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HUMAN RANDOMIZED CONTROLLED TRIAL

Erbium-doped: yttrium-aluminum-garnet (Er:YAG) versus scaling and root planing for the treatment of periodontal disease: A single-blinded split-mouth randomized clinical trial

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Abstract

Background: This randomized, controlled clinical trial aimed to compare the differences in periodontal clinical outcomes, duration of the procedure, and patient's experience between conventional scaling and root planing and erbium-doped: yttrium-aluminum-garnet (Er:YAG) in the treatment of generalized moderate to severe chronic periodontitis or generalized Stages II or III, and Grade B periodontitis based on the Centers for Disease Control (CDC), American Academy of Periodontology (AAP), and European Federation of Periodontology (EFP) definitions.

Methods: Thirty subjects were initially recruited. In a split-mouth fashion, right and left sides were randomly allocated into two treatment arms: conventional scaling and root planing (C-SRP) versus laser-assisted scaling and root planing (L-SRP). A blinded examiner recorded clinical measurements at baseline and 3 months. Duration of the procedure was also recorded for each visit, and the patient's experience was assessed with a questionnaire at baseline, 1, and 3 months.

Results: The final sample consisted of 26 subjects. Both treatments resulted in overall improvement, but no significant differences were found between modalities for clinical attachment gain or probing depth reduction. The duration of the procedure was approximately half for L-SRP, and postoperative sensitivity was greater in C-SRP.

Conclusions: The low-energy protocol with Er:YAG (50 mJ) used for the non-surgical treatment of moderate-severe chronic or Stage II-III, Grade B periodontitis performed in this study population was a treatment modality that yielded similar clinical improvements when compared to conventional scaling and root planing.

KEYWORDS
chronic periodontitis, Er:YAG, randomized controlled trial, root planing

1 | INTRODUCTION

The primary aim of non-surgical periodontal therapy is to halt disease progression by eliminating periodontopathogenic bacteria to reduce inflammation and allow re-attachment of periodontal tissues.[1] Scaling and root planing (SRP) is effective in the management of periodontitis[2,3] and it is traditionally performed with hand and power-driven instruments, both of which have shown similar success in the task of calculus removal.[4-7] Nevertheless, there are also well-known limitations. When performing SRP in areas with probing depths (PD) >5 to 6 mm, complete debridement of local irritants has proven a challenge from many clinicians as a substantial amount of subgingival calculus is left on the roots.[8,9] Also, the smear layer left on roots after SRP contains bacteria, endotoxins, and contaminated cementum,[10] all of which have been hypothesized to hinder epithelial re-attachment, posing yet another issue to non-surgical conventional therapy. The previously listed factors, when combined with a complex root anatomy,[11,12] have promoted a search for less invasive and more effective treatment approaches, and the adjunctive use of lasers to SRP is a possibility that should be considered to potentially overcome this issue.

The "erbiums," because of the high absorption coefficient in water and hydroxyapatite, seem to be adequate for the effective removal of plaque and calculus.[13-15] The erbium-doped: yttrium-aluminum-garnet (Er:YAG)[*] has a wavelength of 2,940 nm and results in minimal heat generation with proper irrigation, rendering it safe and suitable for efficient subgingival debridement.[15,16]

Numerous in vitro experiments have demonstrated several advantages of Er:YAG: its ability to remove calculus[17] and cementum with minimal thermal damages; its bactericidal effects[16,18-20] and the induction of characteristic micro-irregularities in the root surface after irradiation, all of which may improve biocompatibility.[21-23] Furthermore, several clinical studies have demonstrated the superiority of Er:YAG[21,24,25] in the non-surgical treatment of periodontitis; however, results are varied,[26-28] because of the disparity among studies, primarily in laser settings, treatment modalities, and follow-up times.

Er:YAG settings for periodontal treatment usually range from 100 to 180, 160mJ being the most commonly used.[28] In vivo low-energy (40 mJ) protocols have been published in the literature and have proven to successfully reduce bacterial load; however, the body of evidence is scarce.[29]

Therefore, this study aimed to evaluate the effects of a low-energy protocol with Er:YAG (50 mJ) on clinical attachment levels (CAL) and PD changes, 3 months after non-surgical therapy for the treatment of moderate to severe chronic periodontitis or Stages II or III, Grade B periodontitis (CDC/AAP/EFP).[30] Secondary aims included evaluating the differences in the overall treatment duration between the two treatment modalities and analyzing patients' perception of sensitivity or pain during and after each treatment visit.

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2 | MATERIALS AND METHODS

2.1 | Study design

This study was a single-blinded, split-mouth, randomized, controlled clinical trial approved by Columbia University Irving Medical Center's Institutional Review Board (AAAR6077; ClinicalTrials.gov NCT03628872) conducted in compliance with CONSORT guidelines.[31] The subjects were recruited from March 2018 to February 2019 in the Postgraduate Periodontics Clinic at the Columbia University College of Dental Medicine in New York, New York. Informed consent from each participant was obtained by the provider (DGA) at the time of recruitment, following the principles outlined in the Helsinki Declaration regarding experimentation involving human subjects.

2.2 | Outcomes

2.2.1 | Periodontal measurements

The primary outcome was CAL (mm), for which a full periodontal chart was recorded at baseline, and 3 months after treatment by a blinded examiner (JAS). The recorded measurements included PD, gingival recession, CAL, bleeding on probing (BoP), and plaque index (PI). Baseline findings are summarized in supplementary Table S1 in the online *Journal of Periodontology*. Intra-examiner reliability was assessed within a 2-hour consultation in five different patients (Kappa: 0.983 for PD, and 0.978 for CAL; Intra-class correlation coefficient [ICC]: 0.995 for PD, and 0.997 for CAL).

2.2.2 | Duration of treatment

Treatment duration for each treatment arm was recorded in minutes with a digital timer in a standardized fashion: from the initiation of the instrumentation to the end of treatment.

2.2.3 | Patient's experience

A Visual Analogue Scale (VAS) from 0 to 10 was filled out by each subject at baseline, 1 and 3 months post-treatment to assess their degree of pain or sensitivity: 0-no pain/sensitivity; 5-moderate pain/sensitivity; 10- unbearable pain/sensitivity. This VAS did not intend for the patient to recall their degree of sensitivity immediately post-treatment, but rather at 1 and 3 months. Three months after treatment, an additional questionnaire with three multiple choice questions was given to patients to assess their preferred therapy and their reasoning. Those reasons were divided into three options: (1) felt less uncomfortable, (2) felt less sensitivity after the procedure, and (3) felt like a shorter appointment. Although the questions used in our survey have not been validated, given its simplicity, the information obtained from study subjects was a simple and efficient tool to assess the amount of postoperative discomfort. No thermal tests were performed to clinically assess sensitivity.

2.3 | Participants

2.3.1 | Power calculation and sample size

Following Schwarz et al.'s methodology,[32] the power for this split-mouth study was set at 0.99, with a significance of 0.05 to detect a 1 mm difference with a standard deviation (SD) of 1 mm between groups (δ) using a two-sided paired *t*-test. Based on the calculations, 21 subjects were required for the analysis (STATA v14.0). In a large community-based clinic such as ours, study subjects' retention rate and compliance have been somewhat unpredictable. Thus, an increased sample size of 30 was needed to compensate for potentially high dropout rates (Figure 1).

2.3.2 | Inclusion and exclusion criteria

Subjects included were anyone with periodontitis but in otherwise good general health, ≥18 years of age, ≥20 teeth with five teeth per quadrant, including at least 1 molar, non-smokers or former smokers who quit at least 1 year ago, and had not received any periodontal treatment in the 3 months prior to recruitment.

Exclusion criteria included the presence of uncontrolled systemic diseases that could affect treatment outcomes such as diabetes mellitus with an HbA1C >7%, rheumatoid arthritis or any form of immunosuppression, subjects requiring antibiotic prophylaxis, patients that had received systemic or local delivery of antibiotic therapy 6 weeks before enrollment, chronic intake of NSAIDs (excluding daily intake of acetylsalicylic acid of <100 mg) or steroids, currently undergoing orthodontic treatment, having removable prosthetic appliances, pregnancy, tumors of the oral cavity or the presence of any psychiatric condition that could affect participation.

2.4 | Randomization and allocation concealment

All subjects were de-identified and numbered from 1 to 30. Each subjects' right and left sides were randomly assigned to receive one of the two treatment modalities: conventional scaling and root planing (C-SRP) or Er:YAG laser-assisted scaling and root planing (L-SRP) using random sequences generated by a software application[†]. Allocation was concealed in an encrypted electronic document to which only the provider (DGA) had access, and the document was retrieved during the first treatment appointment, immediately before treatment, to reveal the side allocated to C-SRP, which was always performed first.

2.5 | Interventions

C-SRP and L-SRP were performed in two separate appointments by a single provider (DGA) within 10 days. Oral hygiene instructions, including modified Bass brushing technique, spool flossing method, and interproximal brushing, were reviewed with all participants during the study's first visit and reinforced for all visits afterward. When asked to show their oral hygiene techniques, all patients successfully demonstrated adequate homecare.

2.5.1 | Conventional scaling and root planing (C-SRP)

Treatment was initiated with an ultrasonic scaler[‡] for supra- and subgingival debridement followed by hand instrumentation (11/12 and 13/14 Gracey's curettes, 11/12 and 13/14 mini Gracey's, sickle scaler, and Columbia 4R/4L curette). Finally, the provider (DGA) checked for complete removal of calculus and smooth root surfaces using a periodontal explorer 11/12. Postoperative instructions after C-SRP included continuing with homecare instructions.

[†] Microsoft Excel, Microsoft Corporation, Redmond, WA
[‡] Cavitron 2020, Dentsply Sirona, Charlotte, NC (with Powerline 3 30K Ultrasonic Inserts)

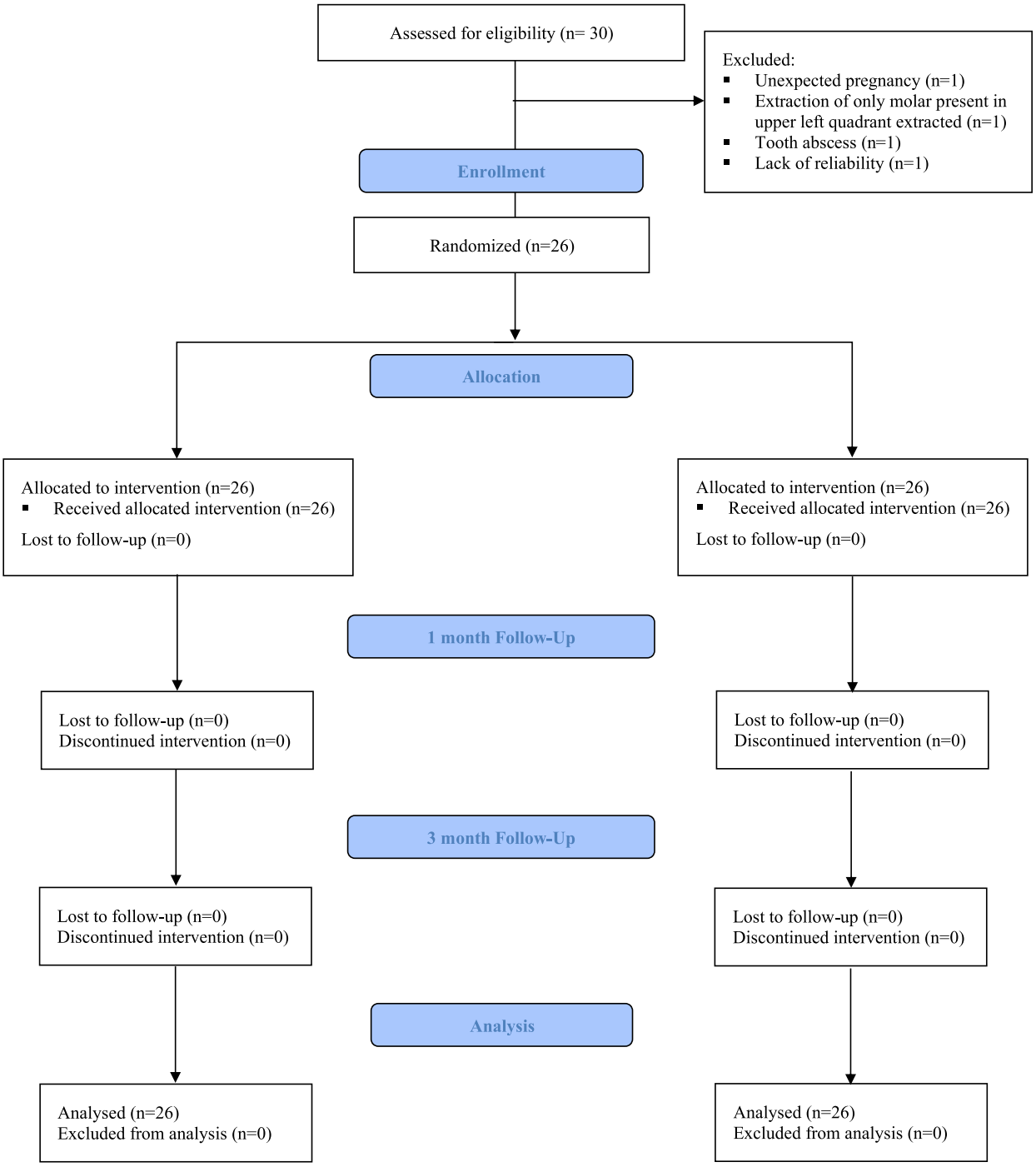

FIGURE 1 CONSORT flowchart

2.5.2 | Er:YAG laser-assisted scaling and root planing (L-SRP)

Treatment was initiated with an ultrasonic scaler[§] used supra- and subgingivally. Based on the recommendations by the manufacturer, the settings for Er:YAG were 50 mJ and 20 pps with air set at seven and water cooling set at 10. C400F and PS600T tips were used for calculus removal, root debridement and decontamination, and the ablation of the diseased pocket epithelium. In addition, removal of inflamed epithelial and connective tissue on the external oral surface of the gingiva and around the gingival margin was also performed. Then, the provider (DGA) checked for complete removal of calculus and smooth root surfaces using a periodontal explorer 11/12. Subsequently, blood

[§] Cavitron 2020 Dentsply Sirona, Charlotte, NC (with Powerline 3 30K Ultrasonic Inserts)

TABLE 1 Sample characteristics ($N = 26$)

		Mean	SD
Age (years)		53.1	7.3
		N	**(%)**
Sex	Male	13	(50.0)
	Female	13	(50.0)
Race and ethnicity	Non-Hispanic White	4	(15.4)
	Non-Hispanic Black	5	(19.2)
	Non-Hispanic Asian	2	(7.7)
	Hispanic	15	(57.7)
	Others	0	(0.0)
Primary language selected for consent and VAS	English	12	(46.2)
	Spanish	14	(53.8)
Diabetes status	Controlled[a]	4	(15.4)
	Non-diabetic	22	(84.6)
Smoking status	Former smoker[b]	4	(15.4)
	Never smoker	22	(84.6)
Hypertension	Yes	7	(26.9)
	No	19	(73.1)

Abbreviations: SD, Standard Deviation; VAS, Visual Analogue Scale.
[a]HbA1C <7.0%.
[b]Quit >10 years ago.

coagulation was accomplished with defocused irradiation and without the cooling water spray at 30 mJ and 10 pps. Irradiation was achieved using the tip parallel to the root surfaces, starting at the deepest portion of the periodontal pocket, in a sweeping motion, slowly moving towards the coronal aspect of the pocket. Postoperative instructions after L-SRP included no brushing or flossing of the treated side for 7 days to maintain the achieved coagulation layer.

2.5.3 | Clinical measurements

A follow-up appointment was given 1 month after the completion of all treatments. No clinical examination was conducted at this time. Three months after the completion of therapy, the blinded examiner (JAS) recorded clinical periodontal parameters, after which the patient received periodontal maintenance by the provider (DGA).

2.6 | Statistical methods

The statistical analysis was *intention-to-treat*, as all 26 subjects completed the intervention and were randomized after the exclusion of the four ineligible patients. There was no change in treatment allocation throughout the study, and analysis was performed only in subjects who completed all visits (Figure 1). The paired *t*-test was used to compare the mean scores of all investigated clinical parameters at the patient level from baseline to 3 months within and between groups.

3 | RESULTS

The final analysis included 26 subjects, 13 males, and 13 females, with a mean age of 53.1 years old, ranging from 33 to 73 years (Table 1). Seven patients had a diagnosis of controlled hypertension, and four subjects were controlled type 2 diabetics with HbA1C <7%. There were four former smokers, all of whom had quit > 10 years before recruitment (Table 1). The reasons for excluding the four subjects in the final analysis were: lack of reliability, an unexpected pregnancy, the need for systemic antibiotics because of emergent tooth abscess, and the extraction of the only molar present in the patient's upper quadrant (Figure 1). The trial was ended in July 2019, when all subjects had finished the 3 months follow-up visits.

Both C-SRP and L-SRP groups showed an overall statistically significant improvement ($P < 0.001$) within each of the treatment modalities at 3 months, with a mean reduction of 0.85 mm in PD for C-SRP and of 0.81 mm for L-SRP; and a mean CAL gain of 0.73 mm for C-SRP and of 0.70 mm in the L-SRP group. These differences in PD reduction ($\Delta = 0.04$) and CAL gain ($\Delta = 0.03$) between treatment modalities were not statistically significant (Table 2).

TABLE 2 Mean differences in probing depths (PD) and clinical attachment loss (CAL) between the two treatment modalities at baseline and 3 months

			C-SRP			L-SRP					
			Mean	**SD**		**Mean**	**SD**	***P*-value**			
Probing depth (PD)											
Overall	Baseline		3.97	0.54		3.93	0.59	*0.633*			
	3 months		3.12	0.56		3.13	0.49	*0.845*			
	Mean difference (SD)	Δ_1	0.85	(0.42)	Δ_2	0.81	(0.48)		Δ	0.05	(0.37)
	P-value		*<0.001*			*<0.001*				*0.516*	
PD >4 mm	Baseline		6.00	0.64		6.03	0.59	*0.822*			
	3 months		4.26	1.03		4.30	0.91	*0.750*			
	Mean difference (SD)	Δ_1	1.74	(0.76)	Δ_2	1.72	(0.74)		Δ	0.02	(0.60)
	P-value		*<0.001*			*<0.001*				*0.884*	
PD >6 mm	Baseline		6.65	2.52		4.80	2.08	*0.964*			
	3 months		6.68	2.55		4.63	2.28	*0.718*			
	Mean difference (SD)	Δ_1	1.85	(1.98)	Δ_2	2.05	(1.75)		Δ	-0.20	(2.50)
	P-value		*<0.001*			*<0.001*				*0.682*	
Clinical attachment loss (CAL)											
Overall	Baseline		4.20	0.80		4.05	0.67	*0.133*			
	3 months		3.47	0.67		3.35	0.45	*0.138*			
	Mean difference (SD)	Δ_1	0.73	(0.38)	Δ_2	0.7	(0.45)		Δ	0.03	(0.36)
	P-value		*<0.001*			*<0.001*				*0.698*	
CAL ≥3 mm	Baseline		4.76	0.76		4.59	0.52	*0.146*			
	3 months		3.87	0.74		3.73	0.48	*0.129*			
	Mean difference (SD)	Δ_1	0.88	(0.38)	Δ_2	0.86	(0.45)		Δ	0.02	(0.40)
	P-value		*<0.001*			*<0.001*				*0.788*	
CAL ≥5 mm	Baseline		6.24	0.69		6.17	0.63	*0.571*			
	3 months		4.78	1.01		4.76	0.87	*0.899*			
	Mean difference (SD)	Δ_1	1.46	(0.70)	Δ_2	1.41	(0.65)		Δ	0.05	(0.64)
	P-value		*<0.001*			*<0.001*				*0.707*	

Abbreviation: SD, Standard Deviation.
Δ = Δ1-Δ2.

To assess responsiveness to treatment of the different severities of periodontitis, PD were grouped in >4 and >6 mm, and CAL in ≥3 and ≥5 mm, which allowed for a better assessment of different diagnoses of periodontitis (Table 2). An average of 31.3% of PD >4 mm per subject in C-SRP and of 29.5% in L-SRP; and a mean of 9.8% of PD >6 mm in C-SRP and of 9.6% in L-SRP were found at baseline (see supplementary Table S1 in online *Journal of Periodontology*).

Analysis of all sites with PD >4 mm within each patient showed an overall mean PD reduction of 1.74 mm per subject in the C-SRP and of 1.72 mm in the L-SRP. Subsequent analysis of all sites with PD >6 mm showed a mean PD reduction of 1.85 mm in the C-SRP group and a slightly superior reduction of 2.05 mm in the L-SRP group. These differences in PD >4 mm (Δ = 0.02), and PD >6 mm (Δ = -0.20) between treatment modalities were not statistically significant (Table 2).

An average of 80% of CAL ≥3 mm per subject in C-SRP and of 78.9% in L-SRP; and a mean of 37.2% of CAL ≥5 mm in C-SRP and of 33.6% in L-SRP were found at baseline (see supplementary Table S1).

Evaluation of all sites with CAL ≥3 mm in each patient showed a mean CAL gain of 0.88 mm per subject in C-SRP and of 0.86 mm in L-SRP. Sites with CAL ≥5 mm showed a mean improvement of 1.46 mm in C-SRP and 1.41 mm in L-SRP. These differences in CAL ≥3 mm (Δ = 0.02), and CAL ≥5 mm (Δ = 0.05) between treatment modalities were not statistically significant (Table 2).

To compare the percentage of sites that had resolved after treatment, analysis of PD 5 to 6 mm recorded in each subject, with or without BoP at baseline that became ≤4 mm without BoP at 3 months, was performed. A resolution of 47.9% of sites with PD 5 to 6 mm for C-SRP and 52.9% for L-SRP (Δ = −5.02, $P < 0.324$) was observed.

TABLE 3 Proportion of sites with PD 5 to 6 mm & PD >6 mm with or without BoP at baseline that showed improvement of PD <4 mm without BoP at 3 months ($N = 26$)

	PD 5-6 mm						PD > 6 mm					
	C-SRP		L-SRP		Mean difference			C-SRP		L-SRP		Mean difference		
	Mean	SD	Mean	SD	Mean	SD	*P*-value	Mean	SD	Mean	SD	Mean	SD	*P*-value
Baseline to 3 months (%)	47.92	29.13	52.93	27.61	-5.02	25.42	0.324	18.65	28.79	31.62	34.59	-12.97	37.32	0.089

Abbreviation: BoP, Bleeding on Probing.
(-) values represent improvements favoring L-SRP over C-SRP.

Similarly, the proportion of sites with PD >6 mm with or without BoP at baseline that became PD ≤4 mm without BoP at 3 months was 18.7% for the C-SRP and 34.6% for the L-SRP ($\Delta = -12.97$, $P < 0.089$) (Table 3).

Baseline data revealed a mean PI of 93.7% (±17.0) in C-SRP and of 94.9% (±16.51) in L-SRP; and a mean BoP of 88.5% (± 26.2) and 91.3% (±23.5) in C-SRP and L-SRP respectively, showing the lack of compliance of the study population.[33]

There was a significant improvement in PI in both treatment modalities, of 32.5% and 29.7% in C-SRP and L-SRP, respectively ($r = 0.934$, $P < 0.001$), with no significant differences observed between groups (mean difference: 2.9%, $P < 0.001$). A significant improvement was also observed in BoP scores, with a 59.3% and 59.9% reduction in C-SRP and L-SRP, respectively ($r = 0.839$, $P < 0.001$), with no significant differences between groups (mean difference:0.6%, $P = 0.867$).

Evaluation of patient experience questionnaires showed that 80.8% of the patients preferred L-SRP, whereas 19.2% reported no differences between therapies and had no preference towards either modality. Out of the 80.8% of the patients who chose L-SRP, 50.7% said that it "felt less uncomfortable," 50% that they experienced "less postoperative pain," and 34.6% that procedure "felt like a shorter appointment" at 3 months. Patients had the option of choosing all the reasons that applied (Figure 2).

A comparison of the patient's reported sensitivity score from baseline to 1 and 3 months after treatment can be observed in Table 4. One month after treatment, 16 patients (61.5%) experienced a greater improvement in sensitivity in the Er:YAG side, whereas only two (7.7%) showed more significant improvement in the C-SRP side. The remaining seven reported no differences in improvement or worsening between sides. Three months after treatment, the two patients that had experienced further improvement with C-SRP at 1 month reported more significant improvement with laser. At 3 months, a total of 18 patients (69.2%) favored L-SRP, and the remaining eight showed no differences in sensitivity (Table 4).

The average time spent during C-SRP was 92.04 minutes, versus an average of 54.15 minutes spent for L-SRP (Table 4).

4 | DISCUSSION

The present study found that both C-SRP and L-SRP were effective in the non-surgical treatment of chronic periodontitis. It should be noted that the population of this study had very poor homecare and had poorly or non-controlled periodontal disease at the time of recruitment, which in the majority of cases had not been previously

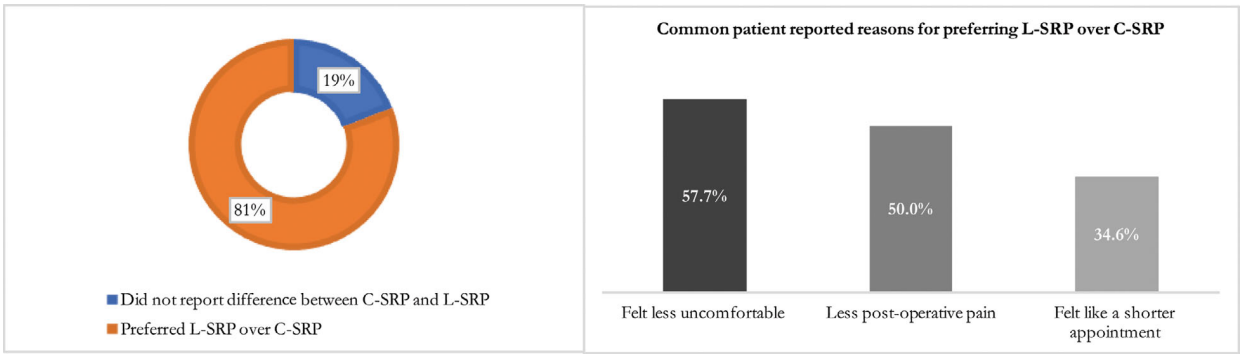

FIGURE 2 Distribution of preferred modality and reason for patients to prefer L-SRP treatment over C-SRP

TABLE 4 Duration of treatment and difference in pain/sensitivity between the two treatment modalities

	C-SRP		L-SRP		Paired *t*-test Mean difference		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P*-value**
Duration of treatment							
Time (minutes)	92.04	25.78	54.15	13.44	**37.89**[a]	18.66	*<0.001*
Pain/sensitivity analysis (VAS from 0 to 10)							
Baseline	2.92	2.15	2.92	2.15	–	–	–
1 month	1.96[b]	1.66	0.81[b]	1.10	**1.15**[a]	1.83	*0.004*
3 months	1.42[c]	1.39	0.12[c]	0.33	**1.31**[a]	1.32	*<0.001*

Abbreviations: SD, Standard Deviation; VAS, Visual Analogue Scale.
[a]Significant value favoring L-SRP over C-SRP.
[b]Significant improvement in pain/sensitivity score from baseline to 1 month.
[c]Significant improvement in pain/sensitivity score from baseline to 3 months.

treated. In accordance with previous studies, both therapies showed significant CAL gain and PD reduction within each group, along with noticeable improvement in PI and BoP. No adverse reactions were noted during the study, and healing was uneventful in all cases. These results are in agreement with previous publications.[21, 34-37]

Analysis of patient experience questionnaires revealed an overall preference for Er:YAG: (1) the reported level of sensitivity was lower with the laser for the vast majority of patients[37, 38] and, (2) it was the preferred modality for 80.8% of the subjects, [37] primarily because of the "scratches" and sounds associated with C-SRP. It should be emphasized that the remaining 19.2% did not favor any of the two therapies.

The differences in treatment time found in this study are in agreement with Schwarz et al., who reported an average of 9 and 15 minutes for SRP of single- and multi-rooted teeth, respectively, contrarily to the 5 and 10 minutes for laser treatment.[31] Similarly, our study showed a decrease in time of almost half favoring Er:YAG. However, it should be noted that some investigations had contradictory findings where longer treatment duration was reported with Er:YAG when compared to mechanical instrumentation.[15] This finding was an unexpected revelation to the authors because previously published reports showed conflicting results. It may be further speculated that the use of Er:YAG was more efficient in removing deposits in this particular group of patients.

The mechanism of action by which L-SRP results in the improvement of periodontal clinical parameters has been previously introduced as the "thermo-mechanical ablation" theory [39] and as the "photothermal evaporation" theory. [40] Loertscher et al., proposed that the energy absorbed by the water in tissues causes evaporation that triggers the development of an underwater cavity that expands and ultimately collapses and disappears.[39] Hibst and Keller stipulated selective vaporization of water that provokes micro-explosions of the tissue, building up the internal pressure that finally leads to the explosive destruction of inorganic substance.[16,40] Moreover, SEM observation of roots treated with Er:YAG showed a significantly higher cell density after irradiation with Er:YAG than ultrasonic debridement. Laser irradiated surfaces were covered by a dense confluent monolayer of healthy fibroblasts firmly

attached to the root surface of better quality than ultrasonic scaling,[41] suggestive of higher biocompatibility and tissue attachment rates. All of the factors above may be used as examples to provide biologic plausibility to Er:YAG's ability to remove calculus, the capability of soft and hard tissue removal, and its bactericidal effects.

For the most part, previous clinical trials all used a substantially higher energy output of 100 to 160 mJ, compared to the much lower energy of 50 mJ used in this study.[21,34,35,36] All Er:YAG studies thus far have included varying ranges of energy settings from 100 to 180mJ, with 160 mJ being the most popular. All had different study designs and treatment protocols, which significantly compromised reproducibility.

The rationale behind the reduction in the energy output was to minimize the potentially detrimental effects of the laser, namely thermal damage, that could explain the discomfort and sensitivity or pain during and after treatment while achieving similar or even superior clinical results in CAL gain and PD reduction. There is a lack of studies favoring Er:YAG therapy regarding patients' comfort and satisfaction. The authors hypothesize that the positive results of the present study were because of the marked reduction in the total energy output in the L-SRP treatment protocol. Hence, according to our results, a lower energy setting did improve patients' experience, intra- and postoperatively, compared to higher energy while yielding results similar to those obtained with conventional scaling and root planing.

A recent systematic review and meta-analysis by Chambrone et al., concluded that only surgical treatment with Er:YAG was beneficial for the treatment of chronic periodontitis, showing modest (<1 mm) but significant improvements in PD and CAL when compared to SRP alone.[28] Moreover, Lin et al.'s recent systematic review and meta-analysis also concluded that Er:YAG laser monotherapy does not yield additional benefits when compared to mechanical instrumentation.[42] In contrast, the most recent AAP best evidence consensus statement on the efficacy of laser therapy concluded that adding laser treatment to conventional SRP results in similar or slightly better clinical outcomes compared to laser treatment alone; however, there is no evidence supporting the stability of these improvements over time.[43]

4.1 | Strengths

To our knowledge, this is the first time that a low-energy setting laser-assisted SRP has been compared to conventional SRP for the non-surgical treatment of periodontal disease in a randomized clinical trial. The low-energy setting used for this study, 50 mJ, did improve patients' experience during and after therapy while achieving similar results to conventional SRP. Hence, these results may be used to justify lowering the energy settings in our daily clinical practice.

4.2 | Limitations and future research

The duration of the study was of 3 months, allowing us to assess only short-term results. Future studies should increase follow-up times to determine the stability of the observed improvements. Upcoming trials should focus on the standardization of treatment protocols to improve reproducibility. It would also be of interest to include smokers and patients with uncontrolled systemic diseases.

5 | CONCLUSIONS

Both treatments, C-SRP and L-SRP, were effective in treating generalized moderate to severe chronic periodontitis or generalized Stages II to IV periodontitis. Similar results were found with the low-energy protocol with Er:YAG in periodontal clinical parameters compared to SRP in this study population. The procedure duration was approximately half in favor of L-SRP, and the postoperative patient-reported sensitivity was significantly lower for L-SRP at 1 and 3 months after therapy.

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AUTHOR CONTRIBUTIONS

Philip Y. Kang and Eric Linden contributed to the conception of this work. Daniela Gurpegui Abud and Jaffer Shariff conducted the literature search, contributed to the design of the study, IRB submission and acceptance, and patient recruitment; they also carried out treatment and clinical examinations, and drafted the manuscript. Jaffer Shariff also conducted the statistical analysis and the interpretation of the data. Philip Y. Kang revised the manuscript.

CONFLICTS OF INTEREST

The authors report no conflicts of interest related to this study.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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