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The effect of different intracanal medications on fracture resistance of root canal dentin

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Abstract

Introduction: This study was conducted to investigate the effect of the newly introduced intracanal medicament (propolis) on the fracture resistance of root dentin compared to Triple antibiotic paste and Chlorhexidine.

Method: The root canals of mandibular premolars ($n = 180$) were instrumented and randomized into four groups; Group Propolis (PRP), Triple antibiotic paste (TAP), Chlorhexidine (CHX) and Control group (CNT) according to the medicament used. Teeth were incubated in 100% humidity at 37 °C for 3 days, one week and one month. After each period, teeth were subjected to a fracture resistance test. Two-way ANOVA and Tukey's post hoc pairwise test were used for statistical analysis.

Results: No significant difference was found between different groups after 3 days and one week. There was a significant decrease ($P < 0.0001$) in fracture resistance after one month for both TAP and PRP while the decrease was not significant for CHX and the control group.

Conclusion: Under the conditions of this study, Propolis and TAP when used as intracanal medicaments adversely affects fracture resistance of root canal dentin, CHX is safe as an intracanal medication regarding the fracture resistance of root canal dentin.

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Keywords: Chlorhexidine; Fracture resistance; Propolis; Triple antibiotic paste

1. Introduction

Objectives of endodontic treatment are to completely disrupt and destroy the bacteria involved in the endodontic infection. Chemomechanical cleaning

and shaping of the root canal system remove most of the root canal irritants; however, total debridement is impeded because of the complex root canal anatomy with the presence of accessory canals, fins and other communications between the main canals. The use of intracanal dressings is recommended to disinfect the root canal system and considered to be an important aspect of root canal treatment [1–4].

Many materials have been introduced as intracanal medicaments. Chlorhexidine gluconate (CHX) has been widely used as a medicament in the treatment of infected root canal systems because it has broad

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spectrum antimicrobial activity, substantivity, low toxicity, and water solubility [5–7]. Triple antibiotic paste (TAP) is one of the most widely used intracanal medicament that was described by Hoshino et al. [8], which is a mixture of metronidazole, ciprofloxacin and minocycline. It has been shown to be very effective in eliminating endodontic pathogens in vitro and in situ [8–10]. Recent trend in endodontics attends the use of biologic medication extracted from natural plants to decrease cytotoxic reactions of most of the commercial intracanal medicaments. New natural product, propolis (bee glue), is a flavanoid-rich resinous product of honeybees. Propolis has been shown to possess antibacterial, antifungal, antiviral, antiinflammatory, hepatoprotective, antioxidant, antitumor, and immunomodulatory effects [11,12]. It was used in dentistry as an anticaries agent [13], a storage medium for avulsed tooth [14], a pulp capping agent [15], and a sealant for dentinal hypersensitivity [16]. Propolis was also proved to be effective against resistant endodontic pathogens [17,18].

Dentin composition has been described based on its organic and inorganic components. Calcium (Ca) and phosphorus (P) present in hydroxyapatite crystals are the major inorganic components of dental hard tissue [19]. Dentinal strength is determined by the link between hydroxyapatite and collagenous fibrils. Exposure of root dentin to the root canal medicaments was shown to affect its physical characteristics and subsequently affects its fracture resistance [20,21]. However there is scarce information about the effect of natural medications on fracture resistance of root dentin therefore, the aim of the present study was to evaluate the effect of the newly introduced intracanal medicament (propolis) on the fracture resistance of root dentin compared to TAP and CHX.

2. Materials and method

2.1. Sample selection

One hundred and eighty freshly extracted, single-rooted human mandibular premolar teeth with approximately the same dimensions were selected and stored in distilled water until till the time of use. Buccolingual and mesiodistal radiographs were obtained. Mesiodistal and buccolingual dimensions were obtained for the specimens; the means were calculated, and specimens that showed 10% or more deviation from the mean were discarded and the selected teeth were examined for any root cracks, abnormal curvatures, calcifications, internal or external resorption.

Table 1
Main ingredients of intra-canal medicaments used in this study.

| Material | Ingredients |
|-------------------------|---|
| Propolis paste | Components in parts by weight: 70% ethanolic extract of raw powder propolis (Imtinan) Unbleached beeswax Lanolin Petrolatum Ethyl aminobenzoate Clove oil |
| Triple antibiotic paste | 1 Ciprofloxacin 1 Metronidazole 1 Minocycline Saline |
| Chlorhexidine | |

All crowns were sectioned to obtain a standardized root length of 14 mm using a diamond saw² under coolant. Size 15 K-file³ was inserted into the canal till the tip was just visualized beyond the apical foramen using surgical operating microscope⁴. Working length was then determined by subtracting one mm from the length of the file. Radicular preparation was done by ProTaper rotary instruments⁵ up to a master apical file F3 using a torque and speed-controlled electric motor.⁶ The speed and torque values were set as recommended by the manufacturer. Irrigation was done using 3 ml of 2.6% NaOCl between each two successive files. Root canals were rinsed with saline as a final flush and dried using paper points.

2.2. Sample classification

Teeth were randomly divided into four equal groups [n = 45] according to the medicament used; group TAP (triple antibiotic paste), group CHX (chlorhexidine gel) and group PRP (Propolis)⁷ and group CNT (control group; with no medication) (Table 1).

2.3. Sample preparation

TAP preparation: The triple antibiotic paste was prepared using metronidazole⁸ (500-mg tablets),

² Isomet 1000; Buehler, Lake Bluff, IL, USA.

³ Mani, Utsunomiya, Tochigi, Japan.

⁴ Zeiss, Oberkochen, Germany.

⁵ Dentsply Maillefer, Ballaigues, Switzerland.

⁶ X Smart; Dentsply Maillefer, Ballaigues, Switzerland.

⁷ Propolis, Imtinan store, Cairo, Egypt.

⁸ Flagyl 500 mg; Aventis, Cairo, Egypt.

ciprofloxacin⁹ (250-mg tablets) and doxycycline¹⁰ (100-mg capsules). The doxycycline capsule content was evacuated in a sterile mortar; a tablet of metronidazole and a tablet of ciprofloxacin were crushed and ground into homogenous powder in the same mortar using a pestle. Saline drops were added and mixed using the pestle until a creamy paste was achieved. The chlorhexidine and propolis, were supplied in paste form from their manufacturers'.

For each group, one mL of the medicament was injected into each canal using a sterile plastic syringe with a 20-G needle. A sterile cotton pellet was then applied, and the orifice was sealed using a temporary restoration¹¹ for the selected observation time. Each group was subdivided into 3 equal subgroups (n = 15) according to the observation time; 3 days, one week and month. Teeth were incubated at 37°C and 100% humidity during different observation periods. After each observation period, root canal medication were removed using ultrasonic activation¹² of 2.5% NaOCl irrigation for 60 s set with recommended manufacturer power 9 with a #15 ultrasonic file. Root canals were finally flushed with 5 ml distilled water.

2.4. Fracture resistance testing

Roots were mounted in acrylic resin¹³ to prepare them for fracture resistance test using Instron 4502 tester.¹⁴ The apical root ends were embedded in 7 mm acrylic resin blocks exposing 7 mm of the coronal end of each root. The acrylic resin was allowed to polymerize for 1 h. A protractor was used to ensure vertical alignment of the long axis of the roots. The blocks with the vertically aligned roots were mounted in the Instron testing machine. Vertical loading force was applied till fracture. A cone shaped rod was mounted on the Instron tester directly over the canal opening of each root and load was applied slowly with increasing force (0.50 inch diameter metal rod with a 5° taper down to 0.25 inch followed by a 45° taper to a blunt tip) at a rate of 1.0 mm per min, until the root fractured. This point was recorded by the computer monitoring software and measured in Newton.

2.5. Statistical analysis

The effects of medicaments type and duration of treatment on fracture resistance were examined using two-way ANOVA followed by Tukey's post hoc test in case of significance $P < 0.05$.

3. Results

No significant difference was found between different groups after 3 days and one week. There was a significant decrease ($P < 0.0001$) in fracture resistance after one month for both groups TAP and PRP while the decrease was not significant for CHX and the control group. After one month, Both TAP and PRP groups recorded significantly lower ($P < 0.001$) fracture resistance values than the CHX and control groups. [Table 2](#).

4. Discussion

Herbal or natural products have been used in dental and medical practice for thousands of years and have become even more popular today due to their high antimicrobial activity, biocompatibility, anti-inflammatory and anti-oxidant properties [22]. However the effect of these materials on fracture resistance of root dentin is important before recommending its use as intracanal irrigating solutions and medicaments.

The root canal dentine surface is porous owing to the patency of dentinal tubules, although they may sometimes be sclerosed. The presence, density, and diameter of the dentinal tubules may be variable hence standardization of samples is an important factor in mechanical testing regarding dimension, extraction time, and storing conditions. In this study like previous fracture load studies [23–25] Buccolingual and Mesio Buccal dimensions were measured so that the selected samples were standardized regarding the remaining dentin thickness of samples subjected to fracture tests. Root canal medications were delivered to the root canals using lentulospiral to allow proper adaptation to root canal dentinal walls. Different observation periods were selected to be similar to that applied in different clinical situations. Canal medications were removed using passive ultrasonic activation of 2.5% NaOCl irrigation for 60 s to ensure complete removal of root canal medication final flush was done with distilled water to stop the effect of sodium hypochlorite on canal dentin.

By time (after one month) there was a significant reduction in fracture resistance of root specimens

⁹ Ciprocil 250 mg; EPICO, Cairo, Egypt.

¹⁰ Vibramycin; Pfizer, Cairo, Egypt.

¹¹ Coltosol F; ColteneWhaledent, Altstätten, Switzerland.

¹² Supprason Booster P5 Satelec, Acteon, France.

¹³ Caulk/Dentsply, Milford, DE, USA.

¹⁴ Instron, Canton, MA, USA.

Table 2

Mean \pm SD (Newtons) of load at fracture for different groups at different observation time.

| | TAP | CHX | PRP | Control |
|-----------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| 3 days | 132.28 \pm 23.78 ^{Aa} | 134.29 \pm 24.18 ^{Aa} | 138.03 \pm 39.45 ^{Aa} | 134.68 \pm 22.02 ^{Aa} |
| One-week | 130.4 \pm 19.57 ^{Aa} | 132.37 \pm 28.72 ^{Aa} | 132.84 \pm 16.79 ^{Aa} | 133.26 \pm 6.74 ^{Aa} |
| One-month | 45.5 \pm 12.71 ^{Cb} | 111.11 \pm 15.9 ^{Aa} | 72.87 \pm 10.24 ^{Bb} | 109.5 \pm 18.45 ^{Aa} |

Different capital letters indicate significant difference between different groups within the same duration. Different lower case letters indicate significant difference between different durations within the same group.

treated using either propolis or TAP compared to their counterparts of three days or 1-week application also when compared to specimens treated using CHX or the control. The relatively long-term exposure of radicular dentine (TAP) caused reduction in root resistance to fracture as using of the TAP might cause demineralization of radicular dentine by the effect of the acidic pastes. Reduction in the mineral component in dentin contributes to reduction in the strength of the tooth structure. These results came in accordance to the results with Yassen et al. [21].

Ethanollic extract of propolis (EEP) is one of the richest sources of phenolic acids and flavonoids [26]. Phenolic acids are weak acids that could be adsorbed on hydroxyapatite molecules [27]. After adsorption, the reaction mechanism might be surface complexation with Hydroxyapatite [27]. Surface complexation is a form of chemical reactions (equilibrium reactions) that take place at the interface between a mineral surface and the solution [28]. This might be the cause for the significant reduction in fracture resistance after using propolis as intracanal medication.

CHX is a positively charged hydrophobic and lipophilic molecule, a synthetic cationic bis-guanide that consists of two symmetric 4-chlorophenyl rings and two biguanide groups, connected by a central hexamethylene chain [29]. CHX is known by its anti-collagenolytic activity, a broad-spectrum MMP-inhibitory effect as well as antimicrobial substantivity [30,31]. In the present study CHX didn't adversely affect the fracture resistance of root canal dentin of the treated samples. This could be explained by the inability of chlorhexidine to dissolve the organic tissue of root dentine. In previous studies [32,33], it was found that CHX didn't adversely affect dentin microhardness. However, Oliveira et al. [34] found a statistically significant decrease in the microhardness of root dentine when 2.0% Chlorhexidine gluconate was used on 10 apical specimens only for 15 min which could not be explained by the authors. This might be due to difference methods used in the study such as difference in exposure time.

Based on the results of this study, propolis and TAP as an intracanal medicament adversely affects fracture resistance of root canal dentin, CHX is safe as an intracanal medication regarding the fracture resistance of root canal dentin. Future studies should be directed to evaluate long term effect of propolis on dentin microhardness and chemical structure.

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