Comparative evaluation of the efficacy of diode laser as an adjunct to modified Widman flap surgery for the treatment of chronic periodontitis: A randomized split-mouth clinical trial

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Abstract:
Background: Periodontitis is a chronic inflammatory disease that is mainly initiated by plaque biofilm which may require treatment using periodontal flap surgery. Recently, diode lasers have become popular in the field of periodontology owing to advantages such as antibacterial effect, promoting angiogenesis, and providing hemostasis. However, scientific data on application of diode laser in periodontal flap surgery and its benefits are limited. Hence, the aim of the study was to investigate the adjunctive effect of removal of remnant pocket epithelium by 980 nm diode laser and biostimulation in modified Widman flap (MWF) surgery for the treatment of chronic periodontitis. Materials and Methods: A total of 20 patients with generalized chronic periodontitis with pocket probing depth (PPD) ≥5mm post Phase I therapy were selected for this split-mouth study. MWF surgery was performed in Group 1, and in Group 2, MWF surgery with adjunctive diode laser de-epithelization and biostimulation was done. Clinical parameters including PPD, clinical attachment level, plaque index, and gingival index were recorded at baseline and 3 months following treatment, and postprocedural pain (Visual Analog Scale [VAS] score) was assessed 1-week posttreatment. In addition, colony-forming units/milliliter (CFU/ml) of anaerobic bacteria at baseline and 3 months were microbiologically examined. Results: MWF surgery along with diode laser led to a significant improvement in Group 2 compared to Group 1 in clinical parameters such as PPD, relative clinical attachment level, VAS score as well as microbial parameter CFU/ml after 3 months. Conclusion: Diode laser as an adjunct to MWF in chronic periodontitis can provide enhanced clinical attachment gain with little postoperative discomfort.

Key words: Chronic periodontitis, diode laser, microbiological analysis, modified Widman flap

INTRODUCTION

Periodontitis is a chronic disease which is caused due to continuous adherence and growth of microbial plaque and calculus on the tooth surface and around the marginal gingiva which encourages an inflammatory reaction.[1] The progression of periodontitis is largely due to host’s immune response to pathogens leading to infection, rather than the infectious agent itself, which finally cause tissue damage in periodontal disease.[2]

Chronic periodontitis is a destructive disease affecting the periodontium of the tooth resulting in alveolar bone resorption.[3] The principle aim of treating periodontitis is to reduce the microbial load either by nonsurgical periodontal therapy or surgical periodontal therapy. The primary goal of nonsurgical mechanical periodontal therapy by scaling and root planing and subgingival irrigation is to reduce the microbial infection, whereas surgical periodontal therapy is performed when nonsurgical therapy fails, which includes flap surgery with or without bone grafting and osseous resection.[4]
One of the most commonly used flaps is modified Widman flap (MWF), given by Ramfjord and Nissle in 1974, which is also recognized as an open flap curettage technique, and it involves removing lining of periodontal pocket and has shown promising results. However, Fisher et al. reported that reverse bevel incision does not remove epithelium completely from the lateral wall of the pocket, especially in interproximal regions. Furthermore, it does not completely eliminate bacteria which is present in the tissues.[3]

There are enough number evidence present that for years, diode lasers have been successfully used in different areas of dentistry with better clinical outcome. The wavelength of diode laser is delivered in a continuous wave or gated pulse in a contact mode, which helps to remove the diseased soft tissue and to decrease the microbial load in periodontal pockets.[8] Diode laser use in various periodontal procedures generates a zone of thermal necrosis of <1 mm, which provides adequate surgical precision and hemostasis for many soft-tissue procedures.[9] Furthermore, various studies have described improved clinical outcomes by employing diode lasers to de-epithelize the underneath lining of the mucoperiosteal flap and also facilitate considerable bacterial reduction.[10] In vitro assessment has shown the diode laser to facilitate more complete removal of remaining epithelium left by reverse bevel incision.[11] Laser energy affects intracellular and extracellular pigmented pathogens.[12] Laser energy has the potential to penetrate 1–2 mm deeper into the tissue. Hence, it is highly effective against tissue invasive periopathogens.[13] To identify the wound healing progression by the use of low-level lasers, various studies have been conducted so far. The low-level lasers chiefly work on the principle of biostimulation or the photo biomodulation.[13] Low-level laser therapy (LLLT) provides an instant analgesic effect; hence, it is extensively used for reducing pain as it accelerates the regenerative process.[14,15] The biostimulatory action is mainly due to cellular changes induced by LLLT by absorption of infrared light energy by mitochondria or on membrane calcium channels leading to increased cellular repair, proliferation, and healing.[16] Mester et al. first studied the effect of LLLT rat model, who found enhanced wound healing.[16]

However, evidence available so far is insufficient to prove adjunctive effect of dental lasers in the surgical periodontal therapy.[17] Thus, the primary purpose of conducting this study was to evaluate and compare clinically and microbiologically the effectiveness of diode laser to facilitate removal of remnant epithelium, reduction of periopathogens, and biostimulation after MWF for the treatment of chronic periodontitis.

**MATERIALS AND METHODS**

**Source of data**

The study was conducted in the Department of Periodontology and Oral Implantology and was approved by the Institutional Ethical Committee. A total of 20 patients within the age group of 25–45 years diagnosed with chronic periodontitis were selected based on the following criteria.

Patients who had at least 2 quadrants with 3 teeth each having a pocket probing depth (PPD) of ≥5 mm post Phase 1 therapy, systemically healthy controls, individuals who had no medical conditions interfering with periodontal health or wound healing, individuals who were ready to co-operate with all the study-related procedures, and those who have signed the informed consent form were included for the study. Patients who were on any drug therapy which is known to influence the periodontium, pregnant or lactating patients, patients who have used antibiotics within 3 months, patients who were on any drug therapy which is known to influence the periodontium, pregnant or lactating patients, patients who were on any drug therapy which is known to influence the periodontium, pregnant or lactating patients, patients who were medically compromised, and patients who had generalized recession were excluded from the study.

**Sample size estimation**

It is evident from literature survey. The expected mean ± standard deviation of parameters of Group 1 and Group 2 is 4.81 ± 61 and 5.54 ± 63, respectively, for power 95% and Λ error 5%. The effect size for parameters was 1.171703. Hence, with the help of G*Power analysis version 3.10, the power and sample size of one group are 95% and 20, respectively. Therefore, the total sample size is 40.[18]

**Study design**

This study was a split-mouth randomized controlled clinical and microbiological study of 3-month duration [Figure 1].

**Presurgical procedures**

The participants received detailed information regarding their condition and treatment plan, and written consent was taken from the patient after explaining the aim of the project. All the patients received a hygienic treatment phase consisting of oral hygiene instructions, supragingival prophylaxis, and nonsurgical procedure comprising thorough subgingival scaling and root planing ≥3 weeks before surgical treatment. All clinical parameters were recorded and microbiological samples were taken at baseline.

**Measurement of clinical parameters**

All the clinical periodontal examination of the patients was done by a single examiner, who was blinded for the study groups. University of North Carolina-15 probe was used to measure the clinical parameters. The following clinical parameters were recorded at baseline and 3 months postsurgery for all the sites: Gingival index (GI) by Loe and Silness.[19] Plaque index (PI) by Turesky–Gilmore–Glickman modification of Quigley Hein PI,[20] Pocket probing depth (PPD) in millimeter was measured on the customized acrylic stent from free gingival margin to the base of the sulcus.

Relative clinical attachment level (r-CAL) in millimeter was measured from a fixed reference point on the customized stent to the base of the sulcus [Figure 2]. Postprocedural pain experience of the patient was recorded using a Visual Analog Scale (VAS)[21] at 1-week postsurgical therapy.

**Surgical treatment procedure**

A single operator treated all the patients who was different from an examiner who recorded clinical parameters. At baseline visit, the quadrants indicated for surgery were divided into Group 1 or Group 2 by a flip of coin. In Group 1, MWF surgery was first performed as described by Ramfjord and Nissle, 1974, followed by sham laser application. No osseous recontouring was done [Figures 3 and 4]. Routine flap closure using 4-0 black silk sutures was done. Noneugenol periodontal dressing Coe-Pak (GC America Inc.) was placed to cover the surgical area after suturing.
Two weeks later, in Group 2, surgery was performed similar to Group 1 except that underside of the flap was lased with diode laser to remove the remaining epithelium. The patient did not know which site would receive laser (980 nm) therapy.

A 980 nm diode laser unit, 400-micron diameter and disposable fiber-optic tip at 1.5 W in contact mode at 45° angle to the inner aspect of the flap was used to remove the remaining epithelium. Facial and palatal flaps were lased for around 10 s in relation to each tooth [Figure 5]. The sites of diode laser irradiation were continuously irrigated with normal saline. Laser plume was removed using high-volume suction and to clear the field, and laser tip debris was continuously cleaned using a moistened cotton swab. No osseous recontouring was done. After complete debridement, flap closure was done using 4-0 black silk sutures and noneugenol periodontal dressing Coe-Pak (GC America Inc.) was given.

Laser biostimulation was done after suturing using diode laser set at 0.5 W in a noncontact mode at baseline and 7 days. Each site was lased for 10 s (60 s/tooth), energy density = 90 J both buccally and palatally/lingually [Figure 6].

Microbiological sample collection
The samples were collected at baseline and 3 months. The area from where plaque sample was to be collected was cleaned superficially with cotton pellet and then dried with a stream of air. Plaque samples were collected by sterilized gingival curette from the depth of pocket [Figure 7], and then, the sample was aseptically transported to 3 ml of phosphate-buffered saline [Figure 8] and immediately mixed using a vortex mixer for 60 s. The vortexed samples were serially diluted, and and 0.2 ml portion of 10⁻¹, 10⁻², 10⁻³ dilutions were spread on a solid agar medium. Trypticase soy agar plates were used for culturing anaerobic bacteria. All the culture plates were incubated for 24–48 h in Gas Pack Jars (Gas Generating Kit, Oxoid) in an atmosphere of 95% H₂ and 5% CO₂ at 37°C. The total viable count (TVC) was determined from the dilution giving 30 ± 300 colonies. TVC was expressed in terms of milliliter of transport medium. All microbiologic data were transformed into colony-forming units/milliliter (CFU/ml).

Statistical analysis
Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25 and Epi Info (Chicago, United States) version 6.0. The P value was taken significant when <0.05 (confidence interval of 95% was taken). Unpaired t-test was used for intergroup comparison. Paired t-test was used to evaluate intragroup comparison. The level of significance was taken at 5% (P < 0.05).

A comparison of all parameters (GI, PL, PPD, r-CAL, VAS score, and CFU/ml) within and between the groups was
performed. Mean change was determined and compared across Group 1 and Group 2, and the following results were obtained.

**RESULTS**

The intragroup comparisons showed that both the groups, i.e., Group 1 (MWF) and Group 2 (MWF + laser), had a significant reduction in PI and GI at all intervals from the baseline, as shown in Tables 1 and 2. Furthermore, the mean PPD at baseline in Group 1 was 6.60 ± 1.19 which reduced to 3.95 ± 0.76 at 3 months and in Group 2 was 6.35 ± 1.18 which reduced to 2.80 ± 0.70 at 3 months. Similarly, the mean r-CAL at baseline in Group 1 was 10.15 ± 0.75 which reduced to 8.10 ± 0.85 at 3 months and Group 2 was 10.00 ± 0.73 which reduced to 7.40 ± 0.94 at 3 months. The mean CFU/ml at baseline in Group 1 was 154.15 ± 68.86 which reduced to 97.00 ± 26.63 and Group 2 was 117.75 ± 54.85 which reduced to 45.60 ± 33.93, respectively [Tables 1 and 2].

However, the intergroup comparison between Group 1 (MWF) and Group 2 (MWF + laser) showed that the difference in mean GI and PI was insignificant [Table 3].

The mean PPD reduction at 3 months was statistically significant ($P < 0.05$) for Group 2 in comparison to Group 1.

The mean r-CAL at 3 months reduced significantly for Group 2 compared to Group 1 ($P < 0.05$). The mean difference in r-CAL from baseline to 3 months was significantly more among Group 2 [Table 3]. The mean CFU/ml at 3 months reduced significantly for Group 2 compared to Group 1 ($P < 0.05$) [Table 4].

The mean VAS score at 1-week follow-up was 4.70 ± 0.86 for Group 1 and 2.90 ± 0.72 for Group 2, respectively [Table 5]. The mean VAS score was significantly less among Group 2 ($P < 0.001$).

**DISCUSSION**

The successful periodontal therapy primarily aims at eliminating or reducing the pathogenic microbial load found in dental plaque.[22] The nonsurgical mechanical therapy may not be sufficient in cases of chronic periodontitis, especially with deep periodontal pockets.[23] Hence, periodontal flap surgery is done, which provides enhanced visualization of the root surface and osseous defects. The primary aim of MWF surgery is to reduce the pocket depth by removing the diseased pocket lining, thus leading to greater attachment gain and reduced microbial load.[24] MWF does not remove complete pocket lining as well as tissue invasive perio-pathogens.[25] To accomplish this, some trials have confirmed the adjunctive use of diode laser
owing to its bactericidal effect.\[^{[6,25-27]}\] The major advantage of using diode laser within a wavelength of 800–980 nm is that it is well absorbed by pigmented tissue which specifically targets the darkened, inflamed tissues and pigmented bacteria. This causes vaporization of water leading to lysis of bacterial cell wall and finally causing cell death.\[^{[6,11]}\] Among soft-tissue lasers for incision, hemostasis and coagulation diode laser are considered very efficacious. However, there are insufficient evidences to support the adjunctive use of diode laser in periodontal flap surgery.\[^{[28,30]}\] Hence, this study was designed to evaluate the same.

The results of the present study showed a significant improvement in all the recorded clinical parameters except for gingival index (GI) and PL from baseline in both the groups. However, Group 2 was found to be better than Group 1 at 3-month follow-up in terms of PPD, r-CAL, CFU/ml, and VAS.

The GI was assessed to monitor the patient’s gingival health and condition. Our study showed an insignificant reduction in gingival inflammation for both the groups from baseline. Similar results were reported by Jonnalagadda et al.\[^{[28]}\] The decrease in GI can be attributed to the effective removal of calculus and diseased granulation tissue leading to reduction in gingival inflammation.

The PI was calculated to assess the oral hygiene status of the patients. The mean PI also showed an insignificant reduction in both the groups from baseline at 3 months. This implies that there is no additional effect of laser on PL indicating the need for regular patient education and remotivation to maintain oral hygiene, which was done.

The PPD measurement is important to evaluate the progression or regression of periodontitis posttreatment. A statistically significant reduction in mean PPD was observed in both the groups from baseline to 3rd month. The laser-treated group was significantly better. Our results are in accordance with the study conducted by Aena et al.\[^{[29]}\] It can be hypothesized that a greater reduction in PPD in the laser-treated group might be due to increased level of anti-inflammatory cytokines and increased microcirculation by the laser irradiation.\[^{[29]}\] The results of the present study also confirm the findings by Karthikeyan et al.\[^{[30]}\] where DL assisted to Kirkland flap surgery has shown more decrease in PPD compared with Kirkland flap surgery alone. In the present study, r-CAL was recorded for evaluating the success of periodontal therapy, thereby indicating the formation of new connective tissue attachment with a gain in CAL in the DL-assisted MWF surgery. On comparison of mean CAL gain in between both the groups, there was a significant improvement in CAL. However, more CAL gain was found in the DL-treated group at 3 months. This can be attributed to more complete

### Table 1: Intragroup comparison of standardized clinical parameters for Group 1

| Parameter | Group 1-modified Widman flap alone | Mean±SD | 3 months | P<0.05 |
|-----------|----------------------------------|---------|----------|--------|
| GI        | 1.45±0.39                        | 0.78±0.50 | <0.001*  |
| PI        | 1.30±0.47                        | 0.55±0.51 | <0.001*  |
| PPD       | 6.60±1.19                        | 3.95±0.76 | <0.001*  |
| r-CAL     | 10.15±0.74                       | 8.10±0.852| <0.001*  |
| CFU       | 154.15±68.859                    | 97.00±26.626| 0.001*  |

Paired t-test. *Significant difference. GI-Gingival index; PI-Plaque index; PPD-Pocket probing depth; r-CAL-Relative clinical attachment; CFU-Colony-forming units; SD-Standard deviation; P-Probability

### Table 2: Intragroup comparison of standardized clinical parameters for Group 2

| Parameter | Group 2-modified Widman flap+laser | Mean±SD | 3 months | P<0.05 |
|-----------|-----------------------------------|---------|----------|--------|
| GI        | 1.40±0.48                         | 0.75±0.60 | <0.001*  |
| PI        | 1.25±0.64                         | 0.50±0.51 | <0.001*  |
| PPD       | 6.35±1.18                         | 2.80±0.70 | <0.001*  |
| r-CAL     | 10.00±0.725                       | 7.40±0.940| <0.001*  |
| CFU       | 117.75±54.845                     | 45.60±33.926| <0.001*  |

Paired t-test. *Significant difference. GI-Gingival index; PI-Plaque index; PPD-Pocket probing depth; r-CAL-Relative clinical attachment; CFU-Colony-forming units; SD-Standard deviation; P-Probability

### Table 3: Intergroup comparison of clinical parameters

| Parameter | Baseline | 3 months | P<0.05 |
|-----------|----------|----------|--------|
| GI        |          |          |        |
| Group 1   | 1.45±0.39| 0.78±0.50| 0.801* |
| Group 2   | 1.40±0.48| 0.75±0.60| 1.000* |
| PI        |          |          |        |
| Group 1   | 1.30±0.47| 0.55±0.51|        |
| Group 2   | 1.25±0.64| 0.50±0.51|        |
| PPD       |          |          |        |
| Group 1   | 6.60±1.19| 3.95±0.76| 0.007* |
| Group 2   | 6.35±1.18| 2.80±0.70|        |
| r-CAL     |          |          |        |
| Group 1   | 10.15±0.75| 8.10±0.85| 0.041* |
| Group 2   | 10.00±0.75| 7.40±0.94|        |

*Significant; *not significant. Unpaired t-test. GI-Gingival index; PI-Plaque index; PPD-Pocket probing depth; r-CAL-Relative clinical level; P-Probability

### Table 4: Intergroup comparison mean colony-forming unit/ml

| Parameter | Group 1-modified Widman flap alone | Mean±SD | Group 2-modified Widman flap+laser | Mean±SD | P<0.05 |
|-----------|----------------------------------|---------|-----------------------------------|---------|--------|
| CFU       | 154.15±68.86                     | 97.00±26.63 | 117.75±54.85                      | 45.60±33.93 | 0.001* |

Unpaired t-test. CFU-Colony-forming units; SD-Standard deviation; P-Probability

### Table 5: Intergroup comparison mean Visual Analog Scale score 1-week postoperative

| Parameter | Group 1-modified Widman flap alone | Mean±SD | Group 2-modified Widman flap+laser | Mean±SD | P<0.05 |
|-----------|----------------------------------|---------|-----------------------------------|---------|--------|
| VAS score | 4.70±0.86                        | 2.90±0.72 |                                   | 0.001*  |

Unpaired t-test. *Significant difference. VAS-Visual Analog Scale; SD-Standard deviation; P-Probability
removal of diseased pocket epithelium in the DL-treated group.\textsuperscript{18} Here authors have tried to explain the adjunctive effect of diode laser as it helps in complete removal remnant epithelium which is not accomplished by modified widman flap alone.\textsuperscript{13} Smith et al.\textsuperscript{13} reported a greater gain in clinical attachment levels with MWF surgery with laser which they speculated is because of reattachment happening with inverse bevel incision along with the use of laser-de-epithelization which favored better wound healing as opposed to healing by long junctional epithelium in the control group.

When considering microbiological parameters, in the present study, the mean anaerobic count (CFU/ml) reduced in both the groups at 3 months significantly. However, in comparison, the DL-treated group showed a greater decrease. These results were consistent with the findings by Gokhale et al.\textsuperscript{31} where they found a statistically significant reduction in CFU of anaerobes in the laser-treated group as compared to the control group. A greater reduction in number of anaerobic pathogens in the DL-treated group can be attributed to absorption by protohemin and protoporphyrin IX pigments by the wavelength of the diode laser used.

To assess the level of patient’s comfort with the treatment, postprocedural pain on a VAS was evaluated and recorded. The mean VAS score was significantly higher in Group 1 as compared to Group 2 indicating the adjunctive biostimulant effect of diode laser resulting in less postoperative pain in Group 2. Chow et al.\textsuperscript{30} have pointed out that laser induces inhibitory effects on the peripheral nerves by slowing the conduction velocity and/or reducing the amplitude of compound action potentials.

The results of our study are encouraging to support adjunctive use of diode laser in periodontal flap surgery as it not only showed improved clinical parameters but also reduced the microbiological load and enhanced patient comfort. Certain limitations of our study were short follow-up period and the absence of histological analysis to assess true regeneration and not employing advanced microbiological analysis. Thus, further studies with larger sample size, longer follow-up, and histological analysis should be undertaken to substantiate these findings.

CONCLUSION

Therefore, within the limitations of the present study, it can be concluded that both MWF alone and MWF with laser could be successfully used to treat chronic periodontitis patients. However, diode laser-assisted MWF in chronic periodontitis can provide enhanced clinical attachment gain with little postoperative discomfort.

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Conflicts of interest
There are no conflicts of interest.

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