Clinical and microbiological evaluation of the synergistic effects of diode laser with nonsurgical periodontal therapy: A randomized clinical trial

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INTRODUCTION

The bacterial composition of the microbial plaque biofilm is the most important causation factor for chronic periodontitis. This plaque biofilm is able to invade the root cementum as well as the epithelial lining of diseased pockets, and hence, disruption of this biofilm is the most effective means of treating periodontal disease. Scaling and root planing (SRP) along with various flap surgical procedures have been performed to reduce the microbial burden of the plaque biofilm. Along with these, the local drug delivery therapy and systemic antibiotic regimens have also been used in the treatment of periodontitis, but in most cases, they also have limited effects. The development of antibiotic resistance in the patients receiving systemic antibiotic therapy should also be emphasized. For the reduction of microorganisms in the subgingival environment, laser therapy can be used as an adjunct to the conventional therapy without any major side effects. The adjunctive use of lasers for pocket therapy (erbium-doped yttrium aluminum garnet and diode lasers) decontaminates the soft-tissue wall as well as root surface area of the periodontal pocket by promoting bacterial reduction. Along with this, the laser also inactivates the endotoxins of the bacteria which get diffused into the root cementum as well as soft-tissue wall of the periodontal pocket.

The diode laser is a semiconductor and the most common diode wavelengths used in dentistry are 610 nm (red) to 980 nm (infrared). It can be operated in both continuous wave and pulsed wave modes (PW) modes. On interaction with the tissue surface, the laser light can be refracted, scattered, absorbed, or transmitted.

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The laser energy absorbed by the tissues can result in warming, coagulation, or vaporization effects depending on the wavelength, power, and optical properties of the tissue. As the diode laser light is highly absorbed in hemoglobin of blood, it becomes an excellent choice for the removal of highly vascular inflamed tissues of the periodontal pocket. Diode laser (wavelength 980 nm and 2 wattage power) has thermal and photodisruptive effects which result in the elimination of periodontal pathogenic microflora. Absorption of laser light leads to elevated tissue temperatures because of which most nonsporulating bacteria, including anaerobes, are readily inactivated.

Despite all the advantageous effects of diode laser, the efficacy of its use as an adjunct to nonsurgical periodontal therapy is still controversial. Hence, the aim of the present study is to evaluate the effectiveness of the use of diode lasers as an adjunct to SRP compared to SRP alone on various clinical and microbiologic parameters in chronic periodontitis patients.

MATERIALS AND METHODS

The sample size was calculated using G-power software. The alpha value was kept as 5%, and the power of the study was chosen to be 80%. The study was conducted in accordance with the Declaration of Helsinki of 1975, as revised in 2000. Initially, 76 patients were assessed and 36 patients were excluded as they were not fulfilling the criteria (study design). Forty patients (19 females, 21 males, mean age 34.2 ± 8.9 years) having chronic periodontitis, who gave their informed consent, were taken from outpatient department of periodontology and implantology. The study protocol was approved by the institutional ethical committee.

Inclusion and exclusion criteria

Patients having moderate periodontal pockets (4–6 mm) and having a minimum of twenty teeth present were included in the study.

Patients who had undergone periodontal treatment within past 6–12 months, had used antibiotics or anti-inflammatory drugs within past 3–6 months, pregnant and lactating females, taking hormonal contraceptives, smokers, alcoholics, and with <20 teeth present were excluded from the study.

Patients who fulfilled the inclusion criteria were randomly allocated by tossing a coin method into two groups: Group I – the test group (SRP + diode laser) and Group II – the control group (SRP). The allocated patients were assessed for the clinical parameters.

Clinical parameters assessed

The clinical parameters assessed were oral hygiene index simplified (OHIs), clinical attachment level (CAL), probing pocket depth (PPD) (6 sites with UNC 15 probe), and bleeding on probing (BOP) at baseline and 4 weeks’ and 12 weeks’ posttreatment.

Microbiological sampling technique

Microbiological sampling was done in addition to the above parameters at baseline and 1 week after treatment in both the groups. A total of eighty anaerobic samples were isolated from 480 sites in forty patients followed by clinical assessment. These were collected by placing two sterile no - 40 paper points inside the pocket for 30 s, and they were transferred to Robertson Cooked Meat Broth medium for microbial culture and analysis. Then, samples were placed into the petri dishes containing blood agar. After 3 days of incubation at 37°C in atmosphere containing 5%–10% CO2, colonies were counted. Then, the results were converted into logarithm values for better understanding.

Clinical procedure

Full-mouth SRP was done with hand and ultrasonic scaling instruments for both Group I and Group II. For test group (along with SRP), laser application was done with 2 watt power, in contact mode with sweeping motion to cover entire epithelial lining from base of the pocket to upward in the subgingival areas for bacterial reduction and coagulation of soft tissue (epithelial side) of the pocket. In the control group, only SRP was done. Then patients were advised oral hygiene instructions which included modified bass brushing technique and warm saline rinses twice daily. Patients were recalled for anaerobic microbiological sampling 1 week after the therapy. Clinical parameters were assessed at 4 weeks and 12 weeks postoperatively.

Statistical analysis

After obtaining the values, they were subjected to statistical analysis. “Paired” t-test for intragroup comparison and “unpaired” t-test for intergroup comparison were used. Wilcoxon nonparametric test for paired samples and between-group differences were assessed using the nonparametric Mann–Whitney U-test. “P” value was kept <0.05 and <0.001 as statistically significant.

RESULTS

Table 1 shows the mean values of OHIs and sulcus bleeding index (SBI). There was decrease in the values of both OHIs and SBI at 1 month and 3 months after the treatment. The mean OHIs values at the baseline were 3.19 ± 1.15 for Group I (SRP and Laser), which were reduced to 1.43 ± 0.58, and for Group II (SRP), the mean values at baseline were 3.24 ± 0.93 which were reduced to 1.32 ± 0.30 at 3 months’ post treatment. For SBI, mean values at the baseline for Group I (SRP and Laser) and Group II (SRP) were 2.32 ± 0.43 and 2.35 ± 0.69, respectively, which were reduced to 1.15 ± 0.33 and 1.59 ± 0.61 at 3 months postoperatively. The reduction in OHIs and SBI from baseline to 3 months was highly significant for both the groups. For SBI, the intergroup comparison of the values at 3 months postoperatively was statistically significant.

The mean values of PPD and CAL are shown in Table 2. The mean value of PPD at baseline was 4.81 ± 0.95 which was decreased to 3.33 ± 0.35 at 3 months’ posttreatment for Group I. For Group II, the baseline values of PPD were 4.97 ± 0.77 and were decreased to 3.66 ± 0.44, 3 months post treatment. For both the groups, this decrease in PPD was highly significant. However, on the intergroup comparison, statistically significant reduction in PPD was seen for the test group. CAL was also found to be decreased from baseline (Group I 3.80 ± 0.92 and Group II 3.37 ± 0.65) to both 1st month and 3rd month postoperatively for both the groups, and the
results were highly significant. More gain in CAL was seen in Group I at 3 months, and the results were highly significant.

When bacterial load was considered, the mean baseline values for colony-forming units (CFUs) [Table 3] were 8.45 ± 0.16 for Group I (SRP and Laser) and 8.50 ± 0.13 for Group II (SRP) which were decreased after the treatment in both the groups to 8.24 ± 0.13 for Group I and 8.32 ± 0.31 for Group II. Both intergroup and intragroup comparisons of mean values of CFU were found to be statistically significant.

### DISCUSSION

The tissues of periodontium are continuously exposed to the toxins secreted by the bacteria present in plaque biofilm which results in the inflammatory process in the periodontal tissues which in turn leads to tissue destruction. Surgical as well as nonsurgical periodontal therapy aims to reduce this microbial burden as well as arrest the tissue destruction process.],[19-21] SRP although has been universally accepted to be effective in this process, complete elimination of periodontal pathogens is not possible using these conventional methods alone.[22] According to a study done by Sbordone et al., there is a repopulation of periodontal pathogenic microbes 21 days after the treatment with SRP.[23] The patients who do not respond to nonsurgical periodontal therapy optimally or the patients with compromised medical health conditions, who are not the candidates for surgical periodontal therapy, may be benefitted from the adjunctive diode laser treatment.[24] In the present study, the diode laser was used as supplementary treatment (along with SRP) which was aimed to reduce or eliminate bacteria residing in the pocket as well as the surrounding tissues.

The mean OHIs and SBI presented significant clinical and statistical improvements in both the treated groups compared to baseline at both 1st month and 3rd month after treatment which is in accordance with the previous studies.[24-26] When the mean SBI index was compared between Group I (SRP and Laser) and Group II (SRP) at 3 months, there was more reduction in BOP in Group I which was statistically significant. More reduction of BOP in Group I may be attributed to the reduction of periodontal inflammation which in turn may be related to the reduction of prostaglandin E2 (PGE2) levels, due to the effects of laser treatment. During periodontal disease process, the levels of PGE2 increase in the connective tissues which are a potent stimulator of inflammation and bone resorption.[27] Laser radiations may reduce and inhibit the PGE2 production.

### Table 1: Oral Hygiene Index-Simplified and Sulcus Bleeding Index obtained in the Group I and Group II from baseline to 3 months

| Group | Mean±SD | P | Pre versus 1 month | Pre versus 3 months | 1 month versus 3 months |
|-------|---------|---|-------------------|-------------------|---------------------|
|       | Preoperatively | After 1 month | After 3 months | Preoperatively | After 1 month | After 3 months | Preoperatively | After 1 month | After 3 months | Preoperatively | After 1 month | After 3 months |
| Group I (SRP and Laser) | | | | | | | | | | | | |
| OHI-S | 3.19±1.15 | 1.14±0.56 | 1.43±0.58 | <0.001** | <0.001** | 0.058 |
| SBI | 2.32±0.43 | 1.42±0.39 | 1.15±0.33 | <0.001** | <0.001** | 0.002* |
| Group II (SRP) | | | | | | | | | | | | |
| OHI-S | 3.24±0.93 | 1.33±0.75 | 1.32±0.30 | <0.001** | <0.001** | 0.971 |
| SBI | 2.35±0.69 | 1.74±0.73 | 1.59±0.61 | <0.001** | <0.001** | 0.320 |
| Intergroup comparison | | | | | | | | | | | | |
| OHI-S | 0.881 | 0.369 | 0.457 | 0.001* | | |
| SBI | 0.849 | 0.095 | 0.007* | | | |

Tests applied: For intragroup comparison - Paired t test; for intergroup comparison -Unpaired t test; Values expressed as means +/- SD (standard deviation).

*P<0.05 was considered as Not Significant; **P<0.05 was considered as Significant; ***P<0.001 was considered as Highly significant.

SRP – Scaling and root planing; OHI‑S – Oral Hygiene Index Simplified; SBI – Sulcus Bleeding Index

### Table 2: Probing pocket depth and clinical attachment level obtained in the Group I and Group II from baseline to 3 months

| Group | Mean±SD | P | Pre versus 1 month | Pre versus 3 months | 1 month versus 3 months |
|-------|---------|---|-------------------|-------------------|---------------------|
|       | Preoperatively | After 1 month | After 3 months | Preoperatively | After 1 month | After 3 months | Preoperatively | After 1 month | After 3 months | Preoperatively | After 1 month | After 3 months |
| Group I (SRP and laser) | | | | | | | | | | | | |
| PPD | 4.81±0.95 | 3.61±0.56 | 3.33±0.35 | <0.001** | <0.001** | 0.024* |
| CAL | 3.80±0.92 | 2.47±0.77 | 1.57±0.56 | <0.001** | <0.001** | 0.001* |
| Group II (SRP) | | | | | | | | | | | | |
| PPD | 4.97±0.77 | 3.87±0.47 | 3.66±0.44 | <0.001** | <0.001** | 0.011* |
| CAL | 3.37±0.65 | 2.78±0.51 | 2.49±0.70 | <0.001** | <0.001** | 0.010* |
| Intergroup comparison | | | | | | | | | | | | |
| PPD | 0.569 | 0.114 | 0.011* | | | |
| CAL | 0.091 | 0.133 | <0.001** | | | |

Tests applied: For intragroup comparison - Paired t test; for intergroup comparison - Unpaired t test; Values expressed as means +/- SD (standard deviation).

*P<0.05 was considered as Not Significant; **P<0.05 was considered as Significant; ***P<0.001 was considered as Highly significant. SRP – Scaling and root planing; PPD – Probing pocket depth; CAL – Clinical attachment level

### Table 3: Colony-forming units (LOG values) obtained in the Group I and Group II from baseline to 1 week

| Group | Mean±SD | Pre versus 1 week (P) |
|-------|---------|-------------------|
|       | Preoperative | After 1 week |
| Group I (SRP and Laser) | 8.45±0.16 | 8.24±0.13 | <0.001** |
| Group II (SRP) | 8.50±0.13 | 8.32±0.31 | <0.001** |
| Intergroup comparison | 0.71 | 0.071 | |

Tests applied: Wilcoxon signed rank test and Mann-Whitney test; P<0.05 was considered as Not Significant; *P<0.05 was considered as Significant; **P<0.001 was considered as Highly significant. SRP – Scaling and root planing.
in periodontal tissues, thus reducing the inflammatory process.\textsuperscript{39} Furthermore, in the inflamed and highly vascular periodontal pocket, the diode laser light gets absorbed by the hemoglobin pigment and helps in the resolution of the disease process.\textsuperscript{10,11,12,34} The ablation and vaporization of the debris and plaque in the periodontal pocket and also the disinfection and removal of infected pocket lining can be done with the use of laser light.\textsuperscript{29} Thus, the use of laser as an adjunctive to SRP helps in the elimination of bacteria and thus useful in reducing PPD and BOP.\textsuperscript{11,30}

In the present study, both the treatment groups showed a statistically significant reduction in PPD as well as CAL postoperatively. Reduction in probing depth and gain in CAL were significantly better for the test group as compared to the control group at 3 months postoperatively [Table 2]. The results of the present study are also supported by a study done by Dukić et al.\textsuperscript{13} A study done by Romanos et al. showed that instrumentation of soft periodontal tissues with 980-nm diode laser led to a complete epithelial elimination when compared to conventional treatment method with hand instruments.\textsuperscript{32} With appropriate power settings, diode laser can have a penetration in the soft tissues to a depth ranging from about 0.5 mm to 3 mm.\textsuperscript{33} Due to this, laser has bactericidal effects on the pathogenic bacteria residing in the pocket epithelium. This leads to complete de-epithelialization of the infected tissue in the periodontal pocket (as compared to mechanical therapy alone) and a better connective tissue attachment and thus more reduction in the PD with the use of adjunctive laser therapy.\textsuperscript{34}

Laser therapy also leads to epithelial changes at the molecular levels (by increasing the levels of vascular endothelial growth factor, transferring growth factor β, and mRNA expression of insulin growth factor on human gingival fibroblasts), thus modulating the connective tissue turnover during wound healing.\textsuperscript{35-37} After the laser therapy, coagulation at the site as well as blood clot stabilization is also shown by various studies.\textsuperscript{38}

The effects of laser irradiation depend on the wavelength of the laser and the absorbing capacity of the lasered tissue. Depending upon the exposure time, the target tissue absorbs a certain amount of laser radiation, and these are transformed into the laser energy to produce the desired effects. The laser beam has a thermal effect on bacteria due to which they are killed and it also inactivates the bacterial toxins which are present in the cementum portion of the root.\textsuperscript{39} In the present study, within Group I (SRP and Laser) and Group II (SRP), significant reductions in the proportions of CFUs were observed 1 week after the treatments. However, the intergroup comparison revealed no significant differences in between the groups. Similar results were found in the study done by Moritz et al. who suggested that irradiation with the diode laser with a wavelength of 805 nm facilitates bacterial elimination from periodontal pockets.\textsuperscript{13}

The use of laser has several advantages such as hemostasis which means bloodless field during the surgical procedure, the sterilization of the wound site, reduced cellular destruction and less swelling of the tissues, increased visualization of surgical sites, decrease of postoperative pain, and thus high patient acceptance.\textsuperscript{30}

The reported results of the use of diode lasers in various studies have been mixed. Some studies reported SRP + laser better than SRP alone.\textsuperscript{30,40,41} In contrast to this, few studies found no additional effects of lasers.\textsuperscript{30,42} From the present study, it can be concluded that the use of laser is beneficial in terms of the pocket depth reduction, reduced BOP, improvement in CAL, and a significant reduction in the bacterial counts which are the main reason for the periodontal disease progression. Even though evaluating microbiota is the gold standard, in the present study, only CFUs were assessed alone which may not determine the effects of laser on the type of bacteria present in the periodontal pockets. For this, a stronger microbial analysis is necessary, and additional randomized controlled clinical trials are necessary to competently assess the efficacy of lasers used adjunctively to mechanical debridement, especially in cases of severe periodontal destruction.

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Conflicts of interest
There are no conflicts of interest.

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