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The effectiveness of high-power diode laser as an adjunct to mechanical instrumentation of deep pockets in a patient with generalized, stage III, grade C periodontitis

Eficácia do laser de diodo de alta potência como coadjuvante à instrumentação mecânica de bolsa profunda em paciente com periodontite estádio III, grau C e generalizada

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ABSTRACT

Periodontitis is an inflammatory clinical condition caused by dysbiotic biofilm that results in progressive destruction of periodontal attachment and can lead

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to tooth loss if left untreated. **Objective:** To evaluate the clinical efficacy of high-power diode laser as an adjunct to mechanical instrumentation in periodontal pockets of a patient with generalized, stage III, grade C periodontitis. **Methods**: 126 sites of a patient were examined at the Clinical Research Laboratory (LabClin) of the Federal University of Campina Grande (UFCG), where the parameters of probing depth (PD), clinical attachment level (CAL) and bleeding on probing (BoP) were evaluated at the beginning of the study and after 3 and 6 months of basic therapy. All sites received non-surgical periodontal treatment which corresponds to scaling and root planing (SRP) and coronary polishing. The deep periodontal pockets with PD ≥ 5 mm, received the adjuvant therapy with diode laser light. **Results**: There was a significant improvement of periodontal parameters of PD, CAL and BoP in all treated sites. In those with PD ≥ 5 mm, the results were similar, with statistically significant reduction of PD, CAL and BoP before and after treatment. After 6 months, all periodontal pockets with PD ≥ 5mm were reduced to values lower than 3. **Conclusion**: The irradiation of deep pockets with high-power diode laser proved to be effective as adjuvant therapy to SRP in patients with generalized, stage III, degree C periodontitis.

Indexing terms: Periodontitis. Lasers. Lasers, semiconductor.

RESUMO

A periodontite é uma condição clínica inflamatória causada por biofilme disbiótico que resulta em destruição progressiva da inserção periodontal e pode levar a perda do dente caso não seja tratada. **Objetivo**: Avaliar a eficácia clínica do laser de diodo de alta potência como coadjuvante à instrumentação mecânica em bolsas periodontais de um paciente com periodontite, estádio III, grau C e generalizada. **Métodos**: Foram examinados 126 sítios de uma paciente, no Laboratório de Pesquisas Clínicas (LabClin) da Universidade Federal de Campina Grande (UFCG) onde foram avaliados os parâmetros de profundidade de sondagem (PS), nível de inserção clínica (NIC) e sangramento à sondagem (SS) no início do estudo e após 3 e 6 meses da terapia básica. Todos os sítios receberam tratamento periodontal não cirúrgico o que corresponde a raspagem e alisamento coronorradicular (RACR) e polimento coronário. As bolsas periodontais profundas com PS ≥ 5 mm, receberam a terapia coadjuvante com luz laser de diodo. **Resultados**: Houve uma melhora significativa dos parâmetros periodontais de PS, NIC e SS em todos os sítios tratados. Nos que apresentavam PS ≥ 5 mm, os resultados foram similares, com redução estatisticamente significativa PS, PIC e SS antes e após a realização do tratamento. Após 6 meses, todas as bolsas periodontais com PS ≥ 5mm foram reduzidas a valores menores que 3. **Conclusão**: A irradiação de bolsas profundas, com laser de diodo de alta potência, mostrou-se eficaz como terapia coadjuvante à RACR em paciente com periodontite estádio III, grau C, generalizada.

Termos de indexação: Periodontite. Lasers. Lasers semicondutores.

INTRODUCTION

Periodontitis is a chronic inflammatory disease of multifactorial etiology that is associated with a dysbiotic biofilm. As it presents as a silent disease, the elimination of bacterial sites is necessary in order to avoid a progressive destruction of the support structures of the tooth [1]. In this perspective, conventional periodontal therapy contributes to the resolution of inflammation and includes biofilm control, supragingival and subgingival scaling, root planing and the adjuvant use of chemical agents. The reduction of microbial load and bacterial metabolic products leads to a reduced inflammatory response and improvement of tissue healing [2].

Conventional treatment alone may fail in some situations, either due to microorganisms pathogenicity or due to difficult access to areas with deep pockets, furcation areas and root concavities, conditions that make it difficult to eliminate bacterial niches through conventional therapy [3].

Under specific conditions, chlorhexidine and systemic antimicrobials can be used as adjuvant therapy to treatment, leading to a significant reduction of microbial load [4,5]. However, the inefficiency of some drugs is evident, probably due to the evolution of resistant strains and to the resulting side effects, such as toxicity, possible allergic reactions and gastrointestinal complications [8]. In view of this, the search for complementary therapeutic approaches has been a strategy of interest to dentists [7].

Currently, high-power lasers are used as adjuvant tools for scaling and root planing or in minimally invasive surgery. In addition, low-power therapeutic lasers are employed for cell stimulation and activation of antimicrobial agents after scaling and root planing (SRP) [2].

In periodontics, among the most used devices, there are neodymium-doped lasers: yttrium-aluminum garnet (Nd: YAG), erbium-doped: yttrium-aluminum garnet (Er: YAG), carbon dioxide (CO2), erbium, chromium-doped: yttrium, scandium, gallium-garnet (Er, Cr: YSGG) and diode laser [7]. The benefits presented by the high-power diode laser stand out due to its ability to reduce pathological agents, thus obtaining satisfactory clinical and microbiological results [8].

Still, at specific wavelengths, this device is able to accelerate tissue healing, promote angiogenesis and prevent root surface ablation. In view of these characteristics, as well as advantages of a lower financial cost compared to other existing lasers, the diode laser becomes an optional and promising modality [9].

Thus, as an alternative tool to reduce or eliminate bacterial count, as well as regenerate the affected tissues and maintain periodontal health, this study aims to evaluate the clinical efficacy of high-power diode laser as an adjuvant therapy to scaling and root planing in patients with generalized, stage III, grade C periodontitis.

METHODS

The study of this clinical case was conducted at the Dental School Clinic of the Federal University of Campina Grande (Patos, PB, Brazil), specifically at the Clinical Research Laboratory (LabClin). It is part of a larger research that was approved by the Committee of Ethics in Research with Human Beings of the Alcides Carneiro University Hospital of the Federal University of Campina Grande, under protocol number 5.115.361.

After anamnesis of patients from the Dental School Clinic of UFCG, it was selected, in the specialty of periodontics, a 51 years old-patient, non-smoker, normoglycemic, without previous treatment in the last 12 months, without use of antibiotics in the last 6 months, without continuous use of anti-inflammatories and which received the diagnosis of generalized, stage III, grade C periodontitis, presenting the following parameters of severity, complexity, extension and distribution: interproximal CAL greater than or equal to 5 mm; ≤ 4 lost teeth due to periodontitis; at least 30% of the teeth with CAL and with the masticatory function still preserved (Figure 1).

In order to diagnose and monitor the periodontal tissue response to conventional therapy, the clinical parameters clinical attachment level (CAL), probing depth (PD) and bleeding on probing (BoP) were evaluated before and after 3 and 6 months of scaling and root planing.

To evaluate the PD, BoP and CAL in the involved elements, an expert used a periodontal probe (North Carolina) in the gingival sulcus at six sites, three vestibular (mesial, vestibular and distal) and three palatine/lingual (mesial, palatine/lingual and distal) (Figure 2).

Figure 1. Clinical condition of the patient selected for the study.

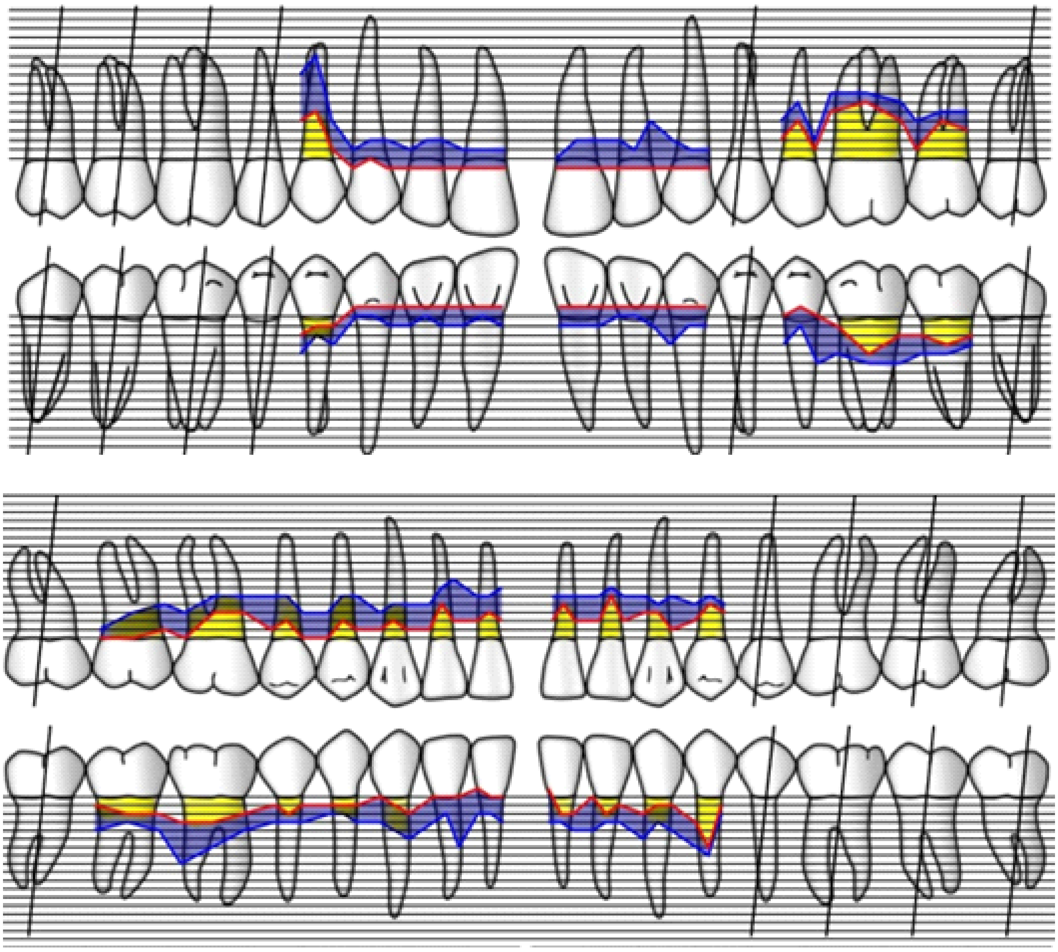

Figure 2. Record of periodontal clinical parameters of the initial condition. Vertical black lines: missing teeth; Red line: gingival margin; Blue line: probing depth; In yellow: recession. Figure source: periodontalchart-online.com/uk/

After periodontal charting, 126 sites were counted and submitted to basic periodontal treatment, being 112 sites with PD ≤ 3 mm, 8 sites with PD > 3 mm and < 5 mm and 6 sites with PD ≥ 5 mm.

The therapeutic protocol was planned to be completed in 2 two weeks, in which four sessions were performed: an initial consultation, two of scaling and root planing and one session for reassessment. In the first session, the patient received oral hygiene recommendations and supragingival scaling in all sites with ultrasonic instrumentation (Ortus Bioscaler®, Brazil) under local anesthesia when necessary.

No present teeth were classified as lost due to periodontitis at this stage of treatment. In the second session, non-surgical mechanical therapy was performed using Gracey curettes (Millennium Golgran®, Brazil) and rubber cup for coronary polishing. A whole mouth decontamination was performed through scaling and root planing in all sites, starting with those with deeper periodontal pockets. In all pockets with PD ≥ 5 mm, an adjuvant therapy with high-power diode laser was applied shortly after conventional treatment, under anesthesia (Articaine 100, DFL®, Brazil). A third session was performed to assess the presence of residual calculus and finish the phase of basic therapy.

For the irradiation of the deep pockets, the laser equipment (TW SURGICAL, MM Optics, Brazil) was used with a wavelength of 808 ± 10 nm, delivered by a 400 µm diameter optical fiber device, parallel to the tooth's long axis up to 1 mm before the base of the periodontal pocket. Then, the fiber was coronally removed in scanning movements with laser light emission using a power of 1.5 W and density power of 1,193.7 W/cm^2, continuously, for 20 seconds in each pocket (Figure 3).

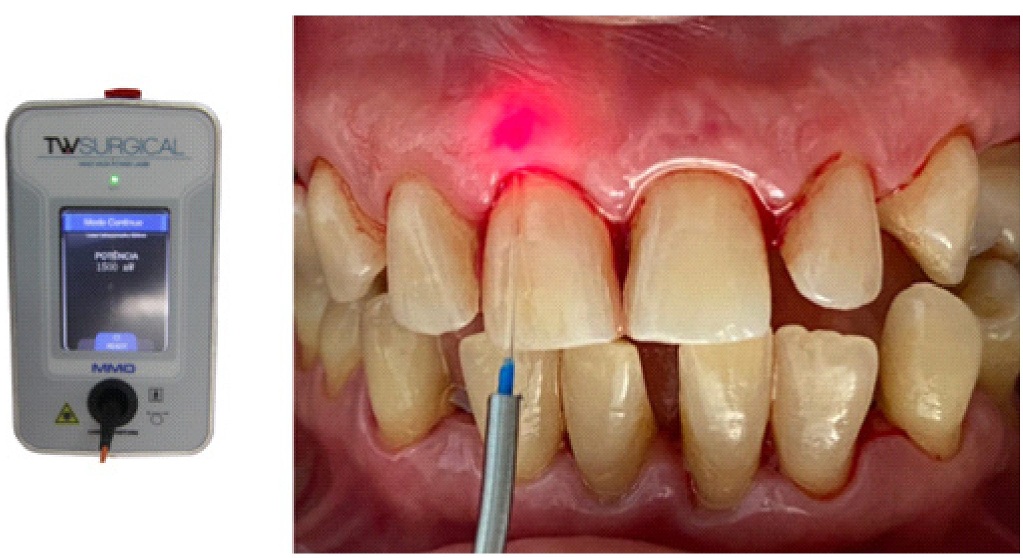

Figure 3. Irradiation of periodontal pockets with laser light (TW SURGICAL, MM Optics, Brazil).

The fourth section, carried out in the second week, was specifically for revaluation of scaling, removal of any residual calculus and monitoring of the study. The patient received a kit with dental brush (Kess Pro, KESS®, Brazil), dentifrice (Colgate Total 12, Colgate-Palmolive Company®, Brazil) and a leaflet of oral hygiene guidance. Oral hygiene practices were reinforced at all visits in order to ensure low levels of biofilm accumulation during the active phase of treatment.

After 3 and 6 months, the periodontal parameters were evaluated again and, when necessary, a new supragingival mechanical therapy was performed in the regions with biofilm accumulation, only with Gracey curettes (Millennium Golgran®, Brazil) and rubber cup for coronary polishing in order to keep biofilm control. Oral hygiene instructions were also relayed.

From the data of periodontal clinical parameters collected previously and after treatment, descriptive statistical analysis was performed aiming to characterize the sample. Measures of central tendency (mean, median) were calculated for quantitative variables, as well as absolute and percentage frequencies for categorical variables. Then, the Friedman ANOVA test and the Cochran's Q test were performed to compare the different parameters according to the three moments. The significance level was set at $p < 0.05$. All analyses were conducted using the IBM SPSS Statistics 25.0 version software, considering a 95% confidence interval.

RESULTS

According to Table 1, considering all sites, there was a statistically significant reduction in the values of probing depth ($p < 0.001$), clinical attachment loss ($p < 0.001$) and bleeding on probing ($p < 0.001$), before and after treatment. Table 2 shows the results for subgroup analysis of sites with PD < 5 mm. Similar results were observed, with a statistically significant reduction in the values of probing depth ($p < 0.001$), clinical attachment loss ($p < 0.001$) and bleeding on probing ($p < 0.001$), before and after treatment. Table 3 shows the results for subgroup analysis of sites with PD ≥ 5 mm. Similar results were also observed, with a statistically significant reduction in the values of probing depth ($p = 0.006$), clinical attachment loss ($p = 0.006$) and bleeding on probing ($p = 0.022$), before and after treatment.

Table 1. Comparative analysis of the values of probing depth, clinical attachment loss and bleeding on probing of all sites according to the different moments, with and without laser application.

Variables	**Evaluation moment**			
	T0	**T90**	**T180**	**p-value**
Probing depth				**< 0.001(1)***
M	2.45	1.82	1.63	
SD	1.22	0.56	0.61	
Me	2.00	2.00	2.00	
IQR	2.00-3.00	1.50-2.00	1.00-2.00	
Clinical attachment loss				**< 0.001(1)***
M	4.04	3.43	2.93	
SD	1.84	1.43	0.99	
Me	4.00	3.00	3.00	
IQR	3.00-5.00	2.50-4.38	2.00-3.50	
Bleeding on probing	**n (%)**	**n (%)**	**n (%)**	**< 0.001(2)***
Yes	101 (76.5)	32 (24.2)	37 (28.0)	
No	31 (23.5)	100 (75.8)	95 (72.0)	

Note. T0 = initial evaluation; T90 = evaluation after 90 days; T180 = evaluation after 180 days; M = mean; SD = standard deviation; Me = median; IQR = interquartile range (25th percentile - 75th percentile); (1) Friedman ANOVA test; (2) Cochran's Q test; *$p < 0.05$.

Table 2. Comparative analysis of the values of probing depth, clinical attachment loss and bleeding on probing of sites with PD < 5 mm according to the different moments, without laser application.

Variables	Evaluation moment			
	T0	**T90**	**T180**	**p-value**
Probing depth				**< 0.001(1)***
M	2.32	1.80	1.62	
SD	1.09	0.55	0.61	
Me	2.00	2.00	1.75	
IQR	1.88-3.00	1.50-2.00	1.00-2.00	
Clinical attachment loss				**< 0.001(1)***
M	3.87	3.40	2.94	
SD	1.64	1.42	1.00	
Me	3.90	3.00	3.00	
IQR	3.00-5.00	2.50-4.13	2.00-3.50	
Bleeding on probing	**n (%)**	**n (%)**	**n (%)**	**< 0.001(2)***
Yes	95 (75.4)	29 (23.0)	36 (28.6)	
No	31 (24.6)	97 (77.0)	90 (71.4)	

Note. T0 = initial evaluation; T90 = evaluation after 90 days; T180 = evaluation after 180 days; M = mean; SD = standard deviation; Me = median; IQR = interquartile range (25th percentile - 75th percentile); (1) Friedman ANOVA test; (2) Cochran's Q test; *p < 0.05.

Table 3. Comparative analysis of the values of probing depth, clinical attachment loss and bleeding on probing of sites with PD S ≥ 5 mm according to the different moments, being T0 without laser application; T90 and T180 with laser application.

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Variables	Evaluation moment			
	T0	**T90**	**T180**	**p-value**
Probing depth				**0.006(1)***
M	5.17	2.25	2.00	
SD	0.41	0.61	0.55	
Me	5.00	2.00	2.00	
IQR	5.00-5.25	1.88-3.00	1.50-2.25	
Clinical attachment loss				**0.006(1)***
M	7.67	4.08	2.67	
SD	2.16	1.77	0.75	
Me	7.50	3.25	3.00	
IQR	5.75-9.50	2.88-5.88	1.88-3.13	

Table 3. Comparative analysis of the values of probing depth, clinical attachment loss and bleeding on probing of sites with PD S ≥ 5 mm according to the different moments, being T0 without laser application; T90 and T180 with laser application.

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Variables	Evaluation moment			
	T0	T90	T180	p-value
Bleeding on probing	**n (%)**	**n (%)**	**n (%)**	**0.022**$^{(2)*}$
Yes	6 (100.0)	3 (50.0)	1 (16.7)	
No	0 (0.0)	3 (50.0)	5 (83.3)	

Note. M = mean; SD = standard deviation; Me = median; IQR = interquartile range (25th percentile- 75th percentile); $^{(1)}$ Friedman ANOVA test; $^{(2)}$ Cochran's Q test; * $p < 0.05$.

Significant improvements were observed in relation to the evaluation of PD, BoP and CAL after 6 months of follow-up (Figure 4). After laser treatment, all periodontal pockets with PD greater than or equal to 5 mm were reduced, stabilizing at values lower than or equal to 3 mm. This result was achieved in the first quarter of evaluation and remained after 6 months of treatment (Figure 5).

DISCUSSION

Periodontal disease is an inflammatory clinical condition caused by bacterial infections in the supporting structures of the tooth, which leads to destruction of the alveolar bone, and can lead to loss of the dental element. This chronic inflammatory process, observed in periodontitis, is a response to tissue aggressions caused by an organized and dysbiotic biofilm [11], which results in progressive destruction of periodontal attachment, manifesting itself clinically as attachment loss, radiographic bone loss, periodontal

Figure 4. Final clinical aspect after 6 months.

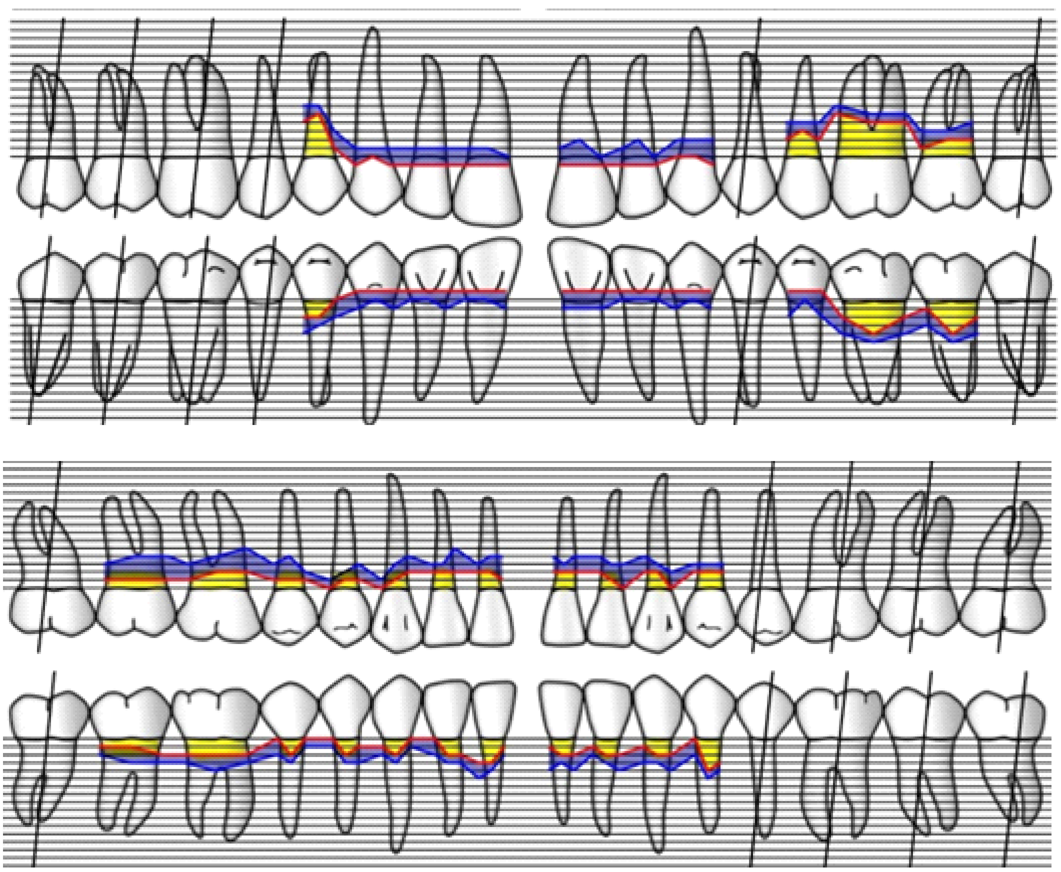

Figure 5. Record of periodontal clinical parameters of the final condition. Vertical black lines: missing teeth; Red line: gingival margin; Blue line: probing depth; In yellow: recession. Figure source: periodontalchart-online.com/uk/

pocket and bleeding on probing [12]. For this reason, the main objective of periodontal treatment is to promote a reorganization of the subgingival microbiota, developing a new "climax community" compatible with periodontal health [13]. Lack of treatment or inadequate treatment results in disease progression and even tooth loss [11].

In 2018, a new classification system for periodontal diseases was adopted, which began to be categorized based on staging as to the severity of tissue destruction and the complexity of the clinical management of the case [13]. Complexity factors such as the presence of deep pockets (greater than or equal to 5 mm), furcation involvement, vertical bone resorption and tooth mobility may hamper treatment and, consequently, limit the success of non-surgical periodontal therapy, that associated with the control of supragingival biofilm is proven to be effective in the treatment of periodontitis [14,15]. However, when present, these complexity factors of stage III of periodontitis may compromise the clinical outcome of mechanical therapy by hindering the access to subgingival biofilm in deep pockets [16].

The gold standard method for treating periodontitis includes periodontal debridement of subgingival biofilm and calculus through SRP [18]. The objective of this mechanical treatment is to decrease or eliminate the supra and subgingival biofilm, as well as to prevent the progression of the destruction of periodontal attachment. Based on comprehensive clinical medical research, effective supragingival biofilm control and

SRP have been proven as effective methods [17]. However, only non-surgical periodontal therapy cannot completely eradicate periodontal pathogens, especially in deep periodontal pockets, nor prevent the invasion of these microorganisms and metabolites in periodontal tissue, which leads to susceptibility to relapses.

In order to enhance the clinical and microbiological effects of scaling and root planing, several studies have tested adjuvant therapies. Among them, the use of systemic antibiotics is the most common and also the most applied in clinical practice [13,19]. The protocol that presented the best results was the one that used the association of amoxicillin (500 mg) with metronidazole (400 mg) for 14 days. Longer periods of exposure to antibiotics are needed to eliminate microorganisms living in a highly organized subgingival biofilm form [13]. However, such therapeutic modality may expose patients to potential risks, such as antimicrobial resistance [21].

With the purpose of overcome these limitations, the planning and introduction of more efficient techniques have stood out in recent decades and laser therapy presents itself as a promising modality [3]. With the advances of optical fibers, there was a significant progress in the clinical application of high-power laser, enabling its use in the area of periodontics. Among these indications, the subgingival use of optical fibers is highlighted, which when inserted into the periodontal pockets, promote bacterial reduction and, when applied with the appropriate irradiation parameters, are considered a technique that does not cause tissue damage [20].

Diode laser light is highly absorbed in blood hemoglobin, making it an excellent choice for removing inflamed tissues from the periodontal pocket. Absorption of laser light raises the temperature of tissues, allowing most non-sporulated bacteria, including anaerobic ones, to be readily inactivated [21]. It was clinically observed an excellent tissue repair and reduction in the levels of gingival inflammation only with 7 days after the irradiation of the pocket. The efficiency promoted by this therapy is related to its bactericidal and detoxifying effects that cause the reduction of gingival inflammation, as well as make it possible to reach inaccessible areas that are not reachable with conventional mechanical treatment [9,10]. Thus, the laser can be used as an adjuvant tool to improve the outcome of periodontal treatment, promoting additional benefits and improving periodontal clinical parameters.

The adjuvant therapy with high-power laser light, supplied with fine optical fiber, can access deep and complex subgingival niches inaccessible to manual instruments [3,7,8]. In this context, a patient with the diagnosis of generalized, stage III, grade C periodontitis was selected for this study because this clinical condition presents some factors of severity and complexity that may hinder the treatment and control of the dysbiotic biofilm.

During the postoperative evaluations, excellent results compared to the initial condition of the patient were obtained. After 6 months of periodontal therapy, the presence of residual pockets was not observed and there were significant improvements in periodontal clinical parameters of probing depth, bleeding on probing and clinical attachment level. These findings corroborate the results of several studies that used high-power laser as an adjunct to SRP [3,6,21,22,23]. A possible biological plausibility for these findings is that laser light reduces the count of periodontopathogenic bacteria, such as Porphyromonas gingivalis [3,24] and Aggregatibacter actinomycetemcomitans [24], as well as the levels of mediators of inflammation in the gingival fluid [25].

A very important factor to achieve the clinical stability parameters of periodontal pocket (PD = 4 mm, without bleeding on probing) [13] is to maintain low biofilm levels in the control and maintenance phase

[14]. In the present study, the patient was guided regarding hygiene, previously and in all postoperative evaluation appointments. One of the important periodontal parameters to evaluate the effectiveness of biofilm control was the bleeding on probing index, which significantly reduced ($p < 0.001$) after 3 and 6 months of periodontal treatment.

Thus, the advantage of the use of high-power laser in the treatment of deep periodontal pockets, in cases of stage III periodontitis, is that the patient will not need to undergo systemic antibiotic therapy for a prolonged period, which results in considerable side effects. High-power lasers can act by eliminating infection, which is a positive aspect not only for their action itself, but also for the possibility of avoiding the use of antibiotics, which can generate strains of more resistant bacteria [26].

It was conducted a systematic review of the literature with published clinical trials on the subject to define the laser protocol for this study [27]. It was observed that the clinical protocols of high-power diode laser as adjuvant therapy to scaling and root planing in the treatment of periodontitis are quite heterogeneous, specifically regarding to fiber diameter, wavelength, power and intensity of the laser, making it difficult to define a standard protocol for periodontal clinical practice. However, some parameters used seemed to be defined, such as: power ranging from 1 to 3 W, 300 or 400 µm fiber and irradiation time of 20 to 30 seconds. Thus, the laser was used in a power of 1.5 W, continuously, for 20 s in each periodontal pocket, with a 400 µm diameter fiber optic device.

The main limitation of this study is the lack of comparison of clinical parameters with deep pockets treated only with SRP. Since this is a clinical case study with the objective of evaluating the tissue response to periodontal treatment in patients with generalized, stage III, grade C periodontitis, the laser was used only in the deep pockets to observe its effects in the greater complexity sites of this clinical condition. Therefore, the ideal protocol for treatment of periodontitis with high-power diode laser as an adjunct still needs better evidence and the results of this study represent a contribution to decision-making in periodontal practice, regarding the use of diode laser in the treatment of deep pockets.

CONCLUSION

In short, an advantage is observed in the use of diode laser as a complementary treatment in periodontics. The diode laser represents a promising alternative as an adjunct in the treatment of periodontal pockets. However, there is a need for standardization of the protocols and parameters used for more satisfactory results.

The irradiation of deep pockets with high-power diode laser proved to be effective as an adjuvant therapy to scaling and root planing in patients with generalized, stage III, grade C periodontitis.

Collaborators

Conceptualization, WMJL and JNLS; Data curation, WMJL; RQFR; LSBS and JNLS; Formal analysis, WMJL; RQFR; LSBS; IMB; MJASP and JNLS; Investigation, WMJL; RQFR; LSBS; IMB; MJASP and JNLS; Methodology, WMJL; MJASP and JNLS; Project administration, WMJL; RQFR; and JNLS; Resources, WMJL; RQFR; LSBS; IMB; MJASP and JNLS; Surpervision, WMJL and JNLS; Validation, WMJL; Visualization, WMJL; RQFR; LSBS; IMB; MJASP and JNLS; Writing – original draft, WMJL; RQFR; LSBS; IMB; MJASP and JNLS; Writing – review & editing, WMJL; RQFR; LSBS; IMB; MJASP and JNLS.

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