Clinical Practice Article

Evaluation of Photodynamic Therapy in Teeth with Fistula and Apical Periodontitis: Case Series Report

ABSTRACT

Aim: This case series aimed to demonstrate the adjunctive effect of antimicrobial photodynamic therapy (aPDT) in the treatment of teeth with fistula and apical periodontitis.
Presentation: The six participants underwent conventional endodontic treatment combined with aPDT using diode laser equipment with a wavelength of 660 nm, power of 100 mW, irradiated for 2 minutes at each point, and a pre-irradiation time of 1 minute with the photosensitizer. All cases were performed at the University Health Clinic of the Catholic University of Uruguay. Infection resolution was achieved 15 days after the treatment was completed in all cases.
Discussion: conventional endodontic treatment for these infectious conditions typically requires multiple sessions, increasing the overall cost. Additionally, patients with these infections often self-medicate with antibiotics, which raises the risk of bacterial resistance development.
Conclusion: aPDT can be indicated as an adjunctive treatment to conventional endodontic therapy, reducing both costs and the risks associated with the development of bacterial resistance.

Keywords: methylene blue, sodium dodecyl sulfate, antimicrobial phototherapy

1. INTRODUCTION

The evidence demonstrates the polymicrobial etiology of endodontic infections, where bacteria and their products are the primary agents responsible for the development, progression, and spread of apical periodontitis. The microbial factors within the root canals extend to the apical tissue, leading to chronic inflammatory responses. Consequently, apical periodontitis results from the complex interaction between microbial factors and the host's immune response [1,2].

When an endodontic infection becomes chronic, it may drain to the gingival surface through intraoral communication referred to as a sinus tract or fistula. The fistula may be located either near or distant from the origin of the infection. Therefore, the trajectory of the sinus tract serves as a guide to identifying the focus of the infection. [1–3]. Fistulography identifies this pathway and involves the insertion of a flexible, radiopaque gutta-percha cone into the sinus tract entrance until resistance is encountered. At this point, a radiograph is taken, and the trajectory of the cone visible in the image enables identifying the origin of the infection.

The most recommended treatment for eliminating a fistula is endodontic therapy in conjunction with antibiotic therapy. This treatment includes debriding the affected area to remove necrotic tissue. [3].

In recent years, antimicrobial photodynamic therapy (aPDT) has been used as a minimally invasive treatment, adjunctive to conventional therapy for periodontitis. Unlike antibiotics, it exhibits low toxicity and there have been no reports of bacterial resistance. [4–6].

The mechanism of action can be described by the Jablonski diagram, where the photosensitizer (PS) absorbs visible light at an appropriate wavelength, transitioning from the ground state to the first excited singlet state, which has a short lifetime. In this state, the PS can lose energy through fluorescence or convert to the triplet state via intersystem crossing. From the triplet state, which has a longer lifetime compared to the singlet state, the PS can lose energy through phosphorescence or participate in the generation of reactive oxygen species (ROS) through two distinct mechanisms: Type I reaction, which occurs via electron transfer, forming free radicals, or Type II reaction, which involves energy transfer to molecular oxygen, generating singlet oxygen. The occurrence of Type I and Type II reactions depends on various factors, such as the physicochemical properties of the PS and the microenvironment in which it is located. The microenvironment affects PS aggregation state and the amount of oxygen [7,8].

The class of photosensitizers (PS) frequently employed in Dentistry are phenothiazines, represented by methylene blue (MB) and toluidine blue (TB). These are heterocyclic compounds consisting of two benzene rings fused to a nitrogen and a sulfur atom. They exhibit absorption of visible light in the range of 600-660 nm [2,4,7,9].

It has been found that the use of sodium dodecyl sulfate (SDS) can control the aggregation of methylene blue (MB), resulting in an increased formation of monomers through enhanced electrostatic and hydrophobic interactions between its molecules. [7,10,11].

The wavelength, light intensity, exposure time, and the absorption capacity of the photosensitizer determine the outcomes. [12]. Therefore, the efficacy of aPDT depends on the optimization of these parameters [13,14].

The aim of this case series was to evaluate the reduction of fistulas after conventional endodontic treatment combined with aPDT using a diode laser device and MB in SDS [15,16].

2. METHODOLOGY

2.1 Ethics and disclosure

This study was conducted in accordance with Decree 158/19 of the Executive Branch, which regulates research involving human subjects in Uruguay. The study was also governed by the Personal Data Protection Law and the Habeas Data Action - Law 18.331.

This case series was initiated only after the submission and approval of the project by the Research ethics Committee of the Catholic University of Uruguay (UCU) (211103b).

The participants were recruited at the University Health Clinic of UCU, where all clinical procedures were performed. Participants were required to read, understand, and sign the Informed Consent Form.

2.2 PREPARATION OF PHOTOSENSITIZER

MB was prepared under aseptic conditions in amber glass bottles, starting with a 1% MB solution to form a 0.005% aqueous solution in 0.25% of SDS.

2.3 IRRADIATION SOURCE

A diode laser equipment (THERAPY EC, DMC, São Carlos, Brazil) with a wavelength of 660 nm and a power of 100 mW was used, with a 1-minute exposure time of the PS at the site before light irradiation (pre-irradiation time), following the parameters listed in the table below (Table 1).

Table 1. Laser parameters

Parameters	Value
Wavelength	660 nm
Operating mode	Continuo
Power	100 mW
Aperture diameter	0.38 cm^2
Power density at aperture	260 mW/cm^2
Radiant exposure	31.6 J/cm^2
Irradiated site	Root canal orifice and fistula

Number of irradiated site	02
Number of sessions	01
Radiant energy	12 J per site
Pre-irradiation time	60 s

2.4 TREATMENT PROTOCOL

Initial periapical radiographs were taken for all participants, with the placement of the gutta-percha cone for fistulography, as well as at 15 and 30 days after the intervention completion, always using the X-ray film holder to maintain consistency across all images (Fig. 1).

Initial and post-intervention photographs were taken to document the clinical presence of the fistula (Fig.2). All participants were treated by an experienced endodontist, who was responsible for performing the procedures and collecting the data. Working length was determined radiographically, and canal preparation was performed using an endodontic rotary motor (Dentsply).

Root canal irrigation was performed using 5% sodium hypochlorite and 2% chlorhexidine. The medication between appointments was administered with calcium hydroxide.

The application of aPDT was performed at two points: at the entrance of the root canal and on the gingival mucosa where the fistula was observed. The PS was applied to the site per 1min (pre-irradiation time), followed by light irradiation for 2 min.

3. ELIGIBILITY CRITERIA

3.1 INCLUSION CRITERIA

Having at least one single-rooted tooth with apical periodontitis and the presence of a fistula;
No presence of periodontal pockets greater than 4 mm;
Over 18 years of age

3.2. EXCLUSION CRITERIA

Use of antibiotics in the last three months;
Comorbidities such as cancer, diabetes, coagulation disorders, anemia;
Participants undergoing orthodontic treatment;
Pregnant women or breastfeeding individuals;
Participants with teeth that cannot undergo absolute isolation.

4. RESULTS

Among the participants, 2 were female and 4 were male, with an average age of approximately 36 years. All teeth exhibited negative horizontal percussion and positive vertical percussion. None had temporary or complex restorations, and only one participant presented with grade I dental mobility (Table 2).

Table 2. Treated participants

Age	Gender	Teeth	Vertical percussion	Horizontal percussion	Mobility
62	F	32	Positive	Negative	Negative
32	M	22	Positive	Negative	Negative
28	F	31	Positive	Negative	I
34	M	42	Positive	Negative	Negative
26	M	21	Positive	Negative	Negative
36	M	11	Positive	Negative	Negative

In all treated participants, fistula closure was observed 15 days after the treatment. Below, we present images of two participants where fistulography and fistula closure are observed.

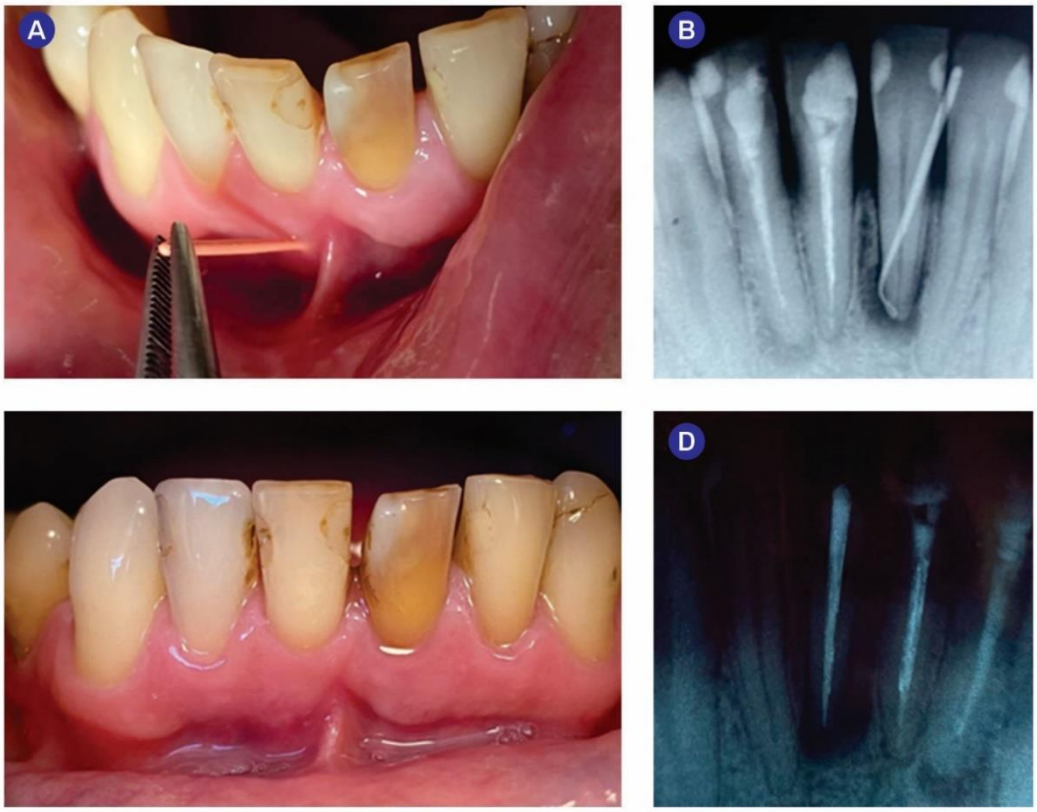

Fig. 1 A – Gutta-percha cone at the entrance of the fistula; B – Radiographic image with the gutta-percha cone indicating the fistula pathway – fistulography; C – Image of the case without the fistula 15 days after treatment completion; D – Radiographic image of the completed case

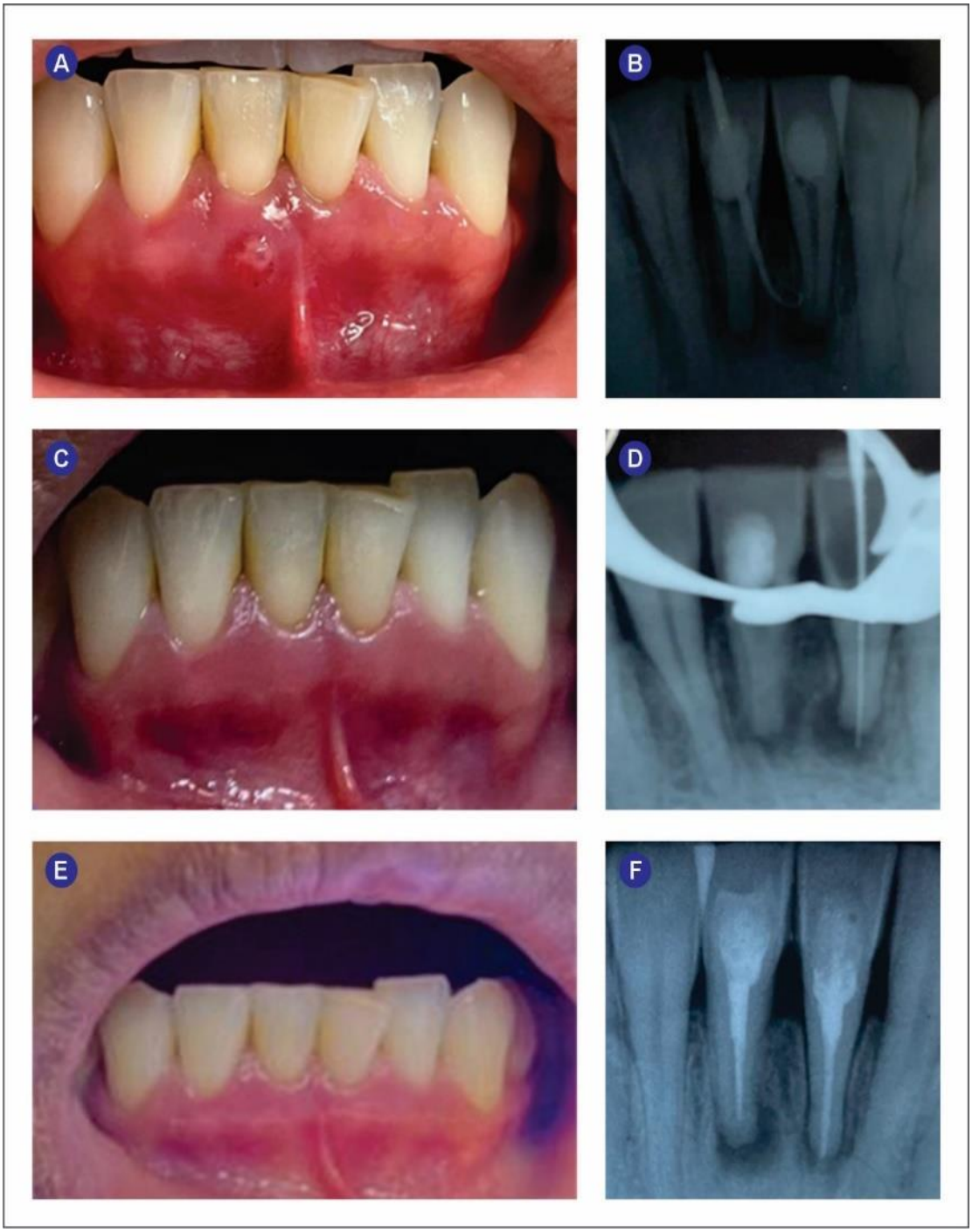

Fig. 2. A – Initial photo showing the fistula; B – Initial radiographic image with the gutta-percha cone in the fistulography; C – Photo of the case 15 days after completing treatment; D – Radiographic image from the odontometry phase; E – Case after 30 days; F – Radiographic image 30 days after treatment completion

5. DISCUSSION

The aim of this case series was to evaluate the reduction of fistulas after conventional endodontic treatment combined with aPDT using a diode laser device and MB in SDS. This case series arises from the concern of treating teeth with fistulas, as these cases often require multiple clinical sessions, making the procedure expensive.
The results of various clinical studies indicated that aPDT used as an adjunct to conventional endodontic therapy achieved a significant additional reduction in the intracanal microbial load [1,8,17] and this study supports this trend.
Antibiotic resistance has become a growing global problem, with excessive prescription and self-medication being key contributing factors. The antimicrobial effects of aPDT may serve as an alternative to local intracanal antibiotic therapy, helping to prevent the rise in resistance, as no bacterial resistance to this adjunctive therapy has been reported to date. [5].
During the execution of this study, difficulties were encountered in conducting follow-up sessions, as participants tended to miss appointments after the resolution of the case. Additionally, individuals with fistulas often turned to self-medication with antibiotics, limiting their participation in the research.

6. CONCLUSION

aPDT, unlike antibiotics, has low toxicity and there are no reports of bacterial resistance. Therefore, it can be recommended as an adjunctive treatment for apical periodontitis with fistula.

CONSENT

All authors declare that written informed consent was obtained from the patient for publication of this case series report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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