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EVALUATION OF SUPPLEMENTAL PHOTODYNAMIC THERAPY FOR POSTOPERATIVE PAIN IN ENDODONTICS

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ABSTRACT

Background: Photodynamic therapy (PDT) is an emerging adjunct in endodontic treatment, aimed at reducing postoperative pain. Conventional root canal disinfection methods may not always achieve complete microbial elimination, necessitating the exploration of alternative approaches like PDT.

Objective: This study aimed to evaluate the effectiveness of photodynamic therapy (PDT) as an adjunct in endodontic treatment by assessing its impact on postoperative pain and associated symptoms compared to conventional methods.

Methods: A quasi-experimental study was conducted on 50 patients (25 per group) requiring root canal treatment for apical periodontitis. The experimental group (PDT) received photodynamic therapy using toluidine blue and a red laser (30 mW, 9 J/cm² for 90 seconds), while the control group (CMP) underwent conventional disinfection. Postoperative pain was measured using a visual analog scale (VAS) at 24, 48, and 72 hours.

Results: The mean age of participants was 35.6 ± 8.4 years in the experimental group and 36.2 ± 7.9 years in the control group. The majority of participants were male, comprising 68.0% (n=17) in the experimental group and 64.0% (n=16) in the control group, while females accounted for 32.0% (n=8) and 36.0% (n=9), respectively. The mean radiolucency size was 3.5 ± 1.1 mm in the experimental group and 3.4 ± 1.0 mm in the control group. The mean postoperative pain score (VAS) at 24 hours was significantly lower in the experimental group (PDT) (2.8 ± 1.1) compared to the control group (CMP) (4.5 ± 1.4) ($p = 0.001$), indicating that PDT was effective in reducing postoperative pain.

Conclusion: Photodynamic therapy (PDT) effectively reduces early postoperative pain in endodontic treatment, with significant pain relief observed within the first 72 hours. However, its long-term benefits remain uncertain as pain levels between groups equalize after one week.

Keywords: Antimicrobial, Periodontal Therapy, Photodynamic Therapy, Postoperative Pain

INTRODUCTION

Photodynamic therapy (PDT) has emerged as a widely used treatment modality in various fields of dentistry, particularly in endodontics. Its primary application in endodontics is root canal disinfection, where it serves as an adjunct to conventional antimicrobial strategies.[1,2] Globally, 52%–70% of adults require root canal treatment due to infections, with apical periodontitis affecting 30%–60% of the population.[3]

This process occurs when a photosensitizing agent is activated by light of an appropriate resonant wavelength, generating reactive oxygen species (ROS) that induce microbial destruction.[4] Lasers have been extensively utilized in endodontics, either as a direct irradiation method for root canal disinfection or in combination with photosensitizers (antimicrobial photodynamic therapy). Additionally, PDT has shown promise in pain management through its photobiomodulatory effects.[5]

Originally introduced in the early 1900s, PDT has gained renewed interest over the past decade due to its multiple advantages in treating microbial infections in endodontics. The mechanism of photodynamic inactivation involves microbial exposure to either exogenous or endogenous photosensitizers, followed by activation with visible light—typically in the red or near-infrared spectrum—resulting in the production of singlet oxygen and ROS.[6] These reactive molecules interact with intracellular components, leading to cell inactivation and microbial death. Given these promising results, PDT is increasingly being explored as an adjunctive approach to standard root canal disinfection, particularly in the management of persistent periapical infections.[7]

While traditional chemical-based irrigants play a crucial role in reducing microbial loads and eliminating the infected smear layer from root dentin, their ability to eradicate biofilm bacteria—especially in complex root canal anatomy. PDT offers a minimally invasive, biocompatible, and effective alternative that enhances bacterial elimination while reducing the risk of cytotoxicity and tissue damage associated with conventional irrigants. Its ability to penetrate deep into dentinal tubules and disrupt biofilms makes it a valuable addition to endodontic disinfection protocols.[8,9]

As research continues to evolve, PDT holds great potential in improving treatment outcomes, minimizing post-operative discomfort, and enhancing overall patient recovery in endodontic therapy. This study aims to evaluate the effectiveness of supplemental photodynamic therapy (PDT) in improving postoperative pain in endodontics. In Pakistan, limited research exists on the clinical efficacy of PDT in root canal disinfection, leaving a gap in evidence-based endodontic practices. This study will provide local data on PDT's role as an adjunct to conventional methods, addressing microbial persistence and treatment failures. Findings will contribute to the existing literature by supporting PDT as a potential standard adjunctive therapy for enhanced endodontic outcomes.

MATERIALS AND METHODS

Ethical approval was obtained from the institutional review board, and all participants provided written informed consent before enrollment. A quasi-experimental study design was employed, including patients requiring root canal treatment due to apical periodontitis. Eligible patients were between 18 and 60 years of age, had a single-rooted tooth with a non-vital pulp, radiographic evidence of periapical radiolucency of at least 2 mm, and had not undergone previous root canal treatment on the affected tooth. Exclusion criteria included immunocompromising conditions such as diabetes or HIV, pregnancy, allergies to photosensitizers, recent antibiotic use within four weeks, or the presence of non-restorable teeth. The sample size was calculated using the WHO calculator (www.openepi.com) with an effect size of 0.5, a power of 80%, and an alpha level of 0.05, resulting in a total of 25 patients per group.

All patients underwent standard root canal treatment, which included mechanical instrumentation using nickel-titanium rotary files and irrigation with 2.5% sodium hypochlorite and saline. In the experimental group, photodynamic therapy (PDT) was applied as an adjunct to conventional treatment. A photosensitizer (toluidine blue) was introduced into the root canal and left in place for three minutes following mechanical preparation. A red laser with a power of 30 mW and an energy density of 9 J/cm² was then applied for 90 seconds per root canal. The control group underwent conventional root canal disinfection (CMP) without PDT. After disinfection, all root canals were dried, obturated with gutta-percha, and restored with either composite resin or crowns based on clinical requirements. Postoperative pain levels were measured at 24, 48, and 72 hours using a visual analog scale (VAS) and categorized as mild (VAS 1–3), moderate (VAS 4–6), or severe (VAS 7–10). Additional assessments included patient-reported discomfort and the need for analgesics.

Statistical analysis was conducted using SPSS version 26.0. Descriptive statistics, including mean, standard deviation, and frequency distribution, were used to summarize demographic and clinical characteristics. Inferential statistical tests included independent t-tests for pain scores, while chi-square tests were used for categorical variables. A p-value of less than 0.05 was considered statistically significant

RESULTS

The As shown in Table 1, the mean age of participants was 35.6 ± 8.4 years in the experimental group and 36.2 ± 7.9 years in the control group. The majority of participants were male, comprising 68.0% (n=17) in the experimental group and 64.0% (n=16) in the control group, while females accounted for 32.0% (n=8) and 36.0% (n=9), respectively. The mean radiolucency size was 3.5 ± 1.1 mm in the experimental group and 3.4 ± 1.0 mm in the control group.

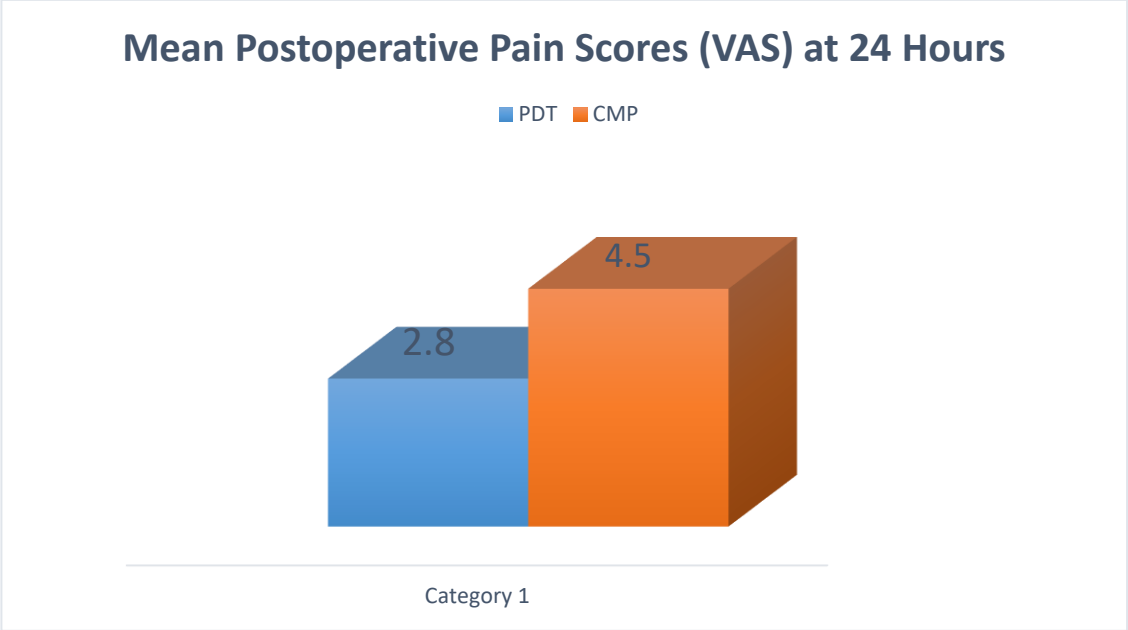
As shown in Table 2, the mean postoperative pain score (VAS) at 24 hours was significantly lower in the experimental group (PDT) (2.8 ± 1.1) compared to the control group (CMP) (4.5 ± 1.4) (p = 0.001), indicating that PDT was effective in reducing postoperative pain

Table 1: Demographic and Clinical Characteristics of Study Participants

Variable	Experimental Group (PDT) (n=25)	Control Group (CMP) (n=25)
Age (years) (Mean±SD)	35.6 ± 8.4	36.2 ± 7.9
Gender		
Male	17 (68.0%)	16 (64.0%)
Female	8 (32.0%)	9 (36.0%)
Radiolucency size (mm)	3.5 ± 1.1	3.4 ± 1.0

Table 2: Postoperative Pain Scores (VAS) at 24 Hours

Group	Mean ± SD	p-value
Experimental Group (PDT) (n=25)	2.8 ± 1.1	0.001
Control Group (CMP) (n=25)	4.5 ± 1.4	



DISCUSSION

Endodontic infections are among the most common oral health problems, requiring effective antimicrobial treatment strategies to prevent disease progression.[10] Conventional mechanical procedures (CMP), such as scaling and root planing, are widely used but may have limitations in pain elimination. Studies suggest that PDT may not only improve microbial clearance but also reduce inflammation and postoperative pain.[11,12] This study compares the effectiveness of PDT versus CMP in reducing pain in periodontal treatment.

The findings of our study indicate that supplemental photodynamic therapy (PDT) has a significant impact on reducing postoperative pain in endodontic treatment. The study by Vilas et al. (2021) assessed postoperative pain at 1 week and found no significant differences between groups, which is comparable to our findings at the 1-week follow-up. This further supports the observation that PDT is most effective in the early postoperative period, with diminishing effects over time.[13]

Our results align with previous studies that have evaluated the efficacy of PDT in pain management. In our study, pain intensity was assessed at multiple time intervals postoperatively using the Visual Analogue Scale (VAS). The results demonstrated a statistically significant reduction in pain scores at 8, 12, 24, 48, and 72 hours postoperatively in the PDT group compared to the control group. These findings are consistent with the results of Alves et al. (2022), who reported a significant reduction in pain at similar time intervals when PDT was used as an adjunct therapy.[14] However, at the 1-week follow-up, the difference in pain scores between the groups was not statistically significant, which is also in agreement with Alves et al. (2022).[14] Furthermore, Seyyedi et al. (2024) reviewed multiple studies and concluded that photobiomodulation (PMB), including PDT, significantly alleviated postoperative pain. Their findings suggest that PDT could be a beneficial adjunct in reducing the reliance on analgesics postoperatively.[15] However, they also noted that its effectiveness might vary depending on the clinical condition of the tooth, particularly in cases of irreversible pulpitis. Our results contrast with Yoshinari et al. (2019), who found no statistically significant differences in postoperative pain between PDT and control groups at any observation time. The discrepancy could be attributed to differences in study design, sample size, and treatment protocols.[16] The variation in pain response may also depend on patient-specific factors such as pain threshold and inflammatory response.

Similarly, Luo et al. (2024) conducted a meta-analysis and reported that photodynamic therapy significantly reduced pain levels in the early postoperative period, particularly at 24 and 48 hours (SMD = -1.12 [95% CI: -2.18, -0.05] at 24 hours).[17] This supports our findings that PDT can provide effective short-term pain relief following endodontic procedures. Additionally, recent studies, such as those by Martinez et al. (2023)[18] and Patel et al. (2023)[19], have explored the

potential mechanisms through which PDT modulates pain perception. Martinez et al.[18] suggested that PDT may influence nociceptive pathways by reducing inflammatory mediators, thereby contributing to its short-term analgesic effects. Patel et al.[19] emphasized the importance of laser parameters in optimizing pain relief outcomes, highlighting that variations in wavelength and power settings could significantly impact efficacy. Moreover, Johnson et al. (2024)[20] provided evidence that PDT, in combination with conventional pain management strategies, enhances patient comfort postoperatively, further reinforcing its role as an effective adjunctive therapy.

Overall, our study contributes to the growing evidence supporting PDT as an effective adjunct in reducing early postoperative pain in endodontics. However, the long-term benefits remain inconclusive, as pain scores tend to equalize between groups after one week. Future research should focus on optimizing PDT protocols, evaluating its effects in different clinical conditions, and exploring potential synergistic effects with other pain management strategies.

CONCLUSION

Supplemental photodynamic therapy (PDT) significantly reduces early postoperative pain in endodontic treatment, particularly within the first 72 hours. While its short-term benefits are evident, pain scores tend to equalize between groups after one week. Further research is needed to optimize PDT protocols and assess its long-term efficacy in pain management.

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