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Tanta Dental Journal 11 (2014) 1—11

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Effect of different irrigant solutions on microhardness and smear layer removal of root canal dentin

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Received 15 February 2014; revised 23 March 2014; accepted 23 March 2014
Available online 10 May 2014

Abstract

Aim: To compare the effect of different irrigants on root dentin microhardness and smear layer removal.
Materials and methods: A total of 50 roots were equally divided into two halves to measure dentin microhardness and to evaluate the amount of smear layer. One hundred root halves were divided into five equal groups 20 sample each according to the final irrigants used: Group 1: 2.5% NaOCl, Group 2: 2.5% sodium hypochloride (NaOCl) followed by 7% malic acid (MA), Group 3: 2.5% NaOCl followed by 17% ethylenediamine tetraacetic acid (EDTA), Group 4: 2.5% NaOCl followed by mixture of tetracycline, acid and detergent (MTAD) and Group 5: saline. Ten root halves from each group were prepared to measure dentin microhardness at baseline measurement and after treatment to determine the change in microhardness, while the remains 10 root halves were prepared for scanning electron microscope to evaluate the amount of smear in the coronal, middle and apical thirds.
Results: Data were analyzed using one-way ANOVA and Student's *t*-test for microhardness and Kruskul—Wallis and Mann—Whitney for smear layer. Malic acid showed the greatest significant reduction in dentin microhardness ($P < 0.05$), followed by EDTA, MTAD, NaOCl and saline (control). EDTA, malic acid and MTAD efficiently removed smear layer, respectively, in the coronal and middle thirds of root canal. However, in the apical region, malic acid showed more efficient removal of the smear layer than the other irrigants.
Conclusion: Malic acid is the most efficient final irrigant solution after NaOCl irrigation throughout instrumentation.

Keywords: Microhardness; Smear layer; Irrigant solution; MTAD

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Peer review under the responsibility of the Faculty of Dentistry, Tanta University

ELSEVIER Production and hosting by Elsevier

 http://dx.doi.org/10.1016/j.tdj.2014.03.001

1. Introduction

Success in endodontic therapy depends on chemo-mechanical debridement of the root canal system through the use of instruments and effective irrigant solutions [1]. Mechanical instrumentation of the root canals produces a smear layer composed of organic and inorganic substances such as dentin particles, necrotic debris, and odontoblastic processes. The smear layer is an amorphous irregular thin layer that covers the prepared canal walls and occludes the orifices of the dentinal tubules. It also hinders the penetration of intracanal medications and sealers into the dentinal tubules. Removal of the smear layer improves the fluid tight seal of the root canal system [2]. Effective cleaning of the canal system requires the use of irrigation solutions during instrumentation and irrigation, which serve variety of purposes including antibacterial action, tissue dissolution, cleaning and chelating [3].

Although some authors suggest retaining the smear layer because it acts as a barrier against bacteria and other irritants, its total removal is preferred to improve the adaptation of the filling materials to the root canal dentin, reduce apical and coronal microleakage of the root canal filling materials and facilitate the diffusion of the irrigants and medications to the root canal system [4].

Sodium hypochlorite (NaOCl) with a concentration ranging between 1% and 5.25% is the most widely used irrigant in root canal treatment and considered as an effective antimicrobial agent and an excellent organic solvent for vital, necrotic, and fixed tissues [5]. However, it is highly irritating to periapical tissues, especially at high concentrations. Therefore it should be used at the lowest effective concentration and should not be forced beyond the apex [6]. However, its capacity to remove the smear layer from the root dentin appears to be limited [7].

Chelating agents decalcify the dentin by combining with the calcium ions of the tooth structure, unlike acids, which dissolve the inorganic structure of dentin by their low pH[8].

The decalcifying effect of chelating agents depends largely on application time, solution pH, and concentrations [9]. Ethylene diaminetetraacetic acid (EDTA) is generally accepted as the most effective chelating agent in endodontic therapy. It is used to enlarge root canals, remove the smear layer, and prepare the dentinal walls for a better adhesion of filling materials. The disodium salt of EDTA at 17% concentration and neutral pH is widely preferred for root canal treatment [10].

Malic acid is a mild organic acid used as acid conditioner for dentin and enamel etching in adhesive dentistry because it can decalcify and chemically adhere to hydroxyapatite [11]. This material was suggested to remove the smear layer efficiently throughout the root canal with different concentrations (5%, 7%, 10%, or 15%) of malic acid but when it is used at concentrations more than 7% cause damage to inter-tubular dentin [12].

MTAD can eliminate microbes (eradicate *Enterococcus faecalis*) that are resistant to conventional endodontic irrigants and dressings [13,14]. It is also an effective solution for the removal of the smear layer when used as a final rinse [15].

It was found that the irrigant solutions can affect the microhardness of radicular dentin that consequently affects the clinical performance of endodontically treated teeth [16]. Apart from advantages of irrigating solutions such as flushing out debris, disinfection, smear layer removal, and lubricating dentinal walls, canal irrigants may induce adverse changes in physical properties of dentin, including the microhardness [17]. Although a reduction in microhardness facilitates the instrumentation throughout the root canal, it may also weaken the root structure [18]. Microhardness determination can provide indirect evidence for losing or gaining any mineral substance in the dental hard tissues [19].

Therefore it is important to study the effect of different irrigant solutions, NaOCl, Malic acid, EDTA and MTAD on both the microhardness of root canal dentin and smear layer removal as well as clarifying the correlation between smear layer removal and microhardness.

2. Materials and methods

Fifty straight single-rooted lower premolars with relatively similar dimension and morphology, freshly extracted with closed apices were collected from adult patients. Each tooth was radiographed to confirm the presence of a single canal. Teeth with previous root caries, cracks, curved canals, endodontic treatment, internal resorption or calcification were excluded. The selected teeth were cleaned from soft and/or hard attached tissues, decontaminated by immersion in 5.25% sodium hypochlorite solution for 30 min and stored in sterile saline solution at room temperature all over the study [8].

The crowns of all specimens were cut transversally at the cemento-enamel junction (CEJ) with double-faced diamond disc at low speed, with water coolant, to obtain a 15 mm $\pm$ 0.5 mm root length. The fifty specimens were randomly divided into two parts 25 each. The first part was used to test the surface microhardness of root canal dentin and the other part