

Efficacy of Three Different Endodontic Irrigation Systems in the Removal of Intracanal Smear Layer at Apical Third of Root Canals: A Scanning Electron Microscopy Study

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Abstract: The study was conducted to compare the efficacy of three different endodontic irrigation systems in the removal of the smear layer at apical third of root canals. Sixty recently extracted, non-carious human intact single-rooted premolars were selected and divided into four groups (n=15) according to the root canal irrigation systems; syringe and needle irrigation as control (C), Endovac irrigation (EV), ultrasonic irrigation (US) and EndoVac (EV) irrigation system. All groups were prepared to #40 apical size and subjected to final irrigation by using four different irrigation/activation systems. After splitting the samples, one half of each root was selected for examination under a scanning electron microscope (SEM). The irrigation systems were compared using Kruskal-Wallis and Mann-Whitney U tests, P values were computed and compared with statistical significance at the P=0.05 level. In the apical part of the canal none of the methods could completely remove the entire smear layer but the EndoVac system showed the significantly better removal of smear layer and debris than the other methods. Within the limitations of the present study, the EndoVac system cleaned the apical part of the canal more efficiently than sonic, ultrasonic and syringe and needle irrigation.

Keywords: Smear layer, Endovac, Endoactivator, Ultrasonic irrigation, needle irrigation, SEM.

INTRODUCTION

The final aim of any endodontic therapy is to eliminate root canal infection and prevent its reinfection. Thus, chemo-mechanic preparation of the root canal system becomes an important stage in the treatment process.

Dentin debris is formed by the mechanical action of instruments in association with organic tissue, microorganisms, and auxiliary chemical substances during chemo-mechanical preparation (CMP), forming the so-called smear layer [1]. It has been demonstrated that the smear layer itself may be infected and may protect the bacteria within the dentinal tubules [2]. The smear layer has also been shown to hinder the penetration of intracanal disinfectants and sealers into dentinal tubules and has the potential of compromising the seal of the root canal filling [3]. Chelating solutions such as ethylenediaminetetraacetic acid (EDTA), citric acid, and maleic acid have been reported as suitable for

removing the smear layer [4]. But an efficient and effective system is required to deliver such chemicals all the way to the working length. Traditionally, needles with varying diameters and configurations attached to a syringe have been used for the same purpose. The needle irrigation is a positive pressure irrigation system which delivers solutions no further than 1mm past the tip of the needle and is relatively ineffective in cleaning the apical third of the canal walls [5]. The apical part of the canal, with its cul-de-sac configuration, presents a special challenge and several studies have indicated that syringe and needle irrigation tends to leave this parts of the canal covered with smear layer and debris, despite

application of EDTA [6]. To counter this problem, new irrigation systems and devices have been introduced to increase the effectiveness of root canal debridement. Ultrasonic and sonic have been widely used for irrigant activation inside the canal space. Compared with sonic energy, ultrasonic energy produces high frequencies with low amplitudes. The files are designed to oscillate at ultrasonic frequencies of 25-30 kHz [7]. EndoActivator (Dentsply, Tulsa Dental Specialties, Tulsa, OK), an irrigant activation system, works on the principle of sonic activation of files (1-6 kHz) to produce hydrodynamic intracanal fluid agitation [8]. One of the recent introduction to the field of endodontics, EndoVac (SybronEndo Corporation; Orange, CA, USA), is an apical negative pressure irrigation device that is designed to deliver irrigating solution to the apical end of the canal system and suction out debris [9]. The aim of this study was to compare the efficacy of three different endodontic irrigation systems in the removal of the smear layer from the apical third of root canals by means of scanning electron microscope.

METHODOLOGY

Sixty recently extracted human mature permanent mandibular premolars were used for the study. The teeth were digitally radiographed using both buccal and proximal views to confirm a single patent root canal devoid of any complex root canal anatomy. Teeth selected had root curvature not greater than 10 degrees and root length not shorter than 12mm. Any visible debris and calculus were removed using ultrasonic instruments and teeth were stored in 0.4% thymol solution to further use. Teeth were decoronated, and root length was standardized to 12mm by using a diamond disc operated at low speed. An ISO size #10 K file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the root canal until just visible at the apical foramen. The working length (WL) was established 1 mm short of the length. Each apex was sealed with sticky wax and teeth were placed in test tubes filled with a polyvinyl siloxane (Aquasil Ultra Monophase, DENTSPLY) to simulate the clinical situation. A coronal reservoir was created for irrigant placement with a size 4 Gates Glidden drill placed 4 mm into the canal [10]. The root canals were prepared with ProTaper rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) up to apical size #40 (F4). The canals were irrigated with 2 ml, 5% Sodium hypochlorite (J.L.Morrison India Ltd.) between each file using a 30 gauge needle (Canal Clean; Biodent Co. Ltd., Korea) placed 1mm from the WL. The apical patency was checked after each instrument with a #10 K-file. At the end of instrumentation, irrigation was done with 5 ml saline to remove any remaining NaOCl. The specimens were then randomly divided into four groups according to the activation modality of irrigants used (n=15). In each group, the final irrigants used were 5 ml, 17% EDTA (Prevest Denpro, Jammu, India) and

5 ml, 5% Sodium Hypochlorite (NaOCl), activated according to the manufacturer's protocol.

GROUP C (Control): 5 ml, 17% EDTA was delivered using a 30 gauge side vented needle and left in place for 1 minute per canal. The procedure was then repeated with 5 ml, 5% sodium hypochlorite.

GROUP EA (Endo Activator): Each canal was irrigated with 5 ml, 17% EDTA using 30 gauge needles. The red (25/04) Endo Activator tip was used to activate the intracanal solution at a speed of 10 kHz for 1 minute. The procedure was repeated with 5 ml, 5% sodium hypochlorite for 1 minute. The protocol used was as suggested by Ruddle [8].

GROUP-US (Ultrasonics): In this group, 5% Na OCl and 17% EDTA were each activated for 1 minute by using #20/0.02 taper ultrasonic file (Satelec, France) at 1 mm from the WL. The tip was operated by a piezoelectric unit (P5 Newtron; Satelec) at power setting 5. The canal was irrigated with 2.5 mL irrigant after 30 seconds of ultrasonic activation, with a total volume of 5 mL per irrigant [11].

GROUP-EV (Endovac): With this technique, macro-irrigation was done during instrumentation. Following this, a modified protocol described by Saber *et al.* [11] was used in our study; wherein only 2 micro-irrigation cycles were used instead of 3 micro-irrigation cycles as originally suggested by Neilson and Craig Baumgartner [12]. A total of 5 mL of 5% NaOCl and 5 mL of 17% EDTA were used at a flow rate of 1.8 mL min⁻¹ through the microcannula.

Finally, the specimens were irrigated with 5 mL sterile distilled water, dried, temporarily sealed, and stored separately in labeled bottles containing 10% formaldehyde as a fixative for any remaining soft tissue debris. The teeth were grooved along the buccal and lingual planes by using a diamond disc at low speed taking care not to perforate the root canal. The roots were then split longitudinally with a bibivelled chisel and a mallet, exposing the entire root canal. One half of each root was selected depicting the entire root canal length and prepared for scanning electron microscope examination. The selected samples were progressively dehydrated using graded concentrations of aqueous ethanol (70%, 80%, 90%, and 100%) for 24 hrs at each concentration. After dehydration, the samples were placed in a vacuum chamber and sputter coated with a 30 nm gold layer. The samples were then analyzed using a scanning electron microscope S-3000 H (Hitachi, Japan). The dentinal wall of the root canals was examined at the apical third level (2-3mm from the apex) at a magnification of 1000 x for the presence or absence of smear layer and patency of dentinal tubules. A magnification of 1000 x was used because it offered a wider view and detailed image of the canal wall surfaces. Photomicrographs of the root canals were

taken at apical level (Figure 1) for scoring individually in a calibrated single blind manner according to the rating system developed by Hulsmann *et al.* [13] and modified by Caron *et al.* [14]. The differences between irrigation techniques were compared non-parametrically using Kruskal-Wallis and Mann-Whitney U tests, P values were computed and compared with statistical significance at the P=0.05 level. All statistical analyses were performed using SPSS 20 software (IBM SPSS Inc., Chicago, IL).

RESULTS

The mean scores and comparisons between the groups have been depicted in Table 1. The mean apical smear layer score was highest for control group C (5.0) followed by Ultrasonics US (4.44), Endoactivator EA (4.00) and least for Endovac EV (3.34). At the apical third, the cleaning efficacy of EndoVac was significantly better than the control (P=0.0001), Ultrasonics (0.0001) and Endoactivator (0.039) groups. Also, the cleaning efficacy of EA was better when compared to control (P = 0.01) and US (P=0.04) groups. US group proved to be better than the control group in cleaning the smear layer at the apical third (P=0.033)

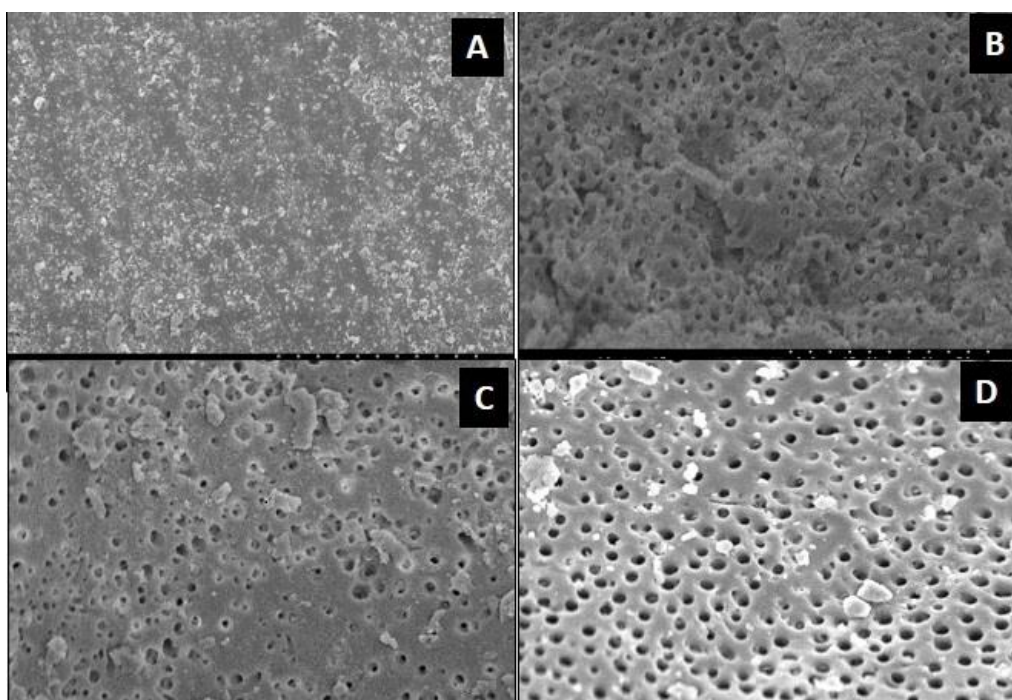


Fig-1: SEM microphotographs of apical third: Control (A), Ultrasonics (B), Endoactivator (C), Endovac (D)

Table-1: Mean smear layer scores and standard deviatons

| Group (n=15) | Mean smear layer score | Standard Deviation |
|--------------------|------------------------|--------------------|
| Control (C) | 5 | 0.3 |
| Ultrasonic (US) | 4.4 | 0.6 |
| Endoactivator (EA) | 4.0 | 0.4 |
| EndoVac (EA) | 3.3 | 0.6 |

DISCUSSION

The present study was undertaken to compare the efficacy of three different endodontic irrigation systems in the removal of the smear layer from the apical third of root canals by means of scanning electron microscope. The apices of all teeth were sealed with sticky wax and the external root surface was sealed with VPS impression material to simulate a "closed system". Similar methods have been proposed by other authors [15, 16]. The "closed system" simulates a natural tooth housed in the oral cavity as the root is enclosed by the alveolar socket. It has been proposed that in vivo, the canal acts like a "closed-end channel," with the apex being the closed end. Thus, gas becomes

trapped at the apical extent of the canal during irrigation delivery, which creates a "vapor lock effect" [17,18]. This phenomenon limits the expression of irrigation solution to approximately 1 mm beyond the irrigation tip in a positive pressure system [18]. Removal of the smear layer is usually accomplished by chemicals capable of dissolving both organic and inorganic components. The recommended combination is a final rinse of 15% or 17% EDTA solution followed by 1%–6% of Na OCl [19,20]. However, there is no consensus on the volume, time and activation method of irrigating solutions. Recently, different irrigation delivery and activation systems have been proposed to improve the distribution of irrigants within the root canal system. In

our study, to increase volume exchange of irrigants at the WL, groups were shaped to a ProTaper F4 (apical size 0.40, taper 6%). Instrumentation to size #40 is required for an efficient irrigation for both positive and negative pressure systems [21]. In our study, the cleaning efficacy of EV was significantly better than the control group. A similar result was described by some other authors, who showed significantly better cleaning with EV compared with traditional positive-pressure irrigation [22-24]. In Endovac irrigation, continuous supply of fresh irrigant was being delivered by negative pressure due to which vapor lock effect might have been avoided, resulting in better cleaning in the apical third [23]. EV performed significantly better than EA at apical third. These results are similar to showed by Manuele *et al.* [25]. Both Ultrasonics and EndoActivator work on the principle of hydrodynamic agitation of irrigants but acoustic microstreaming can only occur in a liquid phase. Therefore, once an activated tip enters the apical vapor lock, acoustic microstreaming, and cavitation becomes physically impossible [26]. Analyses of the microphotographs from the apex showed that the EA resulted in significant increase of smear layer removal when compared with control groups and ultrasonic groups. Similar results were described by Rodig *et al.* [27], who showed significantly greater smear layer removal when the EA was used rather than ultrasonic agitation and a canal brush. Ultrasonics showed poor results, which is in agreement with previous authors [7]. This might be due to reduced time of activation (1 minute) and possible contact between the ultrasonic file and the canal wall. In the present study the conventional syringe and needle irrigation system, which acted as control, showed larger amount of debris and smear layer than any other system because flushing action of syringe irrigation is relatively weak and is dependent not only on the anatomy of the root canal but also on the depth of placement and the diameter of the needle [5].

CONCLUSION

None of the systems completely removed the smear layer from root canal walls at the apical part of the canal. EndoVac system showed significantly better cleaning than the needle, sonic and ultrasonic systems.

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