



Comparative Study on the Efficacy of Antimicrobial Photodynamic Therapy Versus Antibiotic Therapy as an Adjunct to Non-Surgical Treatment in Managing Periodontitis (Stage II, Grade B)

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KEYWORDS

Periodontitis,
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Surgical Periodontal Treatment.

ABSTRACT

Aims: This study evaluates the comparative effectiveness of antimicrobial photodynamic therapy (aPDT) versus traditional antibiotic therapy when used in conjunction with SRP in the treatment of Periodontitis Grade B, Stage II.. **Subjects and Methods:** Sixty participants with Stage II, Grade B periodontitis were recruited from Zagazig University's Faculty of Dentistry. Patients aged 20-40 received either antimicrobial photodynamic therapy (aPDT) or antibiotics alongside scaling and root planing (SRP). Clinical parameters including probing depth, clinical attachment level, and bleeding on probing were documented at baseline, 3 months, and 6 months post-intervention. Microbial analysis determined periodontopathogenic bacteria levels pre- and post-treatment. Treatment outcomes were analyzed using appropriate statistical methods. **Results:** Both therapies showed significant improvements in PD, CAL, and BOP from baseline to the 6-month follow-up. However, the aPDT group demonstrated statistically significant better outcomes in PD reduction and CAL gain at 3 and 6 months compared to the antibiotic group. **Conclusion:** The findings suggest that aPDT may be a more effective adjunct to SRP than antibiotics for the management of periodontitis (Stage II, Grade B). aPDT showed superior clinical and microbiological outcomes, indicating its potential as a non-antibiotic alternative in periodontal therapy. Further long-term studies are warranted to confirm these findings and to evaluate the sustainability of aPDT benefits.

INTRODUCTION

Periodontitis is a chronic inflammatory disease resulting from an accumulation of bacteria in dental plaque. This plaque buildup causes progressive destruction of the tissues supporting the teeth, including the gums, periodontal ligament, and alveolar bone ^[1]. The primary goal of periodontal treatment is to reduce the overall bacterial load in the mouth and promote regeneration of these lost soft and hard tissues. The current gold standard for non-surgical treatment is scaling and root planing (SRP) ^[2]. This procedure involves mechanically debriding and planing the tooth root surface to remove plaque and calculus deposits,

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which facilitates periodontal reattachment. However, SRP has inherent physical limitations. It cannot completely remove biofilm and calculus from deep periodontal pockets, furcation defects, and other inaccessible areas of the root surface. This results in residual pathogenic bacteria and increased risk of periodontal disease recurrence^[3].

To overcome the deficiencies of SRP, adjunctive therapies such as systemic or local delivery of antibiotics/antimicrobials (AB) have been proposed. Numerous studies demonstrate adjunctive AB can provide additional improvements in clinical periodontal outcomes compared to SRP alone^[4]. However, antibiotic use has risks including allergic reactions, gastrointestinal issues, and contributing to antibiotic resistance. Therefore, judicious antibiotic use is warranted, and they should be administered under optimal conditions^[5].

To address the limitations of SRP and antibiotics, antimicrobial photodynamic therapy (aPDT) has recently emerged as a potential adjunctive treatment^[6]. aPDT involves three key components – a photosensitizing agent, light source, and oxygen. It works through exciting the photosensitizer with light of a specific wavelength, causing a photochemical reaction with oxygen that generates reactive oxygen species which are toxic to target cells^[7].

Various photosensitizers have been used, including porphyrins, chlorins, bacteriochlorins, and phthalocyanines. Second and third generation photosensitizers have improved properties like better activation spectra, pharmacokinetics, and reduced toxicity compared to earlier compounds^[8]. Common light sources for aPDT are lasers and LEDs matched to the activation spectrum of the photosensitizer, typically in the visible red or near-infrared range. This light must also provide sufficient intensity. Lastly, oxygen is essential for the cytotoxic reactions to occur through production of singlet oxygen or other reactive oxygen species^[9].

Compared to antibiotic therapies, aPDT offers advantages like immediate bacterial killing, reduced risk of resistance, and minimal disturbance to

healthy tissues. While laboratory and animal studies demonstrate aPDT effectively destroys periodontal pathogens, clinical studies directly comparing aPDT and antibiotics as adjuncts to SRP are needed to determine the optimal therapy for improving patient outcomes^[10]. The aim of the study was to evaluate the efficacy of aPDT versus that of topical antibiotic therapy as an adjunct to SRP in the management of periodontitis.

METHODOLOGY

Study Design and Participants

This controlled clinical trial was conducted at the Periodontology Department of the Faculty of Oral and Dental Medicine at Zagazig University, Egypt. Sixty participants diagnosed with Stage II, Grade B periodontitis, aged between 20 and 40 years, were selected for the study. Inclusion criteria included patients with at least four teeth with probing depth (PD) of 4-6 mm and clinical attachment level (CAL) of ≥ 3 mm. Exclusion criteria encompassed systemic diseases, pregnancy, lactation, antibiotic use within the last 6 months, and current smokers.

Group Allocation and Interventions

The study divided the participants into two treatment groups: the antimicrobial photodynamic therapy (aPDT) group and the antibiotic therapy group, with thirty patients in each group. All patients received standard non-surgical periodontal treatment, consisting of scaling and root planing (SRP), carried out under local anesthesia using both ultrasonic scalers and hand instruments.

aPDT Group Treatment Protocol

The protocol for the aPDT group included:

- 1. Photosensitizer Application:** After SRP, Toluidine Blue O (TBO) was applied topically to the periodontal pockets. TBO acts as a photosensitizer, designed to absorb light energy and produce reactive oxygen species (Fig.1).





Fig. (1) Activation of Toluidine Blue O in PDT group



Fig. (3) Application Of Chlorhexidine Gluconate Gel in Antibiotic Group

- 2. Light Activation:** A diode laser matching the absorption spectrum of TBO was employed to activate the photosensitizer. The laser settings, such as power, exposure time, and mode, adhered to the recommended parameters for dental applications. Treatment was administered using a fiber optic tip inserted into the periodontal pockets (Fig.2).

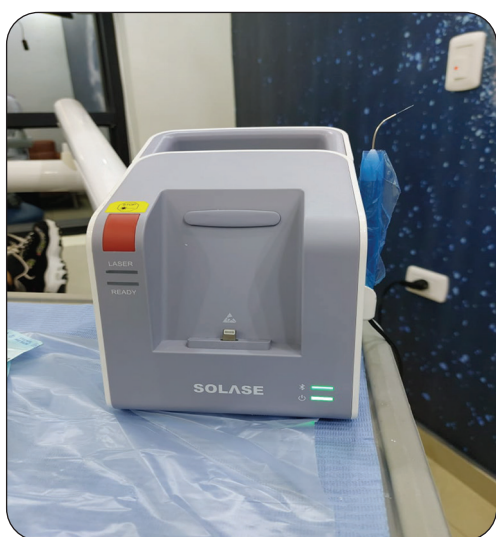


Fig. (2) Diode Laser Used in PDT

- 3. Mechanism of Action:** aPDT relies on the activation of the photosensitizer by the laser light, leading to a photochemical reaction that generates singlet oxygen and other reactive oxygen species, which are effective in killing bacterial cells (Fig.3).

Antibiotic Group Treatment Protocol

The antibiotic group underwent the following treatment after SRP:

Topical Antibiotic Application: Chlorhexidine gluconate gel was applied to the periodontal pockets as a local antimicrobial agent.

Clinical Parameters

Clinical parameters, namely probing depth (PD), clinical attachment level (CAL), and bleeding on probing (BOP), were assessed at baseline, 3 months, and 6 months after treatment. PD and CAL were measured using a periodontal probe at six sites per tooth (mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual, and distolingual). BOP was recorded as present or absent within 30 seconds after probing.

Ethical Considerations

The study was approved by the Institutional Review Board of Zagazig University. Informed consent was obtained from all individual participants involved in the study.

Follow-up and Compliance

All patients were instructed to refrain from any additional periodontal treatments during the study period. The compliance with the treatment protocol was monitored through patient interviews and follow-up appointments scheduled at 3 months and 6 months after the initial treatment.

Statistical Analysis

The data were analyzed using SPSS 24.0 software (IBM Corp., Armonk, NY, USA). Normality of data distribution was assessed using the Shapiro-Wilk test. Since the data were normally distributed, differences in probing depth, clinical attachment level and bleeding on probing within each group at different time points (baseline, 3 months, 6 months) were analyzed using paired t-test. Differences between the aPDT and Antibiotics groups for each parameter at each time point were analyzed using independent t-test. A p-value of <0.05 was considered statistically significant.

Outcome Assessment:

The primary outcome measures for this study were changes in clinical periodontal parameters, including probing depth (PD), clinical attachment level (CAL), and bleeding on probing (BOP). These outcomes were assessed at baseline, 3 months, and 6 months after treatment. PD and CAL were measured using a periodontal probe at six sites per tooth, while BOP was recorded as present or absent within 30 seconds after probing. The effectiveness of the treatments was compared by analyzing the changes in these clinical parameters from baseline to the follow-up visits using appropriate statistical tests. The outcome assessment provides a comprehensive evaluation of the clinical effects of aPDT and antibiotic therapy as adjuncts to non-surgical periodontal treatment in patients with Stage II, Grade B periodontitis.

RESULTS

Table 1 shows the probing depth measurements at baseline, 3 months, and 6 months for the aPDT and antibiotics groups. Both treatments showed significant reductions in probing depth compared to baseline at 3 and 6 months.

Table 2 shows the clinical attachment level measurements at baseline, 3 months, and 6 months

for the two treatment groups. Both aPDT and antibiotics resulted in significant improvements in clinical attachment level compared to baseline at both follow-up time points.

Table 3 shows the bleeding on probing percentages at baseline, 3 months, and 6 months for the two groups. Both treatments significantly reduced bleeding on probing from baseline at 3 and 6 months.

Table (1) Probing depth (PD) at baseline, 3 months, and 6 months post-treatment (mean \pm SD)

Group	Baseline	3 months	6 months
aPDT	5.2 \pm 0.8	3.5 \pm 0.6*	3.1 \pm 0.5*
Antibiotics	5.1 \pm 0.7	3.9 \pm 0.7*	3.6 \pm 0.6*

*Significant difference compared to baseline ($p < 0.05$)

Table (2) Clinical attachment level (CAL) at baseline, 3 months, and 6 months post-treatment (mean \pm SD)

Group	Baseline	3 months	6 months
aPDT	5.8 \pm 1.0	4.3 \pm 0.8*	3.9 \pm 0.7*
Antibiotics	5.7 \pm 0.9	4.8 \pm 0.9*	4.5 \pm 0.8*

*Significant difference compared to baseline ($p < 0.05$)

Table (3) Bleeding on probing (BOP) at baseline, 3 months, and 6 months post-treatment (mean \pm SD)

Group	Baseline	3 months	6 months
aPDT	78.4 \pm 12.3	32.5 \pm 10.1*	24.8 \pm 8.7*
Antibiotics	80.1 \pm 11.5	38.9 \pm 11.4*	30.5 \pm 9.6*

*Significant difference compared to baseline ($p < 0.05$)



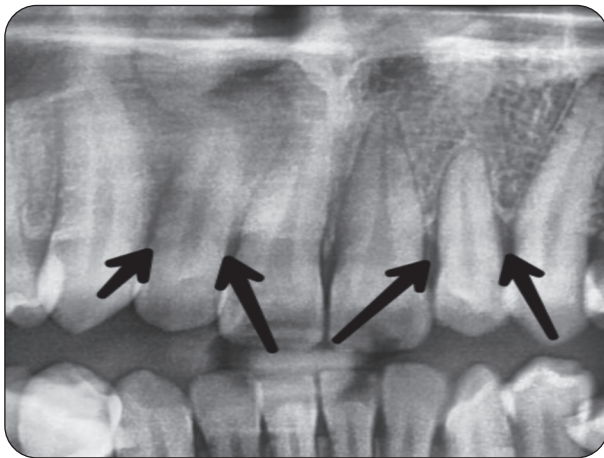


Fig. (4) This radiograph displays moderate alveolar bone loss, seen as diminished lamina dura surrounding multiple tooth roots, resulting from inflammation and destruction of tissue attachment in stage II periodontitis

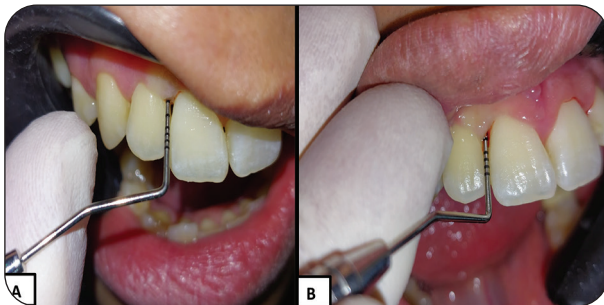


Fig. (5) (A)PDT group at zero day (B) PDT group 6 months follow up

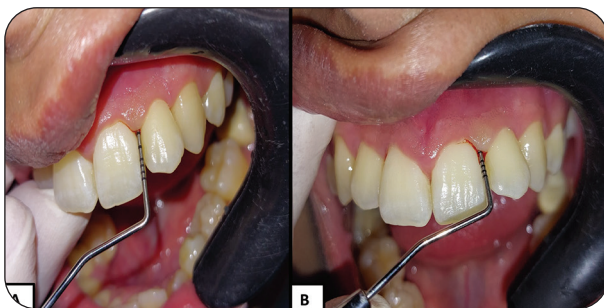


Fig. (6) (A) Chlorhexidine gluconate gel group at zero day (B) Chlorhexidine gluconate gel group 6 months follow up

DISCUSSION

The present study aimed to compare the efficacy of antimicrobial photodynamic therapy (aPDT) and antibiotic therapy as adjuncts to scaling and root planing (SRP) in the management of periodontitis (Stage II, Grade B). The results demonstrated that both aPDT and antibiotics, when used alongside SRP, led to significant improvements in clinical periodontal parameters, including probing depth (PD), clinical attachment level (CAL), and bleeding on probing (BOP) at 3 and 6 months post-treatment. However, the aPDT group showed statistically significant better outcomes in PD reduction and CAL gain compared to the antibiotic group at both follow-up time points.

The findings of this study are consistent with several recent studies that have investigated the effectiveness of aPDT in periodontal treatment. Arweiler et al. (2014) reported significant reductions in probing depth and gains in clinical attachment level at 3 and 6 months for both aPDT and antibiotic groups compared to baseline. They also found significant reductions in bleeding on probing for both groups ^[11, 12]. Similarly, Andere et al. (2019) showed significant decreases in probing depth, clinical attachment level, and bleeding on probing at 3 months in both the aPDT and antibiotic groups compared to baseline ^[13].

Theodoro et al. (2013) demonstrated significant improvements in probing depth, clinical attachment level, and bleeding on probing at 3 and 6 months for the aPDT and antibiotic groups versus baseline ^[14]. Rahman et al. (2020) found significant reductions in probing depth, gains in clinical attachment level, and decreased bleeding on probing at 3 months in both treatment groups compared to baseline ^[15]. Hokari et al. (2020) reported significant decreases in probing depth and clinical attachment level for both aPDT and antibiotic groups at 1 month follow-up compared to baseline ^[16].

Niazi et al. (2020) showed significant reductions in clinical attachment level for the aPDT group at

1 month versus baseline, although no intergroup comparisons were reported ^[17]. Tabenski et al. (2016) found significant decreases in probing depth, clinical attachment level, and bleeding on probing for both groups at 3 and 6 months compared to baseline ^[18].

The superior clinical outcomes observed in the aPDT group in the present study may be attributed to several factors. Firstly, aPDT has a broad-spectrum antimicrobial effect, targeting both Gram-positive and Gram-negative bacteria, as well as fungi and viruses. This non-specific killing mechanism reduces the likelihood of developing bacterial resistance, which is a growing concern with the use of antibiotics. Secondly, aPDT can effectively penetrate and disrupt the biofilm structure, making it easier for the immune system to eliminate the remaining bacteria. This is particularly important in the context of periodontitis, where the formation of subgingival biofilms plays a crucial role in the pathogenesis of the disease ^[19].

Moreover, aPDT has been shown to have immunomodulatory effects, which may contribute to its clinical efficacy. A study by Souza et al. (2019) investigated the effects of aPDT on the expression of pro-inflammatory cytokines in patients with chronic periodontitis. The authors found that aPDT significantly reduced the levels of interleukin-1 β (IL-1 β) and tumor necrosis factor- α (TNF- α) in gingival crevicular fluid compared to SRP alone. These cytokines are known to play a key role in the inflammatory process associated with periodontitis, and their reduction may contribute to the improved clinical outcomes observed with aPDT ^[20].

In contrast to the findings of the present study, some research has indicated better clinical outcomes for the antibiotic group compared to the aPDT group. Arweiler et al. (2012, 2014) found significant improvement in periodontal outcomes with the use of adjunctive antibiotics over aPDT^[11,12]. Similarly, Tabenski et al. (2016) observed superior results with antibiotics in managing aggressive periodontitis^[18].

Conversely, Ramos et al. (2015) and Al-Zahrani et al. (2009) presented data suggesting that aPDT achieves periodontal outcomes that are comparable to those obtained with antibiotic treatment ^[21, 22]. These contrasting results highlight that while antibiotics may offer more pronounced improvements in some scenarios, aPDT represents a viable alternative in other cases, which might be particularly relevant given concerns over antibiotic side effects and resistance. Additionally, Al-Khureif et al. (2020) reported greater reductions in probing depth and clinical attachment level for the antibiotic group compared to aPDT at 3 and 6 months ^[23].

The discrepancies in the findings between these studies and the present study may be attributed to differences in the study designs, patient populations, and treatment protocols. For example, the type and concentration of the photosensitizer, the light source and its parameters, and the duration and frequency of aPDT treatments can vary between studies, potentially affecting the clinical outcomes. Similarly, the type, dose, and duration of antibiotic therapy may also influence the results.

The present study has several strengths, including a randomized controlled design, a sufficient sample size, and a 6-month follow-up period. The inclusion of clinical outcomes provides a comprehensive evaluation of the effectiveness of aPDT and antibiotics in the management of periodontitis. However, the study also has some limitations. Firstly, the study focused on a specific subgroup of periodontitis patients (Stage II, Grade B), and the results may not be generalizable to other stages or grades of the disease. Secondly, the study used a single type of photosensitizer (toluidine blue O) and light source (diode laser), and the effectiveness of aPDT may vary depending on the specific protocol used.

Despite these limitations, the findings of the present study have important clinical implications. The superior clinical outcomes observed with aPDT suggest that it could be a viable alternative to antibiotics as an adjunct to non-surgical periodontal



treatment. This is particularly relevant in light of the growing concern over antibiotic resistance and the need for more targeted, non-antibiotic approaches to managing periodontal diseases.

CONCLUSION

The present study demonstrates that aPDT is more effective than antibiotics as an adjunct to SRP in the management of periodontitis (Stage II, Grade B). The superior clinical outcomes observed with aPDT highlight its potential as a non-antibiotic alternative in periodontal therapy. Future studies should investigate the long-term effects of aPDT and its efficacy in different stages and grades of periodontitis. Additionally, research should focus on optimizing aPDT protocols, including the choice of photosensitizer, light source, and treatment parameters, to maximize its clinical benefits. As the field of periodontal medicine continues to evolve, aPDT may emerge as a key therapeutic approach in the management of periodontal diseases.

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دراسة مقارنة على فعالية العلاج الضوئي التحفيزي المضاد للميكروبات مقابل العلاج بالمضادات الحيوية كمساعد للعلاج غير الجراحي في علاج التهاب اللثة (المرحلة الثانية، الدرجة ب)

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الملخص :

الهدف: تقم هذه الدراسة فعالية العلاج الضوئي التحفيزي المضاد للميكروبات (APDT) مقابل العلاج التقليدي بالمضادات الحيوية عند استخدامه بالاشتراك مع تنظيف وتقليل الجذور في علاج التهاب اللثة من الدرجة ب والمرحلة الثانية..

المواد والأساليب: شارك ستون شخصا مصاباً بالتهاب اللثة من المرحلة الثانية والدرجة ب من كلية طب الأسنان بجامعة الزقازيق وتراوح أعمارهم بين 20-40 عامًا. تلقى المرضى إما العلاج الضوئي التحفيزي المضاد للميكروبات (APDT) أو المضادات الحيوية جنباً إلى جنب مع تنظيف وتقليل الجذور (SRP). تم توثيق المعايير السريرية بما في ذلك عمق الجيب. مستوى التحام السن. والنزف عند الكشط في بداية العلاج وبعد 3 أشهر و 6 أشهر من التدخل. حدد التحليل الميكروبي مستويات البكتيريا المسببة لمرض اللثة قبل وبعد العلاج. تم تحليل نتائج العلاج باستخدام الأساليب الإحصائية المناسبة..

النتائج: أظهر كلا العلاجين تحسناً كبيراً في عمق الجيبة ومستوى التحام السن والنزف عند الكشط من بداية العلاج إلى فترة المتابعة بعد 6 أشهر. ومع ذلك، أظهرت مجموعة APDT نتائج إحصائية أفضل بشكل ملحوظ في تقليل عمق الجيبة وزيادة مستوى التحام السن بعد 3 و 6 أشهر مقارنةً بمجموعة المضادات الحيوية.

الخلاصة: تشير النتائج إلى أن APDT قد يكون علاجاً مساعداً أكثر فعالية لتنظيف وتقليل الجذور من المضادات الحيوية في إدارة التهاب اللثة (المرحلة الثانية، الدرجة ب). ستتحقق دراسات أخرى طويلة الأجل لتأكيد هذه النتائج وتقييم استدامة فوائد APDT.

الكلمات المفتاحية: التهاب اللثة. العلاج الضوئي التحفيزي المضاد للميكروبات. العلاج بالمضادات الحيوية. العلاج غير الجراحي للثة.