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The comparison of penetration depth of two different photosensitizers in root canals with and without smear layer: An in vitro study

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ABSTRACT

Background: The main objective of this study is to evaluate the penetration depth of suggested photosensitizers in the lateral wall of the human root canal.
Materials & methods: Forty extracted single-rooted human teeth with straight canals that extracted for periodontal reasons were collected and stored in the sterile saline until employment in the experiment. Teeth were decoronated to a standard 12 mm root segment using diamond disc. After instrumentation of specimens, the external root surface was sealed with two layers of nail polish to avoid environmental contamination. The apical foramen was subsequently closed with composite material. Teeth were divided randomly in two major groups consist of indocyanine green solution (ICG) and tolonium chloride solution (TCH) with and without EDTA in their subgroups. Specimens in all groups grooved longitudinally with a diamond disc and split in two halves with a stainless steel chisel. The measurements were done by the stereo microscope under 20× magnification in three zones of each specimen and the penetration depth of dye was measured.
Results: The results of this study showed that the mean of lateral penetration depth of ICG (224.04 μm) was significantly ($P < 0.05$) higher than TCH (70.15 μm). Regarding to the influence of EDTA, in ICG group without consideration to the different regions, the usage of EDTA improved the mean of lateral penetration depth of ICG, but this improvement was not statistically significant ($P > 0.05$).
Conclusion: Further to the findings of this study, it could be assumed that ICG could penetrate in deeper regions of the root canal wall.

1. Introduction

The main purpose of current endodontic techniques is eliminating bacteria within the root canal system by using the combination of mechanical instrumentation and chemical irrigation. The removal of infected tissue, elimination of bacteria within the dentinal tubules and root canals, and prevention of recontamination after treatment are the main objectives of endodontic treatments [1]. To achieve these objectives the treatment procedures for treatment of infected root canals should be included: mechanical cleaning and shaping [2], irrigation with antimicrobial agents, such as Sodium hypochlorite (NaOCl) and chlorhexidine, antibacterial dressing application, sealing of the root canals with a 3-dimensional obturation and placing a coronal seal [1,3].

It has been shown that residual bacteria are readily detectable in approximately one-half of teeth just before obturation [4]. Our inability to eliminate bacteria from the infected root canals, leads to the requirement for retreatment and/or periradicular surgery in order to perform a successful treatment against persistent infections [5]. There are some factors responsible for our inability to complete elimination of bacteria from the canals such as: complexities of the root canal system [4,6,7], inadequate instrumentation and missed canals [8].

Canal irrigation is most commonly done by NaOCl. Its penetration into dentinal tubules is approximately 130 μm [9], whereas, scanning electron microscopy (SEM) studies described bacterial penetration up to 1100 μm into dentinal tubules [10]. Meanwhile, it has cytotoxic and neurotoxic effects in extrusion into periapical

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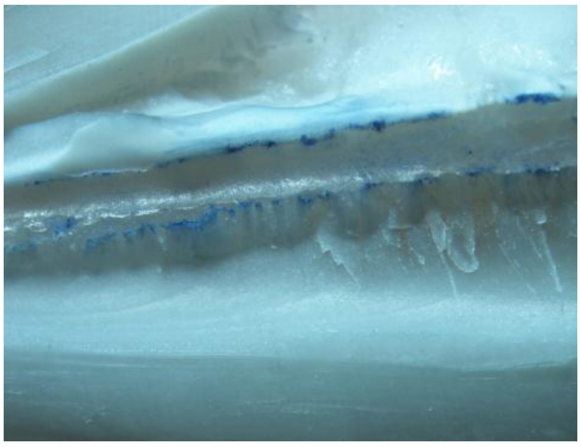

Fig. 1. The specimen in TCH group under the stereo microscope with ×20 magnification.

area [11,12]. Therefore, the creation of new methods in root canal disinfection in order to improve the success rate of our treatment is necessary. We need to develop non-invasive and non-toxic novel antimicrobial strategies that are more efficiently and faster than available antimicrobial agents and at the same time do not permit pathogens to easily develop resistance [13]. One available alternative to current antimicrobial agents is lethal photosensitization (LP). The LP application to treat a disease is known as photodynamic therapy (PDT) [14].

PDT is based on the concept that a nontoxic photosensitizer (PS) can be preferentially localized in certain tissues and subsequently activated by light of the appropriate wavelength to generate singlet oxygen and free radicals, which are cytotoxic to cells of the target tissue [15] (Fig. 1). In biological systems, the lifetime of singlet oxygen and its radius of action are very short (<0.04 s & 0.02 μm respectively) [16], In the other words localization of the photosensitizer will define the site of initial cell damage resulting from PDT. Thus, the reaction will be placed in a very limited space (localized response) and making it ideal for localized applications without any effect on distant cells or molecules [16,17]. It means that the penetration depth of the photosensitizer in dentinal tubules and lateral canals will determine the killing effect of PDT on microorganisms. It has been shown that methylene blue and toluidine blue O are really effective photosensitizing agents for the inactivation of both gram-positive and gram-negative periodontopathic bacteria [17,18].

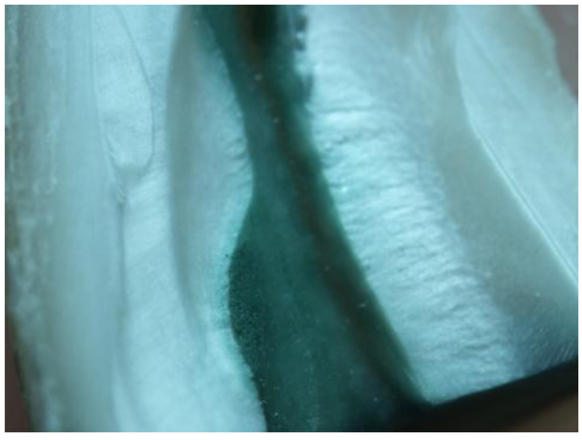

Fig. 2. The specimen in ICG group under the stereo microscope with ×20 magnification.

ICG is a fluorescent dye that is used mainly in medical diagnostics [19]. Nowadays, its usage in dentistry as a photosensitizer is growing up because of its phototoxic effects in combination with the use of lasers.

Smear layer (SL) contains inorganic and organic substances that contain microorganisms, necrotic materials and odontoblastic processes fragments [20]. It has been shown that effectiveness of irrigants and intracanal medicaments in disinfecting of dentinal tubules is diminished in the presence of "smear layer" [21]. It has been shown that after removal of smear layer, adhesion of obturation materials to the canal wall will be stronger [22,23]. Other investigators showed that the penetration of sealers to the dentinal tubules was 10–80 μm after removal of the smear layer, whereas in cases with the intact SL, there was no penetration [24,25]. Regarding the influence of smear layer on microleakage of root canal fillings several investigators have shown less dye leakage after removal of the smear layer [26,27] whereas, others have reported no significant effect of SL removal on the microleakage of root canals [28].

Up to now there is no study investigating the penetration depth of photosensitizers in the dentinal tubules or lateral canals. The present study is conducted to investigate the penetration depth of two kinds of photosensitizers and the influence of smear layer on that.

2. Materials and methods

2.1. Teeth collection

Forty extracted single-rooted human teeth (upper central incisors and upper canines) with straight canals that extracted for periodontal reasons were collected and stored in the sterile saline until employment in the experiment. All patients who their tooth was gathered for using in this study signed an informed consent that permits to use their teeth in this study.

3. Preparation of specimens

Teeth were decoronated to a standard 12 mm root segment using diamond disc (Brasseler USA, Savana, GA). File measurement was taken at the point where the tip of a size # 15 kerr files (Maillefer Instruments SA, Switzerland) become visible at the apical foramen and 0.5 mm will be subtracted to set the working length. Teeth were instrumented in a crown-down manner by a set of M2 rotary files (VDW GmbH, Germany) to achieve a master apical file size of M2# 40, 6% tapered at the working length. The cleaning was done with 10 ml of 2.5% NaOCl throughout the instrumentation sequence. The external root surface was sealed with two layers of nail polish to avoid environmental contamination. The apical foramen was subsequently closed with composite material.

Teeth were divided randomly in four groups. In two groups, shaped canals were irrigated with 17% EDTA for 2 min followed by irrigation with normal saline to remove the smear layer and in other two groups; irrigation was done only by normal saline. Then specimens were sterilized by autoclaving for 15 min at 121 °C.

In two groups, (EDTA group and non-EDTA group) TCH solution (PACT, Cumdente GmbH, Germany) and in other two groups, ICG solution (EmunDo, A.R.C. laser GmbH, Germany) were used. In all groups before filling the root canals with photosensitizers, they dried again with paper cone, afterwards filled with suspected photosensitizer and allowed to incubate for 10 min. After that the root canals dried again with paper cone. Therefore, our groups were as follows:

Group A: TCH solution in root canals without the smear layer.

Group B: TCH solution in root canals with the smear layer.