The importance of photodynamic therapy for decontamination of the root canal system: case reports

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ABSTRACT

Introduction: Endodontic treatment allows for decontamination of the root canal system by means of chemomechanical preparation, intracanal dressing and filling. However, the literature shows that microorganisms may have developed ways of resisting the procedures of traditional method. Photodynamic therapy (PDT) has been incorporated in conventional endodontic treatment as an additional therapeutic measure for microbial control, besides being of easy and rapid application in single or multiple sessions. **Objective:** To clarify the use of PDT as well as its advantages by describing two case reports. **Methods:** Two cases were reported in which clinical examination, pulp sensitivity testing and radiographic examination pointed to diagnosis of pulp and periapical necrosis, suggesting chronic periapical abscess, including presence of extraoral fistula, and periapical granuloma, respectively. After diagnosis had been achieved, conventional endodontic therapy was recommended in association with PDT. **Results:** Radiographs taken after one year demonstrated areas of repair. **Conclusion:** The proposed and described treatment planning was shown to be effective, as it was possible to observe fistula healing, radiographic regression of periapical lesions and bone structure repair.

Keywords: Endodontics. Photochemotherapy. Root canal preparation.

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Introduction

Endodontic treatment is primarily aimed at eliminating inflammation from pulp and periapical tissues by means of chemomechanical preparation, intracanal dressing and filling of the root canal system.[1] However, factors such as anatomical variations in root canal systems, mainly in the apical region, and microbial resistance lead to the possibility of secondary or persistent infections, which can compromise endodontic prognosis even when treatment is performed with maximum rigour.[2]

The main causes of failure in endodontic treatment are recurrent infections, which are characterized by persistence or emergence of periapical lesions following root canal filling.[1] This fact occurs when basic endodontic treatment principles, such as root canal preparation, root filling and crown restoration, are inadequately performed. Uncontrolled contamination by microorganisms and resulting by-products lead to immunological response within the host, thus negatively influencing prognosis.[3]

Antimicrobial chemical agents used during endodontic treatment, such as sodium hypochlorite, chlorhexidine digluconate, and 17% EDTA (ethylenediamine-tetra-acetyl), play a key role in allowing instruments and intracanal dressing (e.g. calcium hydroxide) to reach inaccessible areas. This contributes to reducing the amount of microorganisms.[4,5] However, this requires attention because abusive use of systemic antimicrobial agents can enhance resistance of certain bacteria strains. Therefore, prophylactic measures can be taken for patients with immunological condition or for those who are susceptible to bacterial endocarditis.[4,5]

Although conventional chemomechanical preparation can significantly reduce the amount of microorganisms, complete antisepsis of the entire root canal system is impossible to achieve, although desirable. In fact, literature shows that a variety of bacterial species have developed means to resist the procedures of chemomechanical preparation, thus remaining inside root canal and/or its ramifications, isthmuses and so on, even after the filling procedure. In view of the above, it is necessary to resort to new techniques to ensure success of the proposed endodontic therapy.[6,7]

Positive outcomes have led to the recommendation of PDT to assist conventional endodontic treatment in an attempt to eliminate microorganisms resistant to chemomechanical preparation.[8,9] PDT can also be recommended for endodontic treatment involving one or multiple appointments, as it is easily and rapidly applied,[10] in addition to resulting in no microbial resistance.

PDT is the reaction of specific dye acting as photosensitizer (PS) activated by light (i.e. laser or LED) at a given wavelength in the presence of oxygen. Energy transfer from the activated PS to the available oxygen results in a cytotoxic effect, usually through oxidative reactions.[11,12] Chemical species, such as singlet oxygen, are highly reactive and damage proteins, lipids, nucleic acids and other microbial cell components, thereby causing cell death, mainly by apoptosis.[13]

The photodynamic mechanism can occur via two pathways: type I and type II. Type-I reaction involves electrons in which there is a direct reaction between PS and the organic substrate by means of hydrogen abstraction or electron transference, thus generating free radicals. These free radicals are highly reactive and interact with the available oxygen to produce oxygen reactive species (e.g. superoxide, hydroxyl radicals and hydrogen peroxide) which, in turn, are harmful to cell membrane integrity, by causing irreparable damage. On the other hand, the type-2 reaction is a direct reaction between triplet-state PS and oxygen, thus producing singlet oxygen, a highly reactive state which causes oxidative damage to cell membrane as a result of reaction with organic substrates.[14,15] Because the singlet state has a shorter life-time, it is used in specific applications and, therefore, is more accepted as means to damage microbial cells.[16]

In view of the above, the present study aimed to report and explain the use of PDT in two case reports, as well as to discuss both the technique used and its clinical advantages for decontamination of root canal systems, as an additional endodontic procedure.

Case reports

Clinical case 1

A male patient whose major complaint was a "pimple on his chin", was referred to the dental office by his dermatologist who found no dermatological problem and thus suspected of a possible dental involvement. Clinical examination showed the presence of extraoral fistula in the chin region (Fig 1). Intraoral examination showed extensive resin restoration in tooth #42, absence of periodontal pocket and tooth mobility. Thermal pulp sensitivity testing was performed and negative responses were obtained for the tooth. Radiographic examination showed extensive periapical lesion in the region of tooth #42 (Fig 2). It was then established a pulp diagnosis of necrosis, and periapical diagnosis of chronic periradicular abscess. Therefore, conventional endodontic treatment was performed in association with photodynamic therapy.

In the first session, endodontic access was performed with the aid of a high-speed drill (KG 1012 HL, Medical Burs, Cotia, Brazil), in addition to electronic odontometry with foraminal locator (RomiApex A-15, Romidan, Kiryat Ono, Israel) and rotary file system (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland) with crown-apex technique. Pre-enlargement was carried out with SX file; S1, S2, F1 and F2 files were used at working length, and foramen patency was maintained with #10 C-Pilot file (VWD, Munich, Germany). Additionally, 5.25% sodium hypochlorite (Equilibrium, Vitória da Conquista, Brazil) was used as irrigating solution throughout the chemomechanical preparation. After instrumentation, 17% trisodium EDTA (Biodinâmica, Ibiporã, Brazil) was used for three minutes before another irrigation procedure with sodium hypochlorite. Drying of the root canal was achieved with F2 absorbent paper points (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland). Subsequently, 0.005% methylene blue dye (Blumet 5 DMC, São Carlos, Brazil) was added to the root canal for pre-irradiation time of five minutes before laser application (Whithening Laser II DMC, São Carlos, Brazil) at red wavelength of 660 nm, energy density of 320J/cm^2 and potency of 100 mw by optical fibre in helicoidal movements within the root canal for 90 seconds (Fig 3). After PDT, the root canal was re-irrigated with 5.25% sodium hypochlorite solution (Equilibrium, Vitória da Conquista, Brazil) and dried with F2 absorbent paper points (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland). Afterwards, Calen PMCC (SS White, Rio de Janeiro, Brazil) was used as intracanal dressing for 30 days (Fig 4) while Coltosol (Vigodent, Bonsucesso, Brazil) and glass-ionomer cement (Maxxion R, FGM, Rio Claro, Brazil) were used for double sealing.

Fifteen days after the beginning of endodontic treatment, a follow-up appointment was scheduled and the patient reported to be asymptomatic. Slight tissue contraction was observed in the region, exclusively due to fistula healing (Fig 5).

In the second session, intracanal dressing was removed with 5.25% sodium hypochlorite solution (Equilibrium, Vitória da Conquista, Brazil) and foramen patency was checked with the aid of a #10 C-Pilot file (VWD, Munich, Germany). Trisodium EDTA at 17% (Biodinâmica, Ibiporã, Brazil) was applied before another application of PDT. Root canal system was filled with F2 gutta-percha cone (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland) combined with pulp canal sealer (EWT, Sybronendo, Orange, USA) before definitive restoration with light-curing composite resin (IPS Empress Direct , Ivoclar, Liechtenstein, Switzerland).

One year after endodontic treatment, follow-up radiograph showed an area of bone repair (Fig 6). Follow-up appointments were scheduled every six months for clinical and radiographic control.

Figure 1. Extraoral fistula.

Figure 2. Study radiograph.

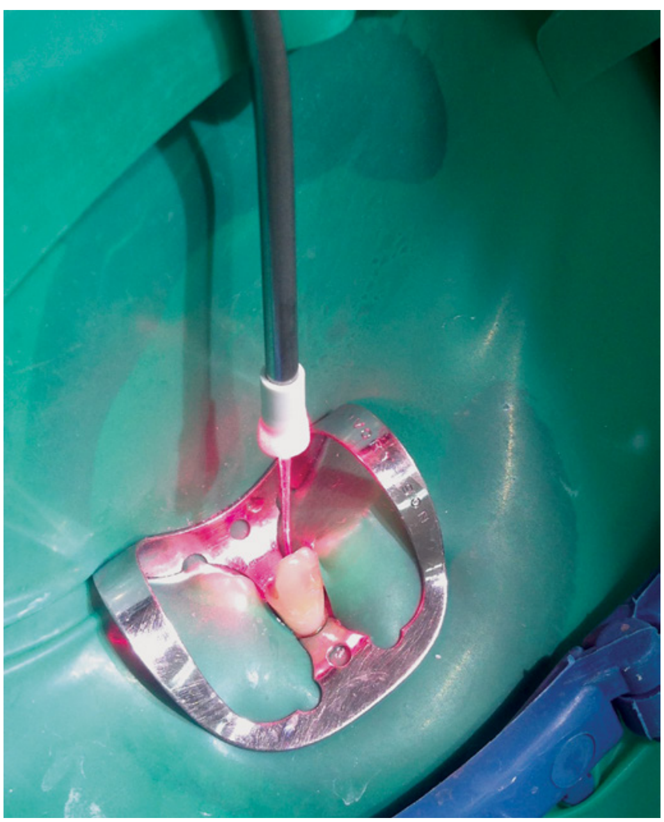

Figure 3. First PDT session.

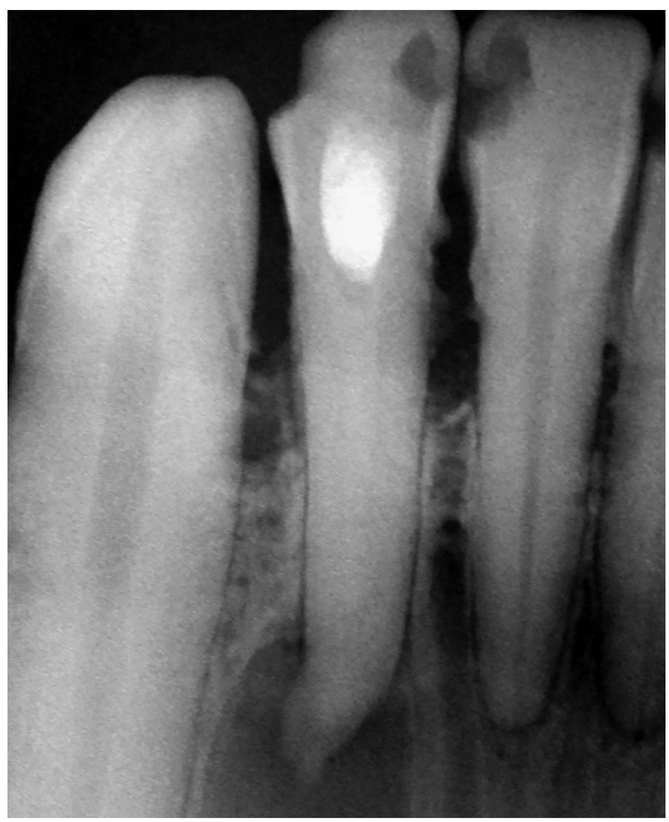

Figure 4. Intracanal dressing.

Figure 5. Fistula 15 days after the start of endodontic therapy.

Figure 6. Control radiography after one year.

Clinical case 2

A female patient attended the dental office after referral by an orthodontist due to a finding on panoramic radiograph taken for orthodontic records and whose image was compatible with and suggestive of periapical lesion in the region of tooth #44 (Fig 7). Radiographic examination revealed extensive restoration near the pulp chamber. Thermal pulp sensitivity testing was performed and only negative results were obtained. Weak sensitivity on palpation and vertical percussion was observed, in addition to tooth colour change. Periodontal clinical examination showed no presence of pocket, and the dental mobility was physiological. It was established, then, pulp diagnosis of necrosis, and periapical diagnosis suggestive of periradicular granuloma. Thus, conventional endodontic therapy was performed in association with photodynamic therapy.

In the first session, endodontic access was performed with the aid of diamond high-speed drill (KG 1013 HL, Medical Burs, Cotia, Brazil), electronic odontometry by foraminal locator (RomiApex A-15, Forum, Israel) and rotary file system (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland) with the crown-apex technique, up to F3 file. Foramen patency was maintained with #15 C-Pilot file (VWD, Munich, Germany). Additionally, 5.25% sodium hypochlorite (Equilibrium, Vitória da Conquista, Brazil) was used as irrigating solution at each file change. After instrumentation, 17% trisodium EDTA (Biodinâmica, Ibiporã, Brazil) was used for three minutes before another irrigation with sodium hypochlorite and drying of root canal with absorbent paper points (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland). Subsequently, 0.005% methylene blue dye (Blumet 5 DMC, São Carlos, Brazil) was added to the root canal for pre-irradiation time of five minutes before laser application (Whithening Lase II DMC, São Carlos, Brazil) at red wavelength of 660 nm, energy density of 320J/cm^2 and potency of 100 mw with optical fibre in helicoidal movements within the root canal for 90 seconds (Fig 7). After PDT, the root canal was re-irrigated with 5.25% sodium hypochlorite solution (Equilibrium, Vitória da Conquista, Brazil) and dried with F3 absorbent paper points (Protaper Universal™, Dentsply/Maillefer, Ballaigues,

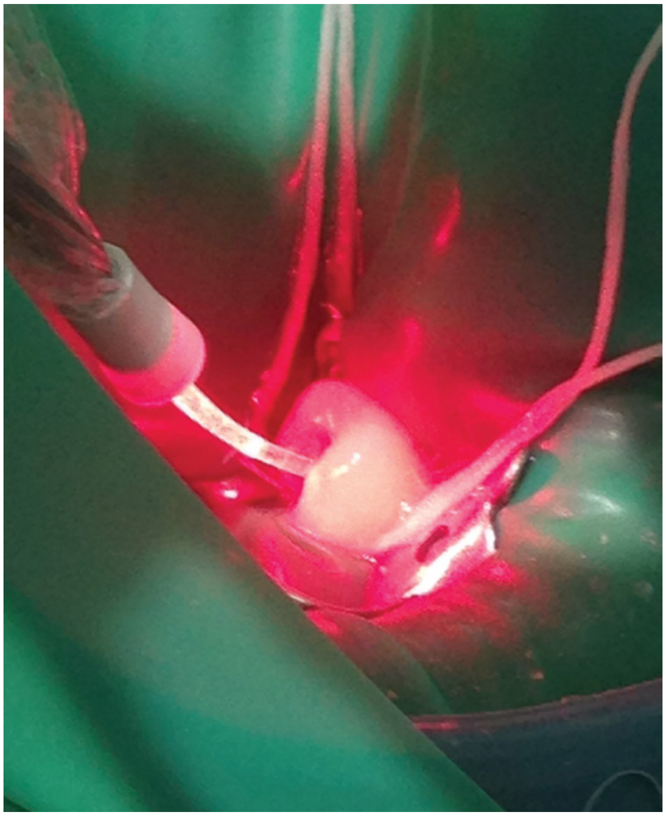

Figure 7. PDT session.

Figure 8. Intracanal dressing.

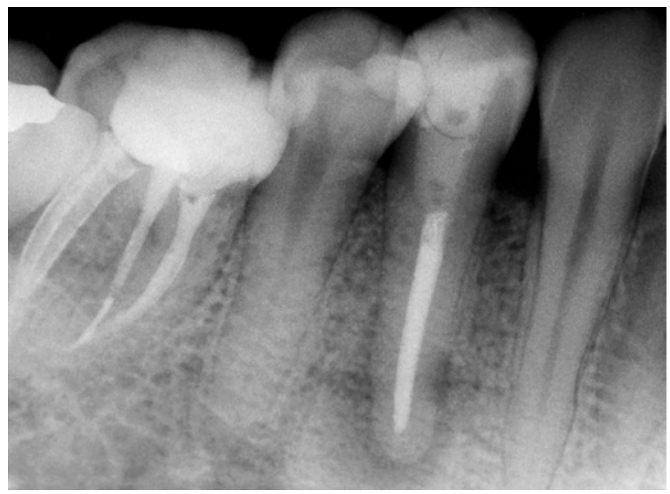

Figure 9. Radiograph of root canal filling.

Figure 10. Control radiograph after two years.

Switzerland). Afterwards, Calen PMCC (SS White, Rio de Janeiro, Brazil) was used as intracanal dressing for 30 days (Fig 8) while Coltosol (Vigodent, Bonsucesso, Brazil) and glass-ionomer cement (Maxxion R, FGM, Rio Claro, Brazil) were used for double sealing.

In the second session, intracanal dressing was removed with 5.25% sodium hypochlorite solution (Equilibrium, Vitória da Conquista, Brazil) and foramen patency was checked with the aid of #15 C-Pilot file (VWD, Munich, Germany); 17% trisodium EDTA (Biodinâmica, Ibiporã, Brazil) was applied before another application of PDT. Root canal system was filled with F3 gutta-percha cone (Protaper Universal™, Dentsply/Maillefer, Ballaigues, Switzerland) combined with pulp canal sealer (EWT, Sybronendo, Orange, USA) before definitive restoration with light-curing composite resin (IPS Empress Direct, Ivoclar, Liechtenstein, Switzerland) (Fig 9).

Clinical and radiographic follow-up two years after endodontic treatment showed recovery of tissues and area of bone repair (Fig 10).

Discussion

The use of light as therapeutic agent was initially thought for treatment of malign neoplasias. After years of studies and in view of constant development and improvement, Dentistry started using light in all dental specialities, from elimination of microorganisms to surgical interventions and tissue repair.[17]

According to Hizatugu and Fregnani,[18] about 500 microbial species have already been related to endodontic infections, among them are those of higher expressivity, namely: *Prevotella*, *Eubacterium*, *Streptococcus* and *Lactobacillus*. However, there is a predominance of gram-positive species in teeth with endodontic failure, with *Enterococcus faecalis* being found in the great majority of cases.[9] This can be explained by greater resistance of this microorganism to both chemomechanical preparation and calcium hydroxide, due to the rigid and stable structure of its peptidoglycan layer (15-80 nm) in cell membrane. Authors have described a successful association of PDT with sodium chlorite as irrigating solution in the elimination of *E. faecalis*, thus suggesting this alternative protocol can be used for conventional antisepsis in cases of persistent infections.[20] This protocol was used in both clinical cases reported herein. The antibacterial power of PDT can be explained by lower attenuation of laser due to absorption optimization produced by the dye and free radicals (cytotoxic) produced by the former, thus causing damage to the bacterial wall.[7,21]

Different authors showed that combining photosensitizer with EDTA is beneficial, since the chelating action of the latter accounts for the removal of smear layer, so that the dye can penetrate enough into the tubules of the root canal and dentine wall.[22] Moreover, this protocol was shown to favour disintegration of bacteria organized in biofilm structures within the root canals, as more dye can penetrate into target bacterial cells, which makes PDT even more efficient. All the aforementioned facts support the use of such a therapy in our two clinical cases.

A combination of PDT with conventional chemomechanical preparation, of which protocol included 2.5% sodium hypochlorite, 3% H_2O_2 and 17% EDTA before application of PDT, combined with the use of calcium hydroxide as intracanal dressing, was assessed,[23,24] and promising results were obtained in teeth with necrotic pulps subjected to the treatment proposed, showing significantly greater reduction in bacterial count following additional application of PDT, as bacteria were almost completely eliminated (i.e. 99.9%). In comparison to both cases reported herein, the same protocol described above was used, except for 3% H_2O_2 and a higher concentration of sodium hypochlorite.

According to some authors,[25] some microorganisms are resistant to antimicrobial treatment. These include several gram-negative anaerobes, such as *Fusobacterium nucleatum* and *Prevotella* species, as well as gram-positive bacteria, such as *Streptococcus gordonii*, *Enterococcus faecalis*, and *Actinomyces* species. There is strong evidence that the increase in diversity of oral bacterial species resistant to antibiotics and the speed by which this situation worsens are strictly related to indiscriminate use of such medications.[22] One of the advantages of PDT over traditional antimicrobial agents is that cell death mediated by free-radical release makes the development of microbial resistance improbable, since it is not necessary to maintain the chemical agent for long periods of time, as it is the case of antibiotics.[1326] These assumptions further support the recommendation of PDT, as occurred in both cases reported herein.

PDT is a useful approach to control oral biofilms in which microbiota is resistant to penicillin and more aggressive to the host, such as *Staphylococcus aureus*.[27] The use of PDT in association with conventional therapy was of great importance for the clinical success reported herein, since one of the cases involved an extraoral fistula, a clinical condition more associated with the presence of gram-negative bacteria.[18] Therefore, despite the chronic clinical condition, this was the technique of choice because it is local therapy requiring no systemic medication and consequently preventing the development of bacterial resistance.

Studies show that besides antimicrobial action, biochemical processes occur concomitantly to PDT, producing a photobiological phenomenon which accounts for tissue repair by means of biostimulation. This biostimulation arises as a result of contention of inflammatory processes, thus allowing for reconstruction of periapical tissues in damaged areas in addition to producing analgesic effects,[11,22,28,29] which are clinically observed through decrease in flare-ups. This confirms the efficacy of PDT, since the aforementioned secondary effects contributed significantly to the clinical success of the cases described above.

Conclusion

Photodynamic therapy (PDT) was shown to have advantages and benefits for endodontic treatment compared to the conventional technique, since it acts directly on the focus of the problem on a highly selective basis. Thus, it becomes a viable option for fighting local infections without systemic medication, in an attempt to eliminate the possibility of bacterial resistance. PDT proved to be effective, since it was possible to observe in the clinical and radiographic exams the reestablishment of the soft and periapical tissues.

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