Comparative Evaluation of Three Different Irrigation Activation on Debris Removal from Root Canal Systems

U Nair, M Natera, K Koscso, P Pillai, C Varella, R Pileggi

Citation

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Abstract

Objective: The purpose of this in vitro study is to evaluate the ability of EndoActivator, F file and passive ultrasonic irrigation to clean canals when compared to syringe irrigation.
Study design: Fifty six teeth were instrumented and irrigated using sodium hypochlorite (NaOCl) and Ethylene Diamine Tetraacetic Acid (EDTA). The teeth were divided into four groups and the irrigants were activated with the EndoActivator, F files or passive ultrasonic irrigation. One group served as the control and received syringe irrigation. The roots were sectioned and debris was scored using scanning electron microscope images of the apical, middle and coronal thirds.Results: The EndoActivator cleaned the apical and the middle third of the canals significantly better than the F-files ($p < 0.05$). F-files performed no better than the control group in the apical third of the canal.Conclusion: None of the systems were able to completely remove the debris from the apical third of the canal.

INTRODUCTION

It is known that cleaning and shaping plays a critical role in the success of root-canal treatment (1). Davis found that even in canals where proper preparation has been performed, there are uninstrumented areas with organic and inorganic debris present (2, 3). Debris present on root canal surfaces, after hand or rotary instrumentations, prevents the complete removal of vital or necrotic pulp tissues and microorganisms, making difficult a complete disinfection of the root canal system (4-6). Removal of organic tissues with the use of sodium hypochlorite (NaOCl) and removal of inorganic components of the smear layers with Ethylene Diamine Tetraacetic acid (EDTA) has been reported to be a useful adjunct to biomechanical preparation of the canals (7, 8).

In a review of the literature, passive ultrasonic irrigation (PUI) was described as an adjunctive treatment for cleaning the root canal system and was more effective than syringe irrigation. Although acoustic streaming and cavitation appears to play an important role in its efficacy, the exact physical mechanism has not been explained (9). Others studies demonstrated that passive ultrasonic irrigation is an effective technique that improves debris removal from inside the canals and isthmuses (6, 11, 12), but the difference in efficacy between the use of passive sonic irrigation and ultrasonic irrigation has been debated (10-12).

Recently, two new activating devices have been introduced to the market: the Endoactivator (Dentsply, Tulsa Dental) and the F-file (Plastic Endo®, LLC). The EndoActivator uses sonic activation of the irrigants with a strong, flexible, medical-grade polymer composition tip. Sonic devices produce a larger disturbance of the irrigating solution around the tip and the mode of vibration is less affected by wall contact than when ultrasonic devices are used (13, 14). Preliminary trials have shown significantly cleaner canals using EndoActivator when compared with traditional irrigation (15). The F™ file is a single-use, plastic rotary file which has a unique file design with a diamond abrasive embedded into a non-toxic polymer. The F- file will remove dentinal wall debris and agitate the irrigant without further enlarging the canal.

A review of the literature reveals that presently there are a few published studies on the cleaning ability of F-Files. The purpose of this in vitro study is to evaluate the ability of EndoActivator, F-file and passive ultrasonic irrigation to clean canals when compared to syringe irrigation.

METHODS AND MATERIALS

SAMPLE SELECTION

Fifty six freshly extracted single rooted teeth were selected for this study. All teeth were radiographed in a bucco-lingual and a mesio-distal orientation, to ensure similar canal morphology. Teeth were stored in 0.9% saline following extraction. The teeth were decoronated to a standardized root length of 16 mm.

ROOT CANAL INSTRUMENTATION

The working length was determined using a size 10 file to the apex and subtracting 1mm from the length. The root canals of teeth in all the groups were instrumented using crown-down technique with Profile GT #40/.06 to the working length (Dentsply –Tulsa Dental, York, PA). During instrumentation, all 4 experimental groups were irrigated with 1 ml of 6.15% NaOCl (Clorox, Oakland, CA) between each file. The teeth were randomly distributed into 4 groups of 14 specimens.

FINAL IRRIGATION

Upon completion of the canal preparation, the apex was sealed with wax to prevent extrusion of irrigant through the apex during final irrigation. Each specimen received a final irrigation with 5ml of NaOCl and 5ml of EDTA, with each irrigant being activated according to their assigned group. All canals were finally irrigated with 5ml of NaOCl.

In group 1, the irrigants were not activated and served as a control.

In group 2, the irrigants underwent passive ultrasonic irrigation for 1 minute each, using Ultrasonic Suprasson P5 Newtron (Satelec Acteon Group, Merignac Cedex, France) at a power setting of 5 with a Satelec K20/21mm ultrasonic tip placed 1mm short of the working length and used in a cyclic axial movement.

In group 3, the irrigants were activated with the Endoactivator at 10,000 cpm for 1 minute using a 20/.04 tip, placed 1mm short of the working length, in a cyclic axial movement.

In group 4, the irrigants were activated with a size 20 F-file at 900 rpm, worked circumferentially along the dentinal walls in a cyclic axial motion, placed 1mm short of the working length for 1 minute.

Each irrigating solution was delivered using a 30-gauge ProRinse needle (Dentsply Tulsa Dental, Tulsa, OK), in a passive up and down motion, inserted to within 2 mm of the apex. Following chemomechanical preparation, the teeth were dried with paper points.

SPECIMEN PROCESSING AND EVALUATION

The specimens were then longitudinally sectioned, using a serrated laboratory diamond disk (Brasseler, Savannah, GA) to groove the buccal and lingual of each root. A 15 blade was tapped with a mallet along the groove to separate the halves. During sectioning, care was taken to avoid penetration into the canal space. Each half was dried for a minimum of 24 hours in a vacuum desiccator, attached to coded stubs, sputtered coated, and viewed with a scanning electron microscope (JOEL JSM – 6400).

Three photographs for each specimen were taken at a magnification of 500x to visualize the coronal, middle, and apical portion of the root canal system. The areas examined for each sample were standardized using parameters similar to those described by AL-Hadlaq (16) and Schafer (5). A digital photograph of the coronal, middle, and apical thirds were taken of each half of each specimen. A total of 336 images were independently analyzed by 2 calibrated, blinded evaluators using the following scoring system as previously described (17): Score 1, clean surface with very little to no debris, presenting open dentinal tubules throughout the canal wall (Fig 1A); Score 2, clean surface with some scattered debris and/or thin homogenous smear layer with some open or partially open dentinal tubules (Fig 1B); Score 3, mostly unclean surface containing debris and smear layer with few visible open or partially open dentinal tubules (Fig 1C); Score 4, unclean surface with large amount of debris and smear layer with no visible dentinal tubules (Fig 1D). When a disagreement in scoring occurred, an additional analysis was performed with both evaluators together until a consensus was reached. After scoring the samples, the code was broken and data was analyzed by Kruskal-Wallis statistical test set at significance level of $P \leq 0.05$.

Figure 1

Figure 1

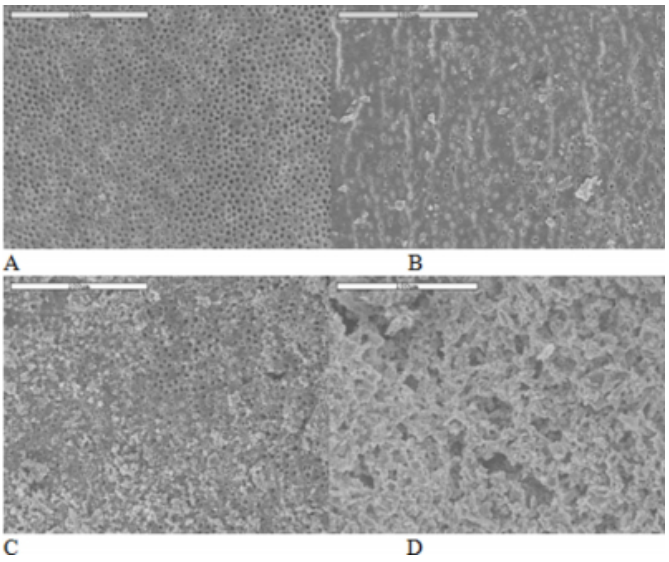

Figure 1 (A) This sample received a score of 1. It shows most of the dentinal tubules are open with a clean surface and very little debris. (B) This sample received a score of 2. It shows a clean surface with very little debris, a thin homogenous smear layer, and some partially open dentinal tubules. (C) This sample received a score of 3. It shows a mostly unclean surface containing debris and smear layer and few open dentinal tubules. (D) This received a score of 4. It shows an unclean surface with large amounts of debris and smear layer with no open dentinal tubules.

RESULTS

The EndoActivator cleaned the apical and the middle third of the canals significantly better than the F files ($p < 0.05$). Ultrasonic and the Endoactivator performed better than the control group in all thirds of the canals. F file was significantly better than the control only in the middle third. All techniques cleaned the coronal third of the canal significantly better than the apical third and the F files and the Ultrasonic cleaned the middle third also significantly better than the apical third. No group demonstrated completely clean canals (Figure 2).

Figure 2

Figure 2

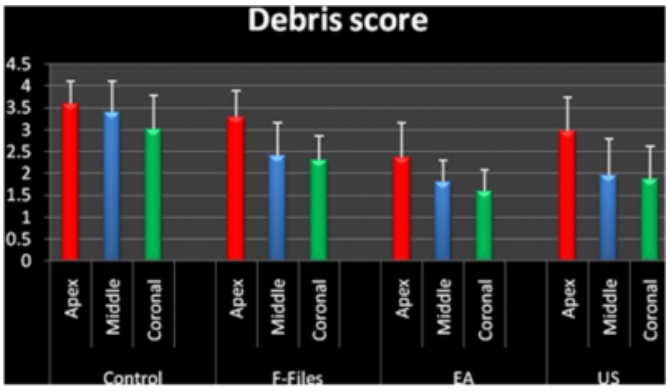

Figure 2 Dentin debris score (0-4) after activation of irrigation solutions (6.15% NaOCl and EDTA) with F-Files, EndoActivator (EA), Ultrasonic (US) and Control group (no activation).

DISCUSSION

Although the removal of smear layer has been shown to improve disinfection of the canal, the currently available techniques fail to do so from the entire canal walls (8, 18). Sabins et al. (12) reported that passive sonic and ultrasonic activation for 30 and 60 seconds produce significantly cleaner canals than irrigation alone, with passive ultrasonic irrigation producing significantly cleaner canals than passive sonic irrigation. Evaluation of root canal and isthmus cleanliness with one minute of ultrasonic needle activation produced significantly cleaner canal walls and isthmuses of vital teeth (19). A study evaluating the effect of different irrigation and activation systems on the penetration of NaOCl into simulated laterals canals, showed that PUI has better penetration of irrigant into lateral canals (20). One minute of ultrasonic activation significantly reduced debris and biofilm on the root canal walls and isthmuses of necrotic teeth after cleaning and shaping (21).

In this in vitro study the apexes of the teeth were blocked using wax to simulate clinical situation with the tooth apex being surrounded by the boney socket (22). This has been reported to cause entrapment of gas in the apical third, also referred to as vapor lock, thus hindering the complete removal of smear layer from this region (22). This could explain the higher debris score for all specimens in the apical third. The greater taper of the root canal preparation has been shown to result in a better removal of the smear layer from the apical third. This was attributed to the greater penetration of the irrigation needle (23, 24). The analysis of

the effect of needle penetration and fluid dynamics using a computer model, showed that placing the needle within 1mm from working length improve irrigants solutions cleaning properties at apical third (25), however clinically this could represent an unsafe situation where NaOCl can be extruded toward periapical tissues.

The inability of the different irrigation regimens to clear the smear layer from the apical third of the canal has led to research specifically aimed at this challenge (20, 26, 27). All of these studies relied on activation of the irrigants to achieve the desired results. In this study, activation of the irrigants with the EndoActivator and Ultrasonic improved the removal of smear layer in all thirds of the canals when compared to the control group. This is in agreement with the recently reported study where the use of an ultrasonic agitation increased the effectiveness of the final rinse procedure in the apical third of the canal walls (26). In the present study F-file did not perform better than the control in removal of smear layer from the apical and coronal third. A recent study which compared the F-Files to the ultrasonics found that the EDTA in the irrigation protocol was the significant contributor to the removal of smear layer rather than the activation technique itself (28). On the other hand Paragliola et al (26) found no difference between F-file and EndoActivator as irrigant agitation protocols in the penetration of an endodontic irrigant into dentinal tubules. Uroz et al concluded that EndoActivator did not enhance the removal of smear layer (27).

To conclude, in this in vitro study all teeth were found to have debris present, especially in the apical third. In summary, all techniques tested showed different degree of effectiveness in debris removal of the root canal system. The results demand the need for better irrigant protocols to completely remove debris from the apical third of the canal.

References

1. Waltimo T, Trope M, Haapasalo M, Orstavik D. Clinical efficacy of treatment procedures in endodontic infection control and one year follow-up of periapical healing. J Endod. 2005; 31: 863-866.
2. Davis SR, Brayton SM, Goldman M. The morphology of the prepared root canal: a study utilizing injectable silicone. Oral Surg Oral Med Oral Pathol. 1972; 34: 642-648.
3. Bahcall JK, Barss JT. Understanding and evaluating the endodontic file. Gen Dent. 2000; 48: 690-692.
4. Hulsmann M, Rummelin C, Schafers F. Root canal cleanliness after preparation with different endodontic handpieces and hand instruments: a comparative SEM investigation. J Endod. 1997; 23: 301-306.
5. Schafer E, Zapke K. A comparative scanning electron microscopic investigation of the efficacy of manual and automated instrumentation of root canals. J Endod. 2000; 26: 660-664.
6. Haidet J, Reader A, Beck M, Meyers W. An in vivo comparison of the step-back technique versus a step-back/ultrasonic technique in human mandibular molars. J Endod. 1989; 15: 195-199.
7. Baumgartner JC, Mader CL. A scanning electron microscopic evaluation of four root canal irrigation regimens. J Endod. 1987; 13: 147-157.
8. Teixeira CS, Felippe MC, Felippe WT. The effect of application time of EDTA and NaOCl on intracanal smear layer removal: an SEM analysis. Int Endod J. 2005; 38: 285-290.
9. van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. Int Endod J. 2007; 40: 415-426.
10. Jensen SA, Walker TL, Hutter JW, Nicoll BK. Comparison of the cleaning efficacy of passive sonic activation and passive ultrasonic activation after hand instrumentation in molar root canals. J Endod. 1999; 25: 735-738.
11. Lumley PJ, Walmsley AD, Walton RE, Rippin JW. Cleaning of oval canals using ultrasonic or sonic instrumentation. J Endod. 1993; 19: 453-457.
12. Sabins RA, Johnson JD, Hellstein JW. A comparison of the cleaning efficacy of short-term sonic and ultrasonic passive irrigation after hand instrumentation in molar root canals. J Endod. 2003; 29: 674-678.
13. Lumley PJ, Walmsley AD, Laird WR. Streaming patterns produced around endosonic files. Int Endod J. 1991; 24: 290-297.
14. Walmsley AD, Lumley PJ, Laird WR. Oscillatory pattern of sonically powered endodontic files. Int Endod J. 1989; 22: 125-132.
15. Ruddle CJ. Hydrodynamic disinfection: tsunami endodontics. Dent Today. 2007; 26: 110, 2, 4-7.
16. Al-Hadlaq SM, Al-Turaiki SA, Al-Sulami U, Saad AY. Efficacy of a new brush-covered irrigation needle in removing root canal debris: a scanning electron microscopic study. J Endod. 2006; 32: 1181-1184.
17. Soares F, Varella CH, Pileggi R, et al. Impact of Er,Cr:YSGG laser therapy on the cleanliness of the root canal walls of primary teeth. J Endod. 2008; 34: 474-477.
18. Violich DR, Chandler NP. The smear layer in endodontics - a review. Int Endod J. 2010; 43: 2-15.
19. Gutarts R, Nusstein J, Reader A, Beck M. In vivo debridement efficacy of ultrasonic irrigation following hand-rotary instrumentation in human mandibular molars. J Endod. 2005; 31: 166-170.
20. de Gregorio C, Estevez R, Cisneros R, et al. Effect of EDTA, sonic, and ultrasonic activation on the penetration of sodium hypochlorite into simulated lateral canals: an in vitro study. J Endod. 2009; 35: 891-895.
21. Burleson A, Nusstein J, Reader A, Beck M. The in vivo evaluation of hand/rotary/ultrasound instrumentation in necrotic, human mandibular molars. J Endod. 2007; 33: 782-787.
22. Tay FR, Gu LS, Schoeffel GJ, et al. Effect of vapor lock on root canal debridement by using a side-vented needle for positive-pressure irrigant delivery. J Endod. 2010; 36: 745-750.
23. Albrecht LJ, Baumgartner JC, Marshall JG. Evaluation of apical debris removal using various sizes and tapers of ProFile GT files. J Endod. 2004; 30: 425-428.
24. Sedgley CM, Nagel AC, Hall D, Applegate B. Influence of irrigant needle depth in removing bioluminescent bacteria inoculated into instrumented root canals using real-time

imaging in vitro. Int Endod J. 2005; 38: 97-104.
25. Boutsioukis C, Lambrianidis T, Verhaagen B, et al. The effect of needle-insertion depth on the irrigant flow in the root canal: evaluation using an unsteady computational fluid dynamics model. J Endod. 2010; 36: 1664-1668.
26. Paragliola R, Franco V, Fabiani C, et al. Final rinse optimization: influence of different agitation protocols. J Endod. 2010; 36: 282-285.
27. Uroz-Torres D, Gonzalez-Rodriguez MP, Ferrer-Luque CM. Effectiveness of the EndoActivator System in removing the smear layer after root canal instrumentation. J Endod. 2010; 36: 308-311.
28. Chopra S, Murray PE, Namerow KN. A scanning electron microscopic evaluation of the effectiveness of the F-file versus ultrasonic activation of a K-file to remove smear layer. J Endod. 2008; 34: 1243-1245.

Author Information

Uma P. Nair
Department of Endodontics, University of Florida College of Dentistry

Marianella Natera
Department of Endodontics, University of Florida College of Dentistry

Kevin Koscso
Department of Endodontics, University of Florida College of Dentistry

Prathibha Pillai
Department of Endodontics, University of Florida College of Dentistry

Claudio H. Varella
Department of Endodontics, University of Florida College of Dentistry

Roberta Pileggi
Department of Endodontics, University of Florida College of Dentistry