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Utilisation of antimicrobial photodynamic therapy as an adjunctive tool for open flap debridement in the management of chronic periodontitis: A randomized controlled clinical trial

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ABSTRACT

Background: Antimicrobial photodynamic therapy (aPDT) has proved to be an effective adjunctive modality with potential benefits in the management of chronic periodontitis. The combination of photothermal and photodynamic effects of Indocyanine green (ICG) dye, when it is photoactivated with a diode laser of 810 nm wavelength, has been well documented in literature.

Aim: This study was conducted to evaluate whether a single session of antimicrobial photodynamic therapy using ICG dye-810 nm diode laser combination can provide a substantial benefit when it is utilised as an adjunct to open flap debridement (OFD) in the management of chronic periodontitis.

Materials and method: Following thorough scaling and root planing, a comparative split mouth randomized controlled clinical trial was carried out on 20 recruited subjects who provided one test (OFD + aPDT) and one control site (OFD alone) each (total 40 treatment sites). The test group was subjected to a single episode of aPDT using ICG photosensitiser dye (1 mg/ml) activated with 810 nm diode laser. The laser was used in a continuous wave, non-contact mode at a power output of 100 mW applied for 30 s/spot (the total of 4 spots per tooth) and delivered by 400 μm fibre, to provide a fluence (energy density) value of 0.0125 J/cm^2 per spot and generate a total energy of 3 J. The following clinical parameters were assessed at baseline and 3 months: probing pocket depth (PPD), relative attachment level (RAL), relative gingival margin level (RGML), plaque index (PI), gingival index (GI), and gingival bleeding index (GBI). Intragroup and intergroup comparison was performed using paired *t*-test and independent samples *t*-test respectively.

Results: Intragroup comparison revealed a statistically significant improvement from baseline visit ($p < 0.05$). Intergroup comparison showed a statistically significant improvement in RAL, RGML and GI in the test group ($p < 0.05$).

Conclusion: Utilisation of ICG dye activated with 810 nm diode laser, which mediated aPDT, has demonstrated surplus clinical improvement following OFD in the management of chronic periodontitis.

1. Introduction

Periodontal flap surgery is an open flap debridement procedure, which eliminates/reduces the periodontal pocket depth with a potential to remove the bacterial biofilm and endotoxins from root surfaces of the teeth and to prevent further clinical attachment loss [1]. Although thorough elimination of the diseased granulation tissue reduces the bacterial pathogen, it still remains a fact that it fails to eradicate the periopathogens [2]. The success of such treatment may also be affected by incomplete diseased granulation tissue removal, inadequate oral hygiene maintenance and failure to comply with supportive periodontal therapy. Hence, development of alternative or exclusive antibacterial therapeutic strategies has become imperative in the evolution of modalities to control microbial growth in the oral cavity.

Recently, an application of light energy with laser, also known as phototherapy to decontaminate the pocket's environment, has been explored. Laser- assisted eradication of the oral pathogenic bacteria associated with periodontitis and peri- implantitis, has been demonstrated [3]. The diode laser is the most popular choice of laser technology for the general dental practitioner, since it is portable and

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convenient to use. In addition, the diode laser wavelengths are radically absorbed by the pigmented tissues, specifically the pigmented pathogenic bacterial strains [4]. Evaluation of in-vitro studies has shown that this method is effective to achieve a thorough elimination of the epithelial lining of the periodontal pocket [4]. Parameters for safe and effective laser use as an adjunctive therapy to the periodontal flap surgery, have been evaluated in very few clinical trials. However, this was associated with a failure to provide any additional benefits over the conventional mechanical debridement modalities in non-surgical periodontal therapy [5] and insignificant clinical improvement was noted [6,7]. Additionally, ablative forms of laser energy exhibit a risk of collateral thermal damage to adjacent non-target tissues [6–8].

Anti-microbial photodynamic therapy (aPDT) also known as photoactivated disinfection (PAD), involves the use of a selective photosensitizer which is activated by a light source of a wavelength corresponding to the absorption maximum of the photosensitizer. The activated photosensitizer reaches the target tissues to bind to the bacterial cell wall and in some instances, penetrates into the cytoplasm [9]. Photo-excitation after interaction with a light of a particular wavelength causes pronounced antimicrobial action at the treatment site [8,10]. The Type 1 reaction mechanism leads to the formation of reactive oxygen species (ROS) whereas singlet oxygen is generated in the Type 2 reaction, which predominates in aPDT. Owing to its short lifetime in biological systems and a small radius of action (0.02 μm) [10], the reaction occurs in a limited space causing a localized tissue response. Furthermore, host tissue damage is not encountered due to the protective presence of keratin which inhibits the cytotoxic activity, thus promoting selective bacterial apoptosis [8,10].

Indocyanine green (ICG), a water soluble tricarbocyanine dye, has proven to be a photosensitiser with an optimal peak absorption at 800–810 nm range of wavelengths [11,12]. This range has a penetration depth of 6–6.5 mm, which exceeds the thickness of the mucous membrane, both in normal and pathological state [13]. The delivery of ICG-mediated photodynamic therapy has shown to be effective in eradicating the deeply seated organisms such as; *Staphylococcus aureus, Pseudomonas aeruginosa*, *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans,* thereby reducing their concentrations and ultimately improving the periodontal status [11,14,15]. Evidence based studies have demonstrated that uptake of anionic ICG in the Gram negative bacterial cell wall with an outer membrane, which is rich in a lipopolysaccharide, was not via simple diffusion. Furthermore, divalent cations like calcium and magnesium, which are predominantly found at anatomical sites associated with bacterial biofilm infections, would increase the uptake of anionic ICG by both Gram negative and positive bacterial cells. They play an important role in the regulation of porin proteins, which mediate the transport of substances across the outer membrane of Gram negative bacteria. Furthermore, neutralization of electrostatic charges by the interaction of these divalent cations with carboxylate and phosphate groups results in reducing the repulsion of anionic ICG by the negatively charged cell wall [16,17].

Following the light absorption, the ICG molecule can follow three different pathways to deactivate its excited state. The first pathway is a conversion of the absorbed energy to fluorescent light, centered at 830 nm, can occur [18]. The second one is that the ICG absorbs the 800 nm near infrared (NIR) light and converts approximately 88% of its absorbed light, which is converted into heat as a result of the internal conversion [18,19]. This phenomenon is known as photothermal and it results in the formation of ROS. This process does not require oxygen for its stimulation or release of the ROS [20]. Thus, the ICG has added a superior value to work efficiently in the anaerobic subgingival environment over the other conventionally used photosensitizers [21]. The third pathway is related to a small part of the absorbed light energy that is transferred to ICG triplet state, which can generate the ROS, such as singlet oxygen. Experimental studies have shown that under cooling conditions in vitro, the generation of the ROS was still detected in ICG-NIR- irradiated cells. This could be as a result of a subordinate photodynamic effect [19]. The harmful effects of the heat generation at the treatment site can be minimized by using a liquid photosensitizer and employing low level laser power settings [11,22,23].

The supplementary use of ICG-laser combination therapy in the non-surgical management of chronic periodontitis has shown to eradicate the disease substantially [24,25], with a radical decline in the pathogenic microbiota. This has led to an improvement in the soft tissue morphology [21,26]. Studies have demonstrated its use in the treatment of intrabony defects after open flap debridement prior to guided tissue regeneration, which have proven its benefits [8]. However, its auxiliary use in open flap debridement to ensure thorough bacterial elimination has not yet been well established. Previous studies examined, the effect of single application of aPDT by utilising a combination of phenothiazine chloride dye and 660 nm diode laser as an adjunct to open flap debridement [27]. The present study, aimed to compare the effect of a single session of photoactivated disinfection, using ICG dye activated with 810 nm diode laser, as an adjunct to the open flap debridement after thorough scaling and root planing. This adjunctive therapy was compared to the conventional open flap debridement in the treatment of chronic periodontitis to examine the possible benefits of new modalities over the traditional surgical approach.

2. Materials and method

2.1. Study design and sample size calculation

The present study was a double blind randomized controlled split mouth clinical trial. Keeping the gain in the relative attachment level (RAL) as the primary outcome variable, the sample size of 40 treatment sites (20 sites per group) was calculated, using STATA (version 10.1, 2011) from STATA Corp. Texas. This sample size selection was required in order to detect a true difference of 1 mm between test and control groups, providing 5% alpha error and 80% power to the study. Taking into consideration the possibility of dropout of the recruited subjects during the follow-up visit, a sample size of n = 50 sites (25 treatment sites per group) was opted. Considering each subject as a unit, providing 2 sites each, a total of 25 subjects from the out-patient department, were included in this study (Fig. 1) [27]. All study sites in each patient were randomly assigned to either of the two groups by lottery method at the preliminary visit [21].

The present study was granted an ethical approval by the Institutional Ethical Committee assigned by Maharashtra University of Health Sciences, India. A case history proforma was designed for the study, including a detailed information related to the patient's chief complaint, treatment and laser protocols, and the clinical parameters assessment at the baseline and subsequent 3 month recall visit. A written informed consent was obtained.

2.2. The criteria for selection

The inclusion criteria:

1 Systemically healthy subjects diagnosed with chronic periodontitis (age ranged 30–55 year old) [28], who were able to provide an informed consent and comply with all study related procedures, including a good plaque control were recruited.
2 All subjects presented with teeth, which had 2 or more pockets associated with persistent probing depth ≥ 5 mm after the initial non-surgical therapy [29], with signs of horizontal bone loss radiographically with the same teeth and their contralateral counterparts.

The exclusion criteria:

1 Subjects with a history of systemic illness, on antibiotic therapy within the last six months of enrolment, history of previous

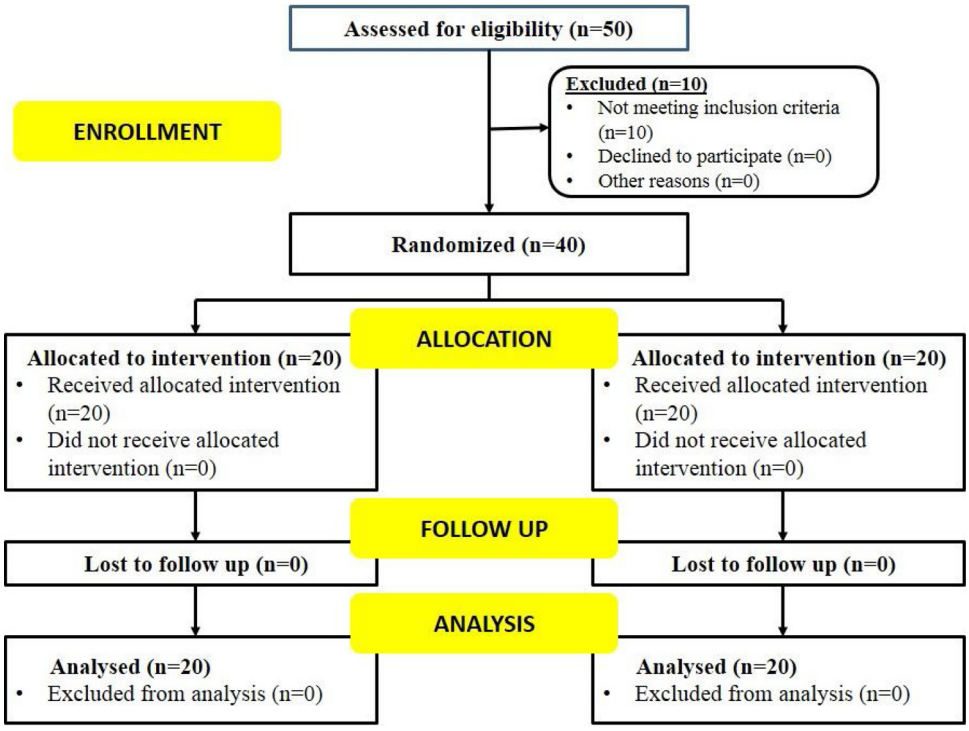

Fig. 1. Consort flow chart.

periodontal surgery, allergy to materials and drugs that were used in this study and pregnant women [30].

2 Subjects with deleterious habits like smoking, tobacco chewing [31].

3 Subjects receiving any other periodontal therapy or aggressive periodontitis cases [32].

2.3. Methodology

2.3.1. The initial visit

After careful clinical evaluation, a total of 25 subjects were recruited in this study. Orthopantomograph assessment was one of the methods of investigations to determine the type of bone loss, while the intra-oral peri-apical radiographs were taken as required. Subjects, who showed signs of horizontal bone loss around teeth radiographically, in the same side and their contralateral counterparts, underwent a full mouth scaling and root planing.

2.3.2. The 4 weeks visit after initial phase therapy

Upon re-evaluation, subjects with the presence of teeth having 2 or more pockets with persistent probing depth ≥ 5 mm and showing similar findings in their contralateral counterparts were included in this study [27,33]. Five out of 25 subjects showed a resolution of probing pocket depth and therefore, they were excluded from the study. Finally, the total number of recruited subjects was 20 (14 females and 6 males). A split mouth design study [27,34] was employed where the 2 treatment sites of each subject were randomly allotted each, to either of the two groups (Fig. 2).

2.3.3. At the baseline visit

A detailed case history of each subject was recorded in the pre-designed proforma. The clinical parameters were measured by an experienced calibrated examiner using University of North Carolina-15 periodontal probe. A customized grooved acrylic occlusal stent fabricated for each site was utilised to provide a reproducible insertion axis at all subsequent appointments [25]. The examiner who performed all measurements was blinded to the type of treatment provided while another examiner performed all treatment procedures. The subjected were blinded.

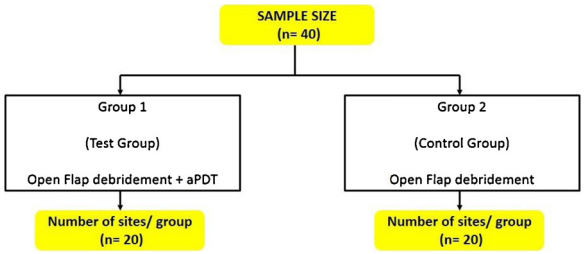

Fig. 2. Distribution of samples.

The assessed parameters were as follows; probing pocket depth (PPD), relative attachment level (RAL) [35], relative gingival margin level (RGML) [36], plaque index (PI) [37], gingival index (GI) [38] and gingival bleeding index (GBI) [39]. Each parameter was evaluated as an average of the mean score of each tooth upon the total number of teeth included in each site.

2.3.4. Surgical procedure

After the baseline assessment, all the sites that belonged to Group 1 underwent an open flap debridement procedure. A crevicular incision was performed, using a number 12 surgical blade. A full thickness muco-periosteal flap was raised, using a periosteal elevator. Following this, a thorough debridement of the root surfaces was performed. Subsequently, the photoactivated disinfection using ICG dye activated with 810 nm diode laser was carried out.

2.3.5. Dye preparation and laser parameters

The photosensitiser used in the study was ICG (Periogreen®, Elexxion AG, Singen, Germany). Accordingly, a dye solution was freshly prepared. Periogreen® tablet was dissolved in sterile water to achieve a concentration of 1 mg/ml for a one-time single quadrant use within 2 h [8] (Fig. 3 a–c). A single session of the above mentioned technique was repeated during each surgical procedure and separate kits were used for

Fig. 3. Apparatus used for aPDT and ICG dye preparation.
1. 3a: Periogreen® kit.
2. 3b: Freshly prepared Periogreen® ICG dye solution.
3. 3c: Laser parameters used with 810 nm diode laser Picasso Lite, AMD Laser™.

Fig. 4. The sequence of the treatment followed in Group 1 (Test group).
1. 4a: Baseline assessment of clinical parameters.
2. 4b: Use of sulcular incision to raise a full thickness mucoperiosteal flap.
3. 4c: Washing the surgical site with freshly prepared ICG dye solution (1 mg/ml).
4. 4d: Activation of dye with 810 nm diode laser.
5. 4e: Interrupted sutures to approximate buccal and palatal flaps.
6. 4f: Suture removal at 1 week after surgery.
7. 4g: Assessment done at 3 months following surgery.

each patient. After complete debridement, each test site was rinsed with ICG dye using a blunt side release cannula. Vacuum suction was used to remove the excess dye from the site and to prevent ingestion of the dye solution. The low level laser therapy (LLLT) effect of the last zone of the beam profile [40] generated by 810 nm diode laser (Picasso Lite, AMD Laser™) activated the dye at a power output of 100 mW in a continuous wave. Its photonic energy was delivered with a 400 µm fibre in non-contact mode and applied for 30 s/spot (total 4 spots per tooth). With reference to these laser specifications, the fluence (energy density) provided was 0.0125 J/cm^2 per spot and the total energy was 3 J [8] (Fig. 4 a–g).

Group 2 (Control sites) received an open flap debridement procedure alone. The wound was closed with interrupted sutures using 3-0 braided black silk suture material for each site of the both groups.

All the subjects received verbal and written post-operative instructions of the periodontal surgical procedures. Furthermore, all the subjects were motivated to improve their oral hygiene habits and maintain compliance. One week after surgery, all the subjects were recalled for suture removal and post-operative evaluation was undertaken. All the clinical parameters were re-assessed 3 months after surgery.

3. Statistical analysis

Data was coded and entered in MS Excel. Statistical software STATA (version 10.1, 2011) from STATA Corp. Texas was used for data analysis. All the measurable parameters were summarized in the form of mean and standard deviation. Intra-group comparison was performed using paired *t*-test for evaluating the significance of difference in means at baseline and 3-months post treatment. Independent samples *t*-test with equal variances was used for inter-group comparison of mean change (from baseline to 3 months). Pearson's co-relation coefficient was calculated to assess the correlation between the two procedures, estimating the mean change or difference (from baseline to 3 months) for various parameters. Significance of correlation coefficient was tested with t-statistics. A p-value < 0.05 was considered statistically significant.

4. Results

After carrying out chronic periodontitis assessment evaluation and thorough non-surgical periodontal therapy [29], 20 subjects (40

Table 1
Distribution of subjects in Group 1 & 2 by their baseline characteristics.

Characteristic	Group 1 (Test group) (n= 20 sites)		Group 2 (Control group) (n= 20 sites)	
	Number	Percentage	Number	Percentage
Age				
30- 34 years	7	35	7	35
35-39 years	6	30	6	30
40-55 years	7	35	7	35
Gender				
Male	6	30	6	30
Female	14	70	14	30

surgical treatment sites) were enrolled in this study. The mean age was 36.85 ± 4.52 year (14 females and 6 males) [28]. In order to avoid any selection bias and to examine the possible benefits of a new adjunctive protocol over the traditional approach, the control sites additionally underwent a flap surgical procedure. All subjects completed the 3 month follow-up. None of the subjects reported any post-operative complications related to soft tissue healing or teeth staining. These findings were in accordance to studies previously conducted, using aforementioned dye-laser combination [21,24–26]. Table 1 depicts the distribution of subjects in Group 1 & 2 at their baseline characteristics.

No difference was noted in the intergroup baseline findings for all clinical parameters. Intragroup comparison indicated that all parameters showed a statistically significant improvement in their values from baseline to 3 months post treatment ($p < 0.0001$) as depicted in Table 2. Table 3 shows the intergroup comparison of change in the parameter values from baseline to 3 months post treatment. The mean changes in Group 1 for RAL, RGML and GI indicates that there was a statistically significant amount of gingival recession in Group 2 in comparison to Group 1, along with an improved gain in the attachment level in the latter. This shows that marked gingival health improvement in a reduced periodontium was observed in the sites belonging to Group 1 over Group 2 sites [41]. Overall, these results suggested that a change in the parameter values from baseline to 3 months post treatment was observed in both groups with a higher impact in terms of uneventful and faster healing and an improvement in the gingival health in the group receiving adjunctive aPDT. Statistically significant findings were noted for RAL, RGML and GI, pointing out a moderate co-relation between the two procedures that were performed in each patient with respect to the above mentioned parameters, which are illustrated in Figs. 5–7 respectively.

Table 3
Inter group comparison of the change in the parameter values (From baseline to 3 months post treatment) in the two groups.

Parameter	Change from Baseline Test Group (n=20) Mean ± SD	Change from Baseline Control Group (n=20) Mean ± SD	p value
PPD (mm)	3.18 ± 0.41	3.1 ± 0.53	0.2044
RAL (mm)	2.83 ± 0.54	2.76 ± 0.63	0.0016**
RGML (mm)	−0.67 ± 0.15	−0.92 ± 0.16	0.0001**
PI	1.46 ± 0.50	1.56 ± 0.54	0.5643
GI	1.67 ± 0.29	1.31 ± 0.36	0.0006**
GBI (%)	60.2 ± 8.9	58.5 ± 9.3	0.5487

Using Independent samples *t*-test.
*p < 0.05 (Significant).
** p < 0.001 (Highly significant).

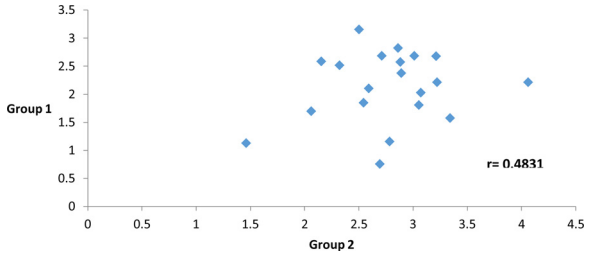

Fig. 5. Scatter plot showing co-relation between Group 1 & 2 for measuring change in RAL (From Baseline to 3 months).

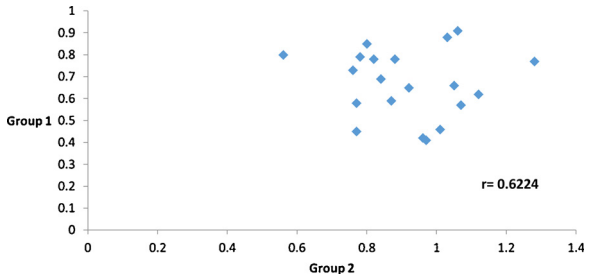

Fig. 6. Scatter plot showing co-relation between Group 1 & 2 for measuring change in RGML (From Baseline to 3 months).

5. Discussion

Periodontitis is a disease, which occurs as a result of unaltered build-up of bacterial biofilms on the tooth surface and acts as a noxious stimulus that mediates the host immune response thus debilitating the sound tooth supporting structures. The errors that occur during DNA replication or constant exposure to chemicals and radiation would result in a mutation, which helps the microbial survival in the presence of

Table 2
Intra group comparison of the parameter values in Group 1 (Test group) and Group 2 (Control group) at baseline and 3 months post treatment respectively.

Parameter	GROUP 1 Values at Baseline Mean ± SD	GROUP 1 Values at 3 months Mean ± SD	p-value	GROUP 2 Values at Baseline Mean ± SD	GROUP 2 Values at 3 months Mean ± SD	p-value
PPD (mm)	5.42 ± 0.28	2.24 ± 0.39	0.0001**	5.48 ± 0.26	2.38 ± 0.42	0.0001**
RAL (mm)	8.25 ± 0.36	5.42 ± 0.55	0.0001**	8.24 ± 0.41	5.48 ± 0.53	0.0001**
RGML (mm)	3.16 ± 0.48	3.83 ± 0.49	0.0001**	3.15 ± 0.56	4.07 ± 0.51	0.0001**
PI	2.14 ± 0.39	0.68 ± 0.25	0.0001**	2.10 ± 0.38	0.73 ± 0.32	0.0001**
GI	2.2 ± 0.32	0.5 ± 0.2	0.0001**	2.2 ± 0.34	0.89 ± 0.34	0.0001**
GBI (%)	70.5 ± 9.99	10.25 ± 4.72	0.0001**	70.5 ± 9.99	12 ± 7.68	0.0001**

Using Paired *t*-test.
*p < 0.05 (Significant).
** p < 0.001 (Highly significant).

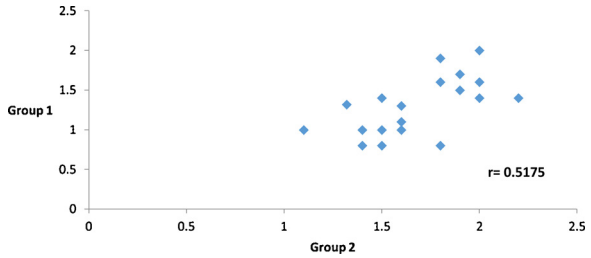

Fig. 7. Scatter plot showing co-relation between Group 1 & 2 for measuring change in GI (From Baseline to 3 months).

the antibiotics. This subsequently would facilitate the development of resistant strains [42]. These findings legitimate the quest to identify new treatment procedures to improve the conventional debridement. The aPDT may augment the periodontal treatment by increasing the bacterial apoptosis, inactivating the bacterial virulence factors and the host cytokines, which would impair the periodontal restoration. This would provide a more favourable healing environment [10,43,44]. The wavelengths that fall within the range of 650–900 nm of the electromagnetic spectrum can activate the chromophores in their corresponding photosensitiser agents, in order to create a 'therapeutic window' where the optimal light-tissue penetration is detected [45]. The aPDT causes damage to the polysaccharides, which present in the cytoplasmic membrane and the bacterial DNA [46,47]. Moreover, since most of the damage that occurred to the microbial biomolecules can be lethal rather than purely inhibiting the growth, the development of resistance to the cytotoxic action of singlet oxygen or the free radicals, which ultimately seem very unlikely [8,43,46,48]. Such dual activity is not exhibited by antibiotics and may represent a significant advantage of aPDT. Furthermore, the latter augments the conventional surgical approach by; accelerating the wound healing by reducing or increasing the inflammation, stimulating the fibroblasts proliferation and, subsequently, of the collagen and elastin, raising the transforming growth factor beta and metalloproteinases, and facilitating the neo-angiogenesis and bone repair [46,49]. Studies have shown that most photosensitizers show a weak tumor selectivity [19]. However, the ICG fluorescence exhibits a high tumor-to-background ratio (255:1), thus minimizing its effect on the adjacent healthy tissues [50]. Therefore, in order to achieve these desirable effects, the present study was conducted using ICG photosensitizer dye along with 810 nm diode laser. The results showed a significant improvement in all parameters and a favourable tissue healing at 3 months post treatment. This was attained by both procedures with a higher influence on the sites receiving an adjunctive aPDT and are in accord to the findings of the previous studies [21,24–26].

Removal of irritants from the root surface and subsequent break in the sub-gingival biofilm formation result in reduction in the probing pocket depth and a gain in the clinical attachment level. Intragroup evaluation in the present study, showed a further improvement in both clinical parameters, which is consistent with previous studies' observations [51–53]. The evaluation of the change in RGML was utilised to calculate the gingival recession in both groups. The test group sites showed a lesser gingival recession post-operatively in comparison to the sites of the control group at 3 months post-operatively and this difference was statistically significant. These observations were in accordance with the study by de Oliveira et al. [54] but were conflicting to the results of the studies conducted by Braun et al. [34] and Carvalho et al. [55]. A significant improvement in PI, GI and GBI scores in both the groups was noted at 3 months post-operatively. These findings could perhaps be due to the reduction in the inflammatory mediators like Interleukin-1β (IL-1β), Interleukin-17 (IL-17) levels thus causing a decrease in the average bleeding on probing over time [56]. The results of PI, GI and GBI scores were correlated to the previous studies reports [55,57,58] but different to the outcomes of others studies [51–53]. Martins SHL et al. conducted a study to evaluate the effect of single application of aPDT using a combination of phenothiazine chloride (Helbo Blue®) dye and 660 nm diode laser (HELBO® TheraLite Laser) as an adjunct to open flap debridement. The authors noted a significant improvement in the clinical parameters as well as a reduction in the red complex pathogens [27]. The findings of the present study were in agreement with the aforementioned study.

A possible clarification for inter-study variability with regards to the clinical parameters discussed above could be explained through a study performed by Lindhe et al. [58], which was carried out to analyse the role played by the patients' self-performed plaque control in preventing recurrent periodontitis after long term evaluation of non-surgical/surgical treatment of periodontal disease. The authors concluded that patients' standard of self-maintained oral hygiene had a decisive influence on the long-term effect of treatment, irrespective to the type of the procedure that was opted. Moreover, it was suggested that the critical determinant in periodontal therapy was not related to the technique (surgical or non-surgical) used for the elimination of the subgingival infection, but the quality of the debridement of the root surface was accountable [58]. In addition, an altered behavioural response of the subjects due to their awareness of being assessed (Hawthorne effect) can also be anticipated as a possible reason for this variation [21,59].

To the best of our knowledge, the present study was the first to evaluate and compare the effectiveness of a single session of aPDT, using ICG (Periogreen® dye) and 810 nm diode laser as an adjunctive modality to open flap debridement in the management of chronic periodontitis, which was assessed over a duration of 3 months. The protocol of the present study included sites showing horizontal bone loss only and hence regenerative procedures were not required. So, the 3 months follow up visit included the re-assessment of clinical parameters without the radiographic evaluation. Furthermore, the treatment approach for the control group was conventional open flap debridement procedure in order to avoid any bias in our findings. Utilization of the aPDT as an adjunct to the surgical debridement of intra-bony defects followed by guided tissue regeneration and bone graft placement, using commercially available products: Methylene blue and 660 nm diode laser (Periowave™ system) [60] and Indocyanine green (Periogreen® dye) and 810 nm diode laser [8], has shown a significant reduction in the clinical inflammation and an early bone fill radiographically at 3 months follow up visit. The results of the present study were in accordance to the clinical findings observed in the above cited literature [8,60].

The laser photonic energy < 200 mW effectively allows the ICG (1 mg/ml) to bind to the bacterial cellular lipoproteins. The repeated aPDT sessions should be indicated according to the severity of the clinical condition [8]. The number of sessions of aPDT and the interval between two sessions varies in all documented clincial studies till date. In spite of the positive outcome of additive sessions of aPDT [24,61–63], the consensus on utilisation of the optimal protocol has not been established yet. The protocol of the present study was in the accordance with the data documented previously in literature [8,21,25,26].

The present study had some limitations. The microbiological parameters were not evaluated in order to observe the exact alterations in the periodontal pathogens following both the treatment modalities. This could have helped in comparing the reduction in bacterial load at the treatment sites. The sample size of the study was 25 patients, but only 20 patients were evaluated. Additionally, a larger sample size would be beneficial to compare the effects of aPDT in a more comprehensive manner. Long term follow-up assessment could have provided a more suitable clinical picture. Lastly, only a single session of aPDT can be provided after open flap debridement unlike the multiple sessions adjunctive to nonsurgical periodontal therapy, which is a shortcoming of this treatment protocol.

6. Future scope of the study

1 The microbial analysis of the periodontal pathogens should be conducted to observe for possible alteration in their concentrations from the baseline to the subsequent visits.
2 Evaluation of inflammatory markers can be performed in order to confirm the post- operative reduction in the clinical signs of inflammation.
3 In bone defects cases, studies are required to evaluate the effect of aPDT in achieving bone infill when the ICG activated with 810 nm diode laser modality is employed.

7. Conclusion

Within the limitations of this study, the data proves, that photoactivated disinfection, using ICG and 810 nm diode laser, resulted in a significant clinical improvement when it was utilised as an adjunct to open flap debridement in the treatment of chronic periodontitis. More randomized controlled clinical trials with sufficient statistical power should be conducted in order to assess the possibilities of using adjunctive aPDT in surgical management of various forms of periodontitis. Likewise, further studies are required to elucidate the beneficial properties of ICG. Hence, the results of the present study could ascertain a beneficial role of adjunctive aPDT using ICG photosensitizer activated with 810 nm diode laser, following open flap debridement in the management of chronic periodontitis.

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Nil.

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