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EFFICACY OF PHOTODYNAMIC THERAPY AND LASERS AS AN ADJUNCT TO SCALING AND ROOT PLANING IN TREATMENT OF CHRONIC PERIODONTITIS

Prerna Kataria[1], Akashdeep Singh[2], Pradeep Shukla[3], Gaurav Malhotra[4], Dhanesh Rao[5]
[1]Professor, Department of Periodontology and Implantology, Divya Jyoti college of Dental Sciences and Research
[2]Post-Graduate Student, Department of Periodontology and Implantology, Divya Jyoti College of Dental Sciences and Research
[3]Professor and Head of Department, Department of Periodontology and Implantology, Divya Jyoti
[4]Professor, Department of Periodontology and Implantology, Divya Jyoti college of Dental Sciences and Research
[5]Senior Lecturer, Department of Periodontology and Implantology, Divya Jyoti College of Dental Sciences and Research
Conflicts of Interest: Nil
Corresponding author: Akashdeep Singh

Abstract:
Introduction: Periodontal pockets possess some degree of challenge for nonsurgical periodontal therapy. Scaling and Root planning (SRP) alone may not be sufficient in cases where surgical therapy is not advised or performed. Recent studies have demonstrated and suggested the use of photodynamic therapy or antimicrobial Photodynamic therapy (aPDT)for the treatment of periodontal disease or infections. The aim of the study was to evaluate the effects of SRP alone and SRP+PDT for treatment of deep periodontal pockets.
Methods: Thirty patients with chronic periodontitis were taken for the study who met the iclusion criteria of periodontal pockets≥6mm and bleeding on probing present in two different quadrants. After SRP, one quadrant was selected for aPDT while other served as a control group. Clinical parameters i.e. Plaque index, Modified sulcular bleeding index, Probing depth and Clinical attachment level were measured at baseline, 1month and 3 months.
Results: All clinical parameters significantly improved in both groups after 1and 3 months. At 1 month, inter-group comparison was statistically significant for mSBI (0.83±o.39 for SRP+aPDT and 0.51±0.45 for SRP alone) and PD (1.75±0.86 For SRP+aPDT and 1.2±0.93 for SRP).At 3 months, no statistical difference was observed for mSBI(0.94±0.44 for SRP+aPDT and 0.70±0.42 for SRP)
Conclusion: Non-Surgical periodontal therapy when performed along with photodynamic therapy plays an adjunct or additional role in the treatment of chronic periodontitis.
Keywords: Chronic Periodontitis, Photodynamic Therapy, Diode Laser, Toludine blue O

Introduction

Photodynamic therapy (PDT), also known as photo-therapy, photo radiation therapy or photo chemotherapy has been developing rapidly within various medical specialties since last few decades. PDT has been used in the treatment of premalignant lesions and recurrent tumours after previous surgery or chemotherapy The therapeutic use of photodynamics continues to expand for the management of various non-oncological diseases and superficial infections like candidiasis and herpes virus infections. Accordingly, the terminology used for treatment changes from PDT associated with treating oncological diseases to photodynamic antimicrobial chemotherapy or antimicrobial photodynamic therapy (aPDT) in treating localized bacterial, fungal, viral and yeast infections aPDT has found its role in periodontal therapy as well. The main objective of the periodontal therapy is to stop the progress of disease by reduction of plaque biofilm, as well as eliminating the factors that favour its deposition. Although, mechanical removal of plaque biofilm by scaling and root planing (SRP) is an essential part of periodontal therapy, complete removal of plaque and plaque retentive factors is not always possible especially in less accessible sites such as deeper pockets and furcation areas. Additionally, bacteria that penetrate the gingival tissue cannot be eliminated by mechanical instrumentation.

To supplement the armament of mechanical debridement, different adjunctive modalities have been evaluated, including the local and systemic use of antibiotics. However, biofilm structure of the dental plaque confers significant resistance to bacterial species against antibiotics. On systemic administration, availability of insufficient con-centration of the drug in gingival crevicular fluid (GCF), disturbance of intestinal micro flora and

development of antibiotic resistant strains are the major disadvantages. Therefore, the development of alternative antibacterial therapeutic modalities such as aPDT becomes important for the effectiveness of periodontal treatment.

The use of aPDT for the management of inflammatory periodontal disease is based on the concept that a photosensitizer, usually a phenothiazine compound, that absorbs light, can be preferentially taken up by bacteria, and subsequently activated by a light of appropriate wavelength, in the presence of oxygen, to generate singlet oxygen and free radicals that are cytotoxic to microorganisms. These cytotoxic species can damage plasma membranes and DNA, resulting in cell death. Cell membranes are destroyed by multiple mechanisms, like lipid peroxidation, inactivation of membrane transport system and inhibition of plasma membrane enzyme activities. Phenothiazine compounds (e.g. toluidine blue O and methylene blue), which bear a positive charge, can directly target both gram-negative and gram-positive bacteria. The positive charge promote the binding of photosensitizer to the outer bacterial membrane, inducing localized damage, which favours its penetration.It is specifically the pathogenic bacteria that are destroyed by aPDT, sparing the host cells. Antimicrobial PDT appears to significantly reduce inflammation without antibiotics and without surgical intervention while providing maximum therapeutic safety. As aPDT utilizes laser light for activation of photosensitizer, it is safe for human tissue .Preferential uptake of photosensitizers by bacteria, precise direction of laser light using optical fibres, broad spectrum effect and no development of resistance on repeated application are the major advantages of aPDT in periodontal treatment. Various clinical trials have evaluated the effect of aPDT in treatment of periodontal infections, but are highly controversial.

There are various limitations of nonsurgical therapy in deep periodontal pockets. In addition to being less accessible for mechanical debridement, deeper sites are difficult to maintain and harbour more anaerobic micro-organisms than shallower pockets. Therefore treatment outcome differs between shallow and deep periodontal pockets even with the same treatment modality. Poten-tial scope of aPDT in deeper pockets and less accessible sites led to the concept of the present study, with the aim to evaluate the effect of adjunctive use of aPDT in treatment of deep periodontal pockets compared to SRP alone.

Methods

Study Design

This split mouth single blinded, randomized controlled clinical trial was approved by the Ethical Committee of

Divya Jyoti (D.J). College of Dental Sciences & Research, Modinagar, on. This trial involved 30 adult patients (age >18 years) of either sex who met the inclusion criteria. The patients were selected from the Outpatient Department of Periodontology and Implnatology at D.J. College of Dental Sciences & Research, Modinagar.

Inclusion criteria were the presence of 2 teeth in different quadrants with probing depth (PD) ≥ 6 mm, and bleeding on probing (BOP). Exclusion criteria were (1) Systemic conditions like uncontrolled diabetes mellitus; (2) Pregnant or lactating women; (3) Any history of smoking or smokeless tobacco use; (4) History of antibiotic use in the last 3 months; (5) Undergoing regular treatment with immunosuppressants, non-steroidal anti-inflammatory drugs, steroids, anticonvulsants, anticoagulants or calc-um channel blockers

Patients who fulfilled the inclusion criteria, were explained the treatment methods, risks and benefits. Thirty patients signed the informed consent form following which detailed history and examination was carried out and recorded

Recording of Clinical Parameters

The following clinical parameters were recorded at 4 sites in all teeth using mouth mirror, explorer and calibrated periodontal probe (UNC-15, Hu-Friedy, Chicago, IL). (1) Plaque index (PI) - Sillness & Loe. (1964), (2) modified sulcular bleeding index (mSBI) - Mombelli et al (1987),

- Probing depth (PD) and (4) clinical attachment level (CAL).

Each patient received oral hygiene instructions. They were also trained in modified Basstechnique. Out of the sites with PD ≥ 6 mm in different quadrants, 2 sites with the deepest PD were selected for evaluation, and acrylic stents were fabricated for the measurement of PD and CAL. The measurements of PD and CAL wererepeated for the selected sites after placing the acrylic stents. A vertical groove was made

in the stent at the site corre-sponding to the deepestPD to reproduce the position and angulation of probe at subsequent visits

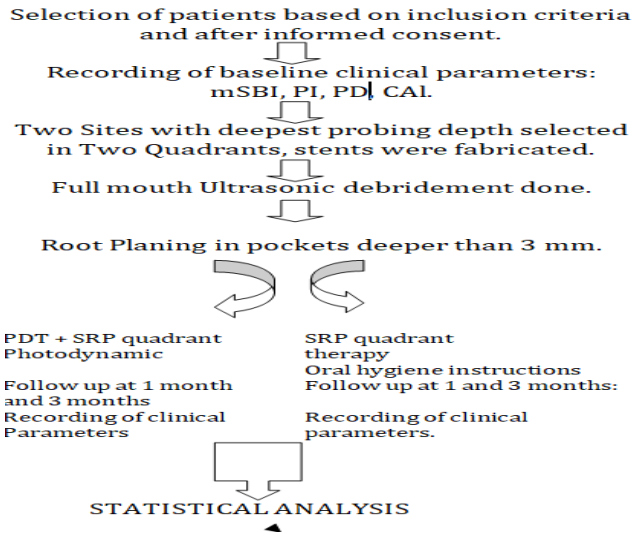
Scaling and Root Planing

Thorough full mouth supragingival and subgingival scaling was performed using ultrasonic scaler and hand instruments. Root planing was done with Gracey curettes, until the root surfaces were hard and smooth. Normal saline (0.9% NaCl w/v) was used to irrigate the operative field.

Antimicrobial Photodynamic Therapy

Randomly, one quadrant was selected for aPDT (test), while another quadrant served as the control. After SRP, haemostasis was achieved and PDT was performed in the test quadrant. Toludine Blue o 1% was injected in the bottom of the pocket using a blunt cannula until it appeared flowing out over the gingival margin. Dye was kept in the pocket for duration of 3 minutes; the pocket was irrigated with normal saline to remove the excess dye. Laser light application was performed circumferentially at six sites per tooth for 1 minute (10 seconds each for mesio-buccal, buccal, disto-buccal, mesio-oral, oral and disto-oral surfaces of tooth), at wavelength of 660 nm, and power density of 100 mW/cm2. Fiber-optic tip of 0.6 mm diameter was inserted to the depth of pocket, followed by illumination for 10 seconds. It was then moved to the next site, till all 6 sites around a tooth were exposed to the laser light all patients were recalled after 1 week to evaluate their adherence to oral hygiene instructions. Clinical parameters were recorded again, 1 month and 3 months after the first application of aPDT

STUDY METHODOLOGY



Results

A total of 60 sites in 30 patients (21 males and 9 females) were selected and randomly assigned to either SRP alone (control) or SRP along with aPDT (test). For statistical analysis, the SPSS version 10.0 (SPSS Inc., Chicago, IL, USA) was used. Values were reported in terms of number (n), mean (μ) and standard deviation (σ). For the comparison of mean values between treatment groups, Student's *t* test was used. The analysis of variance (ANOVA) wasused for comparison of mean values within each treatment group at different time intervals. The level of significance was taken at 5 % ($P < 0.05$).

The average age of patients was 38.67 ± 10.52 years. None of the clinical parameters showed significant inter group difference at baseline

Healing was uneventful in all cases and no adverse effects were reported by any of the subjects after SRP or PDT. There were no drop outs in the patient sample during the course of the study. Mean values of clinical parameters and difference at 1 month and 3 months interval were recorded.

Plaque Index

Mean PI reduction at 1 month was found to be 0.41 ± 0.49 in the control group and 0.46 ± 0.56 in test group, and after 3 months it was found to be 0.44 ± 0.51and 0.60 ± 0.43 respectively. The comparison of the mean PI reduction between two groups at 1 month and 3 months was done using Student's *t* test. No significant inter-group difference was observed after 1 and 3 months.

Table 1:

	SRP	SRP + PDT	p= Value
1 month	0.41±O.49	0.46±0.56	0.57
3 month	0.44±0.51	0.60±0.43	0.11

Comparison of mean changes in plaque index

Probing Depth

The mean PD reduction at 1 month was found to be 1.2 ± 0.93 in the control group and 1.75 ± 0.86 in the test group and at 3 months it was found to be 2.11 ± 1.19 and 2.34 ± 1.09 respectively. Inter-group difference was statistically significant at 1 month, but not after 3 months. This result implies that although the PD decreased significantly in both treatment groups compared to baseline, a combination of SRP and aPDT was more effective in the reduction of PD at 1 month after treatment. However, at 3 months

post treatment intervals both group appeared to have similar reduction in PD.

Table 2:

	SRP	SRP + PDT	p= Value
1 month	1.2 ± 0.93	1.75± 0.86	0.01
3 month	2.11 ± 1.19	2.34 ± 1.10	0.46

Comparison of mean changes in probing index

Modified Sulcular Bleeding Index

The mean mSBI reduction at 1 month was found to be 0.51 ± 0.45 in the control and 0.83 ± 0.40 in the test group, and after 3 months, it was found to be 0.70 ± 0.42 and 0.94 ± 0.44 respectively. The comparison of mean mSBI reduction between the two groups at 1 and 3 months was done using Student's *t* test. At both 1 and 3 months follow up, combination of SRP+aPDT was significantly more effective ($P < 0.05$) in reduction of mSBI as compared to SRP alone.

Table 3:

	SRP	SRP + PDT	p= Value
1 month	0.51± 0.45	0.83 ± 0.40	0.002
3 month	0.70 ± 0.42	0.94± 0.44	0.013

Comparison of mean changes in Modified sulcular bleeding index.

Clinical Attachment Level

The mean CAL gain at 1 month was found to be 0.94 ± 0.95

- in the control group and 1.25 ± 1.10 mm in the test group and at 3 months, it was found to be 1.71 ± 1.24 mm and 2.09 ± 1.34 mm respectively. The results indicate that the CAL improved significantly from baseline to 1 and 3 months post treatment interval in both groups. However, SRP and SRP ± aPDT seems to be equally effective in this regard as the inter-group difference was statistically not significant ($P > 0.05$).

Table 4:

	SRP	SRP + PDT	p= Value
1 month	0.94± 0.95	1.25 ± 1.10	0.11
3 month	1.71 ± 1.24	2.09± 1.34	0.16

Comparison of mean changes in Clinical Attachment Level

Discussion

It has been clearly demonstrated that periodontitis is an infectious disease, and a current concept for treating periodontitis is based on eliminating the infection. As stated by **Rafael Ramos de Oliveira et al. 2009**[67]mechanical therapy of the root surface is the basic perquisite for eliminating the infection & long term treatment success.

The primary goal of periodontal therapy is to create a biologically acceptable root surface by eliminating the biofilm and bacterial metabolic products, thus avoiding progression of inflammation with continuous attachment loss.

Nonsurgical periodontal therapy has shown to be effective and predictable treatment approach. Mechanical debridement can significantly decrease the population of bacteria associated with chronic periodontitis, including *Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, Prevotella intermedia, Tannerella forsythia and Treponema denticola.*

Therefore, alternatives for an efficient adjunctive removal of periodontal bacteria have been proposed, Photodynamic Therapy (PDT). PDT).In dentistry, the first ruby-based laser device was developed by Theodore Maiman in 1960. PDT is based on the principle that a dye as a photosensitizer, binds to the target cells and is activated by light of an appropriate wavelength. By changing the energy status of the molecules in the photosensitizer, free radicals of singlet oxygen are formed, which are toxic to the cell by destroying the membrane, the mitochondria or the nuclei.

In recent years, there has been a growing interest in usage of diode lasers for periodontal treatment due to their antimicrobial and anti-inflammatory properties. Moritz A et al 1998[69]& Qadri et al 2005[70] have shown that use of the diode laser could contribute to significant reduction in bacterial populations and control of periodontal inflammation. Kreisler M et al 2002 showed that diode laser irradiation could stimulate the proliferation of periodontal ligament cells.

Easy to access the periodontal pocket has made PDT the choice for treatment of periodontal pockets. The photosensitiser could be placed directly in the pocket which could then be irradiated either through the thin gingival tissues or via an optical fiber placed directly into the pocket. 320 µm fiber was used in the

study and 1% Toludine Blue O was used as a photosensitizer. (Lui J et al 2011)[73]

Chemically, many photosensitizers belong to dyes and porphyrin-chlorine groups. A variety of photosensitizers include dye like Tricyclic dyes with different meso-atoms — methylene blue, toluidine blue O and acridine orange; and phthalocyanines — aluminum disulfonated phthalocyanine and cationic Zn (II) - phthalocyanine

Among these cationic charged photosensitizers such as Toludine Blue O, Methylene Blue and poly-L-lysine-chlorin-conjugates are more frequently used in disinfection related to periodontopathogens. Biological tissues strongly absorb electromagnetic waves in the range of red to near infrared in electromagnetic spectrum ie 600- 1200 nm. Shorter wavelengths (<600 nm) are absorbed by biological molecules such as Hemoglobin/ myoglobin and the wavelengths above (> 1200) are absorbed by water. Wavelengths within this range penetrate deep inside the biological tissues. Longer wavelengths promote photo activation in deeper tissue layers. (Longo JPF et al 2011)[74]

According to You Chan & Chern Hsiung Lai 2003selection of an effective photosensitizer is essential for the success of the technique. As well as being non-toxic to humans, the ideal photosensitizer needs to absorb a laser beam at the compatible wavelength and has to produce high excitation efficiency. Toludine blue o, which belong to the phenothiazinium family of dyes (which includes Methylene blue), is a well-known photosensitizer.

In the present study, activation of photosensitizer was done on the first day for 30 seconds per tooth in accordance with Lui J, Corbet EF et al. 2011[73], whereas Mohammad S. Al-Zahrani 2009[35]recommended 60 seconds activation.

Clinical studies combining photodynamic therapy with non-surgical periodontal therapy have reported mixed outcomes. Lui J, Corbet EF et al.2011[73]

showed that photodynamic therapy in combination with scaling and root debridement led to a significant improvement in clinical parameters compared with scaling and root debridement alone.

In the present study, significant results in both the groups were observed from baseline to 1 month and 3 months. PDT + SRP proved better in terms of clinical parameters (mSBI and PD) . . de Paula Eduardo C et al 2010& Suokos et al 2011 stated that multiple applications are more beneficial and effective.

The present study was carried out to evaluate the efficacy of Photodynamic therapy as an adjunct to non-surgical periodontal therapy in the treatment of periodontal pockets by changes in clinical parameters.

For this, the split mouth design was used because it excludes the influence of patient's specific characteristics and facilitates the interpretation of trials by minimizing the effects of inter-patient variability (Antezak A.A., Tulloch J.F.C. et al 1990).

The presence of plaque presents a very important and foremost factor in periodontal disease progression. Sites with decreased plaque & deposits have better regenerative & healing response &moreover, if sites maintain good oral hygiene.

The plaque index improved equally at all sites from baseline to month, which supports the decision for using a split mouth design.

In this study there was a statistically significant mean reduction in the plaque index score of Group A & Group B was observed at 1 week, 1 & 3 months, which was in accordance of the findings of the studies by Lui J, Corbet EF et al. 2011[73]& Bernd W. Sigusch et al. 2010[79].

On evaluation of the effect of single dose of Photodynamic therapy using 940nm Nd:YAG Diode laser & 1% Toludine Blue O solution as a photosensitizer, Lui J, Corbet EF et al. 2011[73]observed a statistically significant reduction in the plaque score.

Bernd W. Sigusch et al. 2010[80]made an observation that there was a statistically significant reduction in the plaque index score in the periodontal pockets treated with photodynamic therapy using 660nm soft tissue diode laser & Phenothiazine chloride photosensitizer solution.

On comparison of the mean differences of both the groups i.e Group A & Group B, statistically not significant difference was observed.

Bleeding on probing has been regarded as an objective indicator of gingival inflammation. A high proportion of bleeding on probing – positive sites is considered as uncontrolled inflammation and is associated with an increased possibility of further attachment loss. So, decreased index scores

regarding bleeding on probing is the most objective parameter to analyze the ongoing periodontal disease process & the efficacy of the periodontal therapy.

In Group A & Group B, there was a statistically significant mean reduction in the modified sulcular bleeding index score at all-time intervalswhich was in accordance of the findings of the study done by Linhua Ge et al. 2011[70]& Andreas Braun, Claudia Dehn et al. 2008[33].

On evaluation of the effect of single dose of Photodynamic therapy using soft tissue diode laser of 660nm wavelength & phenothiazine chloride photosensitizer, Andreas Braun, Claudia Dehn et al. 2008[33]observed a statistically significant reduction in the modified sulcular bleeding index score.

On comparison of the mean differences of both the groups Group A showed significant improvement in modified sulcular bleeding index bleeding index scores as in study conducted by Nicos Christodoulides et al 2008[34].

Periodontal pocket is considered as pathognomonic sign of periodontal disease, whereas the probing pocket depth is considered as the yardstick for evaluating the success of the periodontal therapy. Periodontal probing measures the location where resistance is met by the periodontal probe at the base of the pocket. According to Reddy & Jeffcoat 1999[71], this location is related to the position of the soft tissue attachment to the tooth. Its measurement at sequential post-operative examination allows the clinician to determine any improvement in the soft tissue attachment as a result of any periodontal therapy.

In this study there was a statistically highly significant mean reduction in the probing pocket depth of Group A& in Group B, a statistically highly significant mean reduction in the probing pocket depth was observed which was in accordance of the findings of the study done by Polansky R et al. 2009[37], Nicos Christodoulides 2008[34]& Rafael R. de Oliveira et al. 2007[62].

Polansky R et al. 2009[37]who observed a statistically highly significant reduction in the probing pocket depth in periodontal pockets treated with photodynamic therapy using 680nm soft tissue diode laser & photosensitizer solution.

Nicos Christodoulides et al 2008[34]evaluated the effect of photodynamic therapy using soft tissue diode laser & photosensitizer solution on probing pocket depth. A significant reduction in probing pocket depth was observed.

A significant reduction in probing pocket depth was observed by Rafael R. de Oliveira et al.2007[62] on comparing with scaling and root planing alone.

On comparison of the mean differences of both the groups, statistically not significant difference was observed as evaluated by Nicos Christodoulides et al 2008[34].

In this study, gain in attachment was seen at 1 month and 3 months in both the groups .

Gain in CAL was in accordance with a study by Linhua Ge et al 2011[70], Polansky R et al 2009[37], and Campos et al 2013[72].

Our study is in accordance with Rafael R. de Oliveira et al 2007[62], Nicos Christodoulides et al 2008[34], where both the groups showed gain in attachment without statistical significant difference.

On contrary, Andersen R et al. 2007[32] evaluated the clinical effects of a-PDT as an adjunct to SRP over a 12-week period in 33 subjects randomly allocated to receive treatment with either PDT alone or a combination of SRP and a-PDT, or SRP also. CAL, PD and bleeding on probing (BoP) were clinically assessed at 3, 6 and 12weeks after treatment. The addition of a-PDT to SRP was seen to have resulted in a statistically significant improvement in CAL and PD at the 12-week follow-up.

On evaluation of the effect of single dose of photodynamic therapy, using soft diode laser of 660 nm wavelength & phenothiazine chloride photosensitizer., Braun et al 2008[33] observed a statistically significant gain in CAL at 3 months.

Conclusion

Within the limitations of this study, it may be concluded that aPDT plays an additional role in reduction of gingival inflammation when used along with nonsurgical mechanical debridement in deep periodontal pockets. It may be recommended to use aPDT along with SRP for better improvements in gingival bleeding scores. However, since it has primarily antimicrobial action, its role in pocket depth reduction and clinical attachment gain appears to be limited.

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