is 1.55 mm. In the group treated with the Er:YAG laser, the most pronounced reduction in pocket depth is observed in the period from the initial study to the first month—from 4.58 mm to 3.15 mm ($p = 0.00$) (Table 1). The reduction lasted until the sixth month, and between the sixth and twelfth month of treatment there is a slight deepening of the pocket by 0.05 mm ($p > 0.05$). One year after Er:YAG laser treatment of the periodontal pockets, a statistically significant ($p = 0.00$) reduction in the depth of the pockets from 4.58 mm to 2.88 mm is found.

Table 1. Dynamic changes in pocket depth after Er:YAG laser (laser group) and conventional instrumentation (control group).

PPD	Laser Group						Control Group					
	N	$\bar{x}$	S_X	Mean Diff.	t	*p*-Value	N	$\bar{x}$	S_X	Mean Diff.	t	*p*-Value
PPD—baseline PPD—1 month	572 572	4.58 3.15	0.69 1.08	1.43	31.809	***0.00***	527 527	4.59 3.36	0.68 1.09	1.23	27.79	***0.00***
PPD—1 month PPD—3 months	572 572	3.15 2.84	1.08 1.05	0.31	7.035	***0.00***	527 527	3.36 2.91	1.09 1.15	0.44	9.40	***0.00***
PPD—3 months PPD—6 months	572 572	2.84 2.83	1.05 1.06	0.02	0.522	0.60	527 527	2.91 2.95	1.15 1.07	−0.36	0.76	0.45
PPD—6 months PPD—12 months	572 572	2.83 2.88	1.06 0.99	−0.05	1.371	0.17	527 527	2.95 3.04	1.07 1.01	−0.91	2.07	***0.04***
PPD—baseline PPD—12 months	572 572	4.58 2.88	0.69 0.99	1.70	38.421	***0.00***	527 527	4.59 3.04	0.68 1.01	1.55	34.10	***0.00***

Table 2 presents the dynamic changes in GR for both therapeutic approaches. Twelve months after treatment, the increase in recession in both study groups is statistically significant compared to the initially measured values ($p = 0.00$).

The CAL in the control group demonstrates a statistically significant decrease by the third month ($p < 0.05$), decreasing from 4.66 mm in the baseline to 3.56 mm in the first month and 3.10 mm in the third month after treatment (Table 3). The total gain of clinical attachment up to the third month after manual instrumentation is on average 1.54 mm. In the sixth month, there is a slight increase compared to the third month (0.03 mm), which has no significant difference ($p = 0.511$). However, between the sixth and twelfth month after mechanical therapy, a loss of clinical attachment of 0.11 mm is observed, which is

statistically significant ($p = 0.015$). At the end of the observed period (1 year after therapy), a clinical attachment gain of 1.41 mm is reported compared to the initially measured values before treatment with hand instruments, which is statistically significant ($p < 0.001$). A statistically significant decrease in the CAL is observed up to the third month in the laser group as well ($p < 0.05$). One month after laser treatment of the pockets, the level of clinical attachment decreased from 4.71 mm to 3.34 mm. Between the first and third month, a clinical attachment gain of 0.28 mm is observed, which is also significant. In Er:YAG laser-treated pockets, there is some loss of clinical attachment between the third and sixth month, as well as between the sixth and twelfth month, but it is an extremely small difference (0.02 mm and 0.04 mm) with no significant expression. The average gain of a clinical attachment for a period of 1 year is 1.59 mm.

Table 2. Dynamic changes in gingival recession after treatment with Er:YAG laser (laser group) and hand instrumentation (control group).

GR	Laser Group						Control Group					
	N	$\bar{x}$	S_X	Mean Diff.	t	*p*-Value	N	$\bar{x}$	S_X	Mean Diff.	t	*p*-Value
GR—baseline GR—1 month	572 572	0.14 0.18	0.49 0.52	0.04	2.279	***0.02***	527 527	0.09 0.22	0.41 0.61	0.12	6.340	***0.00***
GR—1 month GR—3 months	572 572	0.18 0.22	0.52 0.59	0.03	1.779	0.08	527 527	0.22 0.22	0.61 0.62	0.00	0.069	0.95
GR—3 months GR—6 months	572 572	0.22 0.24	0.59 0.58	0.02	0.973	0.33	527 527	0.22 0.21	0.62 0.63	−0.01	0.507	0.61
GR—6 months GR—12 months	572 572	0.24 0.23	0.58 0.61	−0.01	0.240	0.81	527 527	0.21 0.23	0.65 0.64	0.01	0.620	0.54
GR—baseline GR—12 months	572 572	0.14 0.24	0.49 0.61	0.10	4.325	***0.00***	527 527	0.09 0.23	0.41 0.64	0.13	4.959	***0.00***

Table 3. Dynamic changes in the level of clinical attachment after treatment in both groups.

CAL	Laser Group						Control Group					
	N	$\bar{x}$	S_X	Mean Diff.	t	*p*-Value	N	$\bar{x}$	S_X	Mean Diff.	t	*p*-Value
CAL—baseline CAL—1 month	572 572	4.71 3.34	0.78 1.15	1.37	29.787	***0.00***	527 527	4.66 3.56	0.74 1.21	1.09	23.322	***0.00***
CAL—1 month CAL—3 months	572 572	3.34 3.05	1.15 1.19	0.28	5.671	***0.00***	527 527	3.56 3.10	1.20 1.24	0.45	9.221	***0.00***
CAL—3 months CAL—6 months	572 572	3.05 3.07	1.19 1.22	−0.02	−0.045	0.96	527 527	3.10 3.15	1.25 1.19	−0.03	0.657	0.51
CAL—6 months CAL—12 months	572 572	3.07 3.11	1.22 1.12	−0.04	−1.224	0.22	527 527	3.15 3.26	1.20 1.09	−0.11	2.438	***0.02***
CAL—baseline CAL—12 months	572 572	4.71 3.12	0.78 1.12	1.59	34.068	***0.00***	527 527	4.66 3.26	0.74 1.09	1.40	29.872	***0.00***

In all post-treatment measurements, the reduction in pocket depth in the Er:YAG laser-treated group showed a statistically significant better improvement ($p < 0.05$) except for the third-month result ($p = 0.253$) (Table 4). The biggest difference of PPD between both groups is found in the first month, where the improvement in the laser group is about 0.20 mm more in comparison to the control group. The PPD reduction at 1 year is with 0.15 mm more in the laser group compared with the control group ($p = 0.013$).

Table 4. Comparison of probing pocket depth between both treatment groups up to 1 year.

PPD	Control Group			Laser Group					
	N	$\bar{x}$	S_X	N	$\bar{x}$	S_X	Difference	t	*p*
Initial visit	527	4.59	0.69	572	4.58	0.69	0.01	0.206	0.84
1 month	527	3.36	1.09	572	3.16	1.09	0.20	3.023	***0.00***
3 months	527	2.91	1.14	572	2.84	1.06	0.08	1.143	0.25
6 months	527	2.95	1.06	572	2.82	1.06	0.13	1.982	***0.05***
12 months	527	3.02	1.00	572	2.88	0.99	0.15	2.482	***0.01***

The gain of clinical attachment in the laser-treated periodontal pockets is on average 0.22 mm higher than that in the control group in the first month after treatment, which is significant ($p = 0.002$) (Table 5). At the third and sixth month after therapy, no statistically significant difference for CAL is found between both treatment modalities ($p > 0.05$). One year after the therapy, the laser-treated group demonstrates a clinical attachment gain of 0.13 mm more than in the Gracey curette-treated group.

Table 5. Comparison of clinical attachment level between both groups for the whole study period.

CAL	Control Group			Laser Group					
	N	$\bar{x}$	S_X	N	$\bar{x}$	S_X	Difference	t	*p*-Value
Initial visit	527	4.67	0.74	572	4.71	0.78	0.05	1.075	0.28
1 month	527	3.57	1.23	572	3.35	1.16	0.22	3.108	***0.00***
3 months	527	3.10	1.25	572	3.06	1.20	0.05	0.617	0.54
6 months	527	3.15	1.20	572	3.06	1.23	0.09	1.203	0.23
12 months	527	3.25	1.09	572	3.12	1.14	0.13	1.962	***0.05***

Table 6 presents the differences between both instrumentation methods in terms of bleeding on probing up to one year. In the first and third month after treatment, it is found that Er:YAG laser-treated pockets demonstrate almost 8% and 10% less bleeding sites, respectively, than those instrumented with hand instruments ($p < 0.05$). The values achieved in the sixth month do not indicate statistically significant differences. Regarding the data at 12 months post treatment, the biggest intergroup difference for BOP is demonstrated, with more significant reduction in the number of bleeding sites in the Er:YAG laser-treated group. There are nearly 15% less bleeding sites in the test group than in the control group ($p < 0.05$). In total, the bleeding sites in the test group decreased almost 6 times as a long-term result (1 year after therapy).

Table 6. Comparison of bleeding on probing between both groups up to one year.

Visit	BOP		Difference%	X^2	*p*-Value
	Yes	No			
	%	%			
Control_baseline	87.9	12.1	2.3	1.168	0.28
Laser_baseline	85.6	14.4			
Control_1 month	33.7	66.3	7.8	7.984	***0.01***
Laser_1 month	25.9	74.1			

Table 6. *Cont.*

Visit	BOP		Difference%	χ^2	*p*-Value
	Yes	No			
	%	%			
Control_3 months	27.7	72.3	9.7	14.700	***0.00***
Laser_3 months	18.0	82.0			
Control_6 months	25.8	74.2	1.8	0.458	0.50
Laser_6 months	24.0	76.0			
Control_12 months	33.8	66.2	14.7	33.998	***0.00***
Laser_12 months	19.1	80.9			

Table 7 presents the intergroup comparison of plaque-present surfaces in all the visits tested. Plaque-free sites are approximately 24% in the initial visit for both groups. The achieved differences between both groups at the first, third and twelfth month after treatment are in the range between 4 and 5%, and these differences are significant ($p < 0.05$). The achieved reduction as a long-term effect (reporting at 12 months) in both studied groups demonstrates a decrease in the presence of plaque by more than 2 times, and a significantly greater reduction is achieved in the laser-instructed group ($p < 0.05$).

Table 7. Comparison of full mouth plaque score between both groups for the whole study period.

Visit	FMPS		Difference %	χ^2	*p*-Value
	Yes	No			
	%	%			
Control_baseline	75.9	24.1	−0.6	0.090	0.76
Laser_baseline	76.5	23.5			
Control_1 month	40.9	59.1	5.0	4.767	***0.03***
Laser_1 month	35.9	64.1			
Control_3 months	30.9	69.1	4.6	4.664	***0.03***
Laser_3 months	26.3	73.7			
Control_6 months	44.2	55.8	3.9	2.400	0.12
Laser_6 months	40.3	59.7			
Control_12 months	40.2	59.8	4.7	4.210	***0.04***
Laser_12 months	35.5	64.5			

4. Discussion

It has been proven in the literature that an initial probing pocket depth of 4–6 mm demonstrates a reduction of an average of 1.29 mm and a gain of clinical attachment of 0.55 mm after mechanical nonsurgical periodontal therapy with hand instruments or ultrasonic devices. In the periodontal pockets, where the PPD before treatment is greater than 7 mm, the greatest reduction of the depth is found—2.16 mm and, respectively, the gain of clinical attachment is 1.19 mm. Also, the greatest reduction in pocket depth is reported between the first and third month after non-surgical periodontal therapy, although the healing process lasts up to 9–12 months after treatment [21,22]. These data are also confirmed by the current clinical study with initial PPD between 3.6 and 6.4 mm, where a reduction in pocket depth of 1.55 mm was observed in the control group and 1.70 mm in the test group one year after the initial instrumentation. Although there is a minimal difference in the data between both groups, which is statistically significant, there is no real clinical significance. A more interesting observation is that in both examined groups, the most significant is the reduction of inflammation in the first 3 months. After that, deepening of the PPD is observed in the control group, which is within nearly 1 mm (0.91 mm) up to one year after treatment. In comparison, in the laser-treated group, the reduction in PPD after

the third month remains almost unchanged until the end of the study period, which proves the long-term effectiveness of Er:YAG laser scaling and root debridement. Recent studies by Zhou et al. and Grzech-Leśniak, K. report, although minimal, significant difference in favour of laser instrumentation 6 months after treatment [23,24].

The results of the present study correspond to those of Schwarz et al., who found that the depth of the pocket decreases from 4.9 ± 0.7 mm in the baseline to 2.9 ± 0.6 mm six months after Er:YAG laser therapy. In addition, they observed that the level of clinical attachment varied from 6.3 ± 1.1 mm to 4.4 ± 1.0 mm, and bleeding on probing was reduced by 43% over the study period, where these changes although are slightly more significant in the laser instrumentation group compared to the conventionally treated group. Lack of bleeding on probing, as a sign of elimination of the inflammatory process, is an important clinical assessment parameter for effectiveness of periodontal treatment. Professional mechanical plaque control has been found to reduce BOP with an initial depth of the pockets between 4 and 6.5 mm to an average of 45% throughout the observed post-treatment period [21]. For comparison, the reduction in BOP in the test group in the present study is 75% one year after therapy, with final values of this index below 20%. In contrast, in the control group, the values of the bleeding index are over 30%, which requires additional instrumentation to control the inflammation [1].

The data from the present clinical study demonstrate that Er:YAG laser instrumentation leads to a significant improvement in all observed clinical parameters. Lopes et al. also observe the effectiveness of the Er:YAG laser in non-surgical periodontal therapy, with the follow-up examinations of their study again in the first, third, sixth and twelfth month after treatment [17]. However, they report a greater difference after therapy, which may be due to the greater initial depth of the pocket—about 6 mm, in contrast to the current study, where this depth was about 5 mm [15,25]. The early significant improvement of PPD and CAL in the laser group may be explained by the fact that there is not only mechanical disorganisation of the bacterial biofilm, but also photothermal light effect against periodontal pathogens, which in turn leads to a reduced inflammatory process, resulting in a significant reduction of bleeding and pocket depth [7,26]. Moreover, no side effects were observed for the treatment as well as for the healing period.

The present study possesses some limitations. The time period could be further extended to examine the stability of the results in a longer period in comparison to the conventional treatment. Subgingivally, the root surfaces are instrumented only with the Er:YAG laser without using ultrasonic instrumentation previously which consumes more time. Further clinical studies with longer observation periods and the same parameters of laser instrumentation should be performed to clarify and confirm the abovementioned results.

5. Conclusions

The present clinical study demonstrates that Er:YAG laser instrumentation is effective in the treatment of moderate chronic periodontitis and leads to promising clinical results. Instrumentation with the Er:YAG laser leads to a significant reduction of pocket depth, bleeding on probing and gain of clinical attachment. It should be noted that the values obtained remain significantly lower one year after therapy compared to those measured in the initial clinical visit, which proves the long-term stability of the results.

Author Contributions: Conceptualization, B.Y. and G.T.; formal analysis, E.K.; investigation, B.Y.; writing—original draft preparation, B.Y.; writing—review and editing, G.E.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Medical University of Plovdiv (protocol № 3/5 July 2012).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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