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Efficacy of Apple Vinegar as Final Irrigating Solution in Removing Smear Layer Using XP-Endo Finisher File

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ABSTRACT

Purpose: This study assessed the efficacy of Apple vinegar as final irrigating solution in removing smear layer using XP-Endo Finisher File by scanning microscope. **Material and Methods:** Fifty single rooted lower premolars were selected and prepared using Universal ProTaper rotary files. Samples were divided into two main groups (I,II) regarding the final rinse used (20 samples each) and control group (10 samples): Group I: rinsed with 17% EDTA, Group II: rinsed with Apple vinegar and Control group: irrigated with sterile saline. Each group was subdivided into two subgroups (A,B) regarding the agitation file. Subgroup A: Conventional irrigation, Subgroup B: agitated with XP Endo Finisher. Samples were grooved longitudinally and smear layer was assessed. **Results**: no statistically significant difference in the median scores of smear layer produced by 17% EDTA and Apple Vinegar at coronal, middle and apical root levels when conventional irrigation or XP Endo Finisher were used. There was a significant difference between two irrigating techniques at apical level when 17% EDTA used as final rinse, where XP Endo Finisher showed statistically significant lower median score ($P \leq 0.05$). **Conclusions:** Apple vinegar presented similar smear layer removal efficiency from intraradicular dentin compared to 17% EDTA when used as final rinse. XP-Endo Finisher is a successful agitation system for removal of smear layer from intraradicular dentin.

KEYWORDS

Irrigation,
apple vinegar, agitation techniques,
XP endo finisher file

INTRODUCTION

The success of root canal treatment depends on removing pulp remnants, microorganisms and microbial toxins, which could be achieved through chemomechanical debridement. During chemomechanical

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preparation, debris accumulates on the wall of the canal creating an amorphous layer [1].

The most popular irrigating solution is NaOCl due to its efficacy of tissue dissolution and antimicrobial activity. Even though these excellent properties, its capacity in removing the organic part of the smear layer has been found to be lacking[2]. Chelating agents are efficient in removing the inorganic part of the smear layer. The most common chelating solution is EDTA [3].

Natural irrigants such as apple vinegar have been introduced to minimize the harmful effect of EDTA on dentin and periapical tissues. Using of apple vinegar as irrigant in the chemomechanical process has been proposed due to its promising results that are similar to EDTA [4]. It has high biocompatibility due to containing high concentration of malic acid [5]. Several studies evaluated the effect of apple vinegar on the endodontic microbes and the periapical tissue [6-8]. Apple vinegar is efficient chelating agent with bactericidal effect on microorganisms [9,10].

Several studies evaluated the efficacy of apple vinegar on removing smear layer and they concluded that apple vinegar was more effective when used for one minute as final rinse in removing smear layer without affecting the calcium content of intraradicular dentin compared to 17% EDTA [11-14].

Irrigation techniques have been enhanced the effect of irrigating solutions inside the root canal [15]. Recently, a new nickel–titanium rotary finishing file, the XP-Endo Finisher file (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), was introduced to improve cleaning of the root canal [16].

The basic principles of the XP-endo Finisher file are their shape-memory of NiTi alloy. They are straight at room temperature in M- phase. When they are put in the canal at body temperature, their shape will be changed depend on their molecular memory to the A- phase. This A – phase makes the files reach difficult areas to be cleaned by standard instrument [17].

Evaluation of the power of XP-endo Finisher files after chemomechanical preparation in cleaning the coronal, middle and apical third. These resulted that using XP-endo Finisher after chemomechanical preparation effectively cleaned canal walls and removed smear layer [18,19]. Other studies compared the effect of XP-endo Finisher files and other agitation techniques. They found that agitation improve the cleaning of root canal wall especially at the apical level [20-24]. This study was evaluated the efficacy of Apple vinegar on removing smear layer using XP Endo-finisher file and comparing its results with a well-established one.

MATERIAL AND METHODS

Teeth selection and root canal preparation:

Fifty extracted single rooted lower premolars with single canal were selected and rinsed under water to eliminate the debris. Tooth was decapitated at the cemento-enamel junction under cooling and the root length was 14 mm. Working length was measured by subtracting 1mm when tip of #10 K-file (MANI Inc., Japan) became observed at the apical foramen.

ProTaper Universal rotary NiTi files (Dentsply, Maillfer, Switzerland) were used in a crown-down manner for root canal preparation with torque and speed adjusted according to manufacturers' recommendations for each file used. A set of six instruments were used, the first three files were used for coronal 2/3 preparation and the other three files were used for apical preparation. After each instrument use, irrigation was done with a fresh preparation of 2 ml 2.6% NaOCl solution (Alex. Deteregents and Chemical Co., Egypt) for 1 minute dispensed through a 31 gauge Navi-Tip flexible irrigating needle (Navi-Tip, Ultradent product, South Jourdan, UT).

Samples grouping:

After sample preparation, the samples were divided into two main groups (I, II) according to the

final rinse used (20 samples each) and control group (10 samples): **Group I**: irrigated with 17% EDTA (Amrit Chem& Min. Ag, Mohali, India), **Group II**: Samples were irrigated with Apple vinegar (Kemal Kükrer Apple Vinegar- Turkey) and Control group: Samples were irrigated with sterile saline (Al-Mottahedoon Pharma, Egypt).

Each main group was subdivided into two subgroups (A and B) according to the agitation file used: Subgroup A: Conventional irrigation with no agitation, where the final rinse was done using 5 ml of each solution for 1 minute, dispensed through a 31-gauge Navi-Tip flexible irrigating needle. Subgroup B: Conventional Irrigation agitated with XP Endo Finisher, where the final rinse was done using 5 ml of each solution agitated with XP Endo Finisher (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), where the finisher was taken from sterile packaging, placed in the handpiece and the working length was determined using plastic tube and stopper.

The XP Endo Finisher was used with 16:1 reduction handpiece that was by an electric motor; set at a rotational speed of 800 rpm and a torque of 1 N.cm, then advanced to working length using gentle 7-8 mm lengthwise movements of insertion and withdrawal that was applied in the canal filled with final rinse for 1 minute. When XP Endo Finisher was inserted into root canal, exposed to the temperature of the body, the shape was changed depending on the A- phase. After each use, a file was cooled using ethyl alcohol spray (Medical Union Pharmaceutical, Egypt) through the plastic tube. After the final rinse, all samples were rinsed with distilled water (Ostuka pharm, Egypt) and dried by paper point.

Scanning electron microscopic evaluation:

Groove was done longitudinally on the external surfaces of each sample (buccal &lingual) by a diamond disc, without reach the entire canal, and then carefully splitted by a chisel and mallet. The hemisected side of each tooth which contained the whole length of the root canal was selected. Sample was measured length wise by a caliper at cementoenamel junction (CEJ) to the apex to determine the three root thirds. Points corresponding to the half of the three thirds were demarcated to scan.

Root canals cleanliness and smear layer were evaluated at three root levels by SEM (FEI Company, Nertherland). Photomicrographs were taken under magnification (X 4000) for evaluation of smear layer and analyzed by means of numerical evaluation score [25].

Statistical analysis

Data were explored for normality by checking data distribution and using Kolmogorov-Smirnov and Shapiro-Wilk tests of normality. Data were presented as mean values and standard deviation (SD). For non-parametric data; Kruskal-Wallis test was used to compare between irrigants. Mann-Whitney U test was used to compare between two irrigating techniques. Friedman's test was used to compare between root levels. Dunn's test was used for pair-wise comparisons when Kruskal-Wallis test or Friedman's test was significant. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics Version 20 for Windows.

RESULTS

Comparison of smear layer scores between tested irrigants at each root level:

Minimum, maximum and median of all groups will be presented in table (1). There was no statistically significant difference in the median scores of smear layer produced by 17% EDTA and Apple Vinegar at all levels when conventional irrigation or XP Endo Finisher were used.

Table 1: *Minimum, maximum and median of smear layer scores comparing the tested irrigants and control group at the all root levels by different irrigating technique*

Irrigating technique	Root level	Group I (17% EDTA)			Group II (Apple vinegar)			Control group (Saline)			*P*-value
		Minimum	Maximum	Median	Minimum	Maximum	Median	Minimum	Maximum	Median	
Conventional irrigation	Coronal	1	2	1[B]	1	2	1[B]	3	4	3[A]	0.001*
	Middle	1	3	2[B]	1	2	1.5[B]	3	4	4[A]	0.001*
	Apical	2	3	3[B]	2	3	3[B]	4	5	5[A]	<0.001*
	Total	1.33	2.33	2[B]	1.33	2.33	2[B]	3.67	4.33	4[A]	0.002*
XP Endo Finisher file	Coronal	1	2	1[B]	1	2	1[B]	3	4	3[A]	<0.001*
	Middle	1	2	1.5[B]	1	2	1.5[B]	3	4	4[A]	0.001*
	Apical	2	3	2[B]	2	3	2.5[B]	4	5	4[A]	0.001*
	Total	1.33	2	1.67[B]	1.33	2.33	1.67[B]	3.33	4.33	3.67[A]	0.002*

**: Significant at P ≤ 0.05.*

Comparison of smear layer scores between irrigating techniques within each group at each root level:

Minimum, maximum and median of all groups will be presented in table (2). There was a statistically significant difference between irrigating techniques (conventional irrigation and XP Endo Finisher file) at apical level when 17% EDTA used as final rinse, where XP Endo Finisher file showed statistically significant lower median smear layer score (P = 0.023). Figure (1)

Table 2: *Minimum, maximum and median of smear layer scores comparing the different irrigating techniques at all root levels with the tested irrigants and control group.*

Irrigant	Root level	Conventional irrigation			XP Endo Finisher file			*P*-value
		Min	Max	Median	Min	Max	Median	
Group I (17 % EDTA)	Coronal	1	2	1	1	2	1	0.739
	Middle	1	3	2	1	2	1.5	0.353
	Apical	2	3	3	2	3	2	0.023*
	Total	1.33	2.33	2	1.33	2	1.67	0.029*
Group II (Apple vinegar)	Coronal	1	2	1	1	2	1	0.690
	Middle	1	2	1.5	1	2	1.5	1.000
	Apical	2	3	3	2	3	2.5	0.310
	Total	1.33	2.33	2	1.33	2.33	1.67	0.310
Control group (Saline)	Coronal	3	4	3	3	4	3	0.690
	Middle	3	4	4	3	4	4	1.000
	Apical	4	5	5	4	5	4	0.310
	Total	3.67	4.33	4	3.33	4.33	3.67	0.310

**: significant at P ≤ 0.05.*

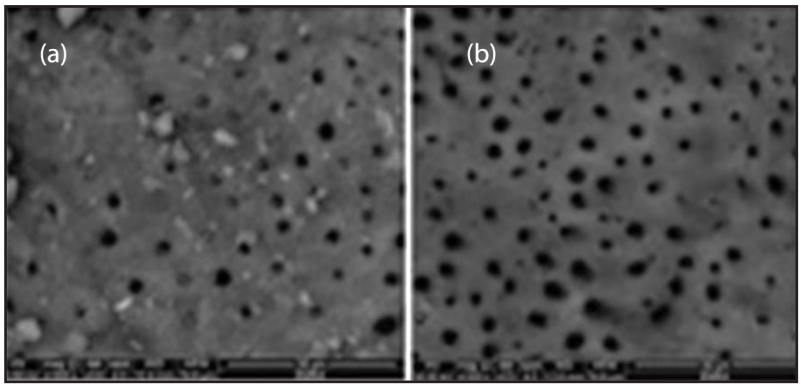

Figure (1) A scanning photomicrograph of the apical level of a root canal rinsed with 17% EDTA by conventional irrigation (A) and XP Endo Finisher file (B).

With group II (Apple vinegar): At the apical level, samples treated with XP Endo Finisher file recorded lower median smear layer scores compared to that recorded with conventional irrigation. However, no statistical significant difference between the two irrigating techniques (conventional irrigation and XP Endo Finisher file) at all levels (P =0.690, 1.000 and 0.310). Figure (2)

Comparison of smear layer scores among the root levels within each group:

The results showed that the apical level showed the statistically significantly highest median smear layer score compared to the middle and coronal levels. However, there was no statistical significant difference between the middle and coronal levels regardless the type of irrigant.

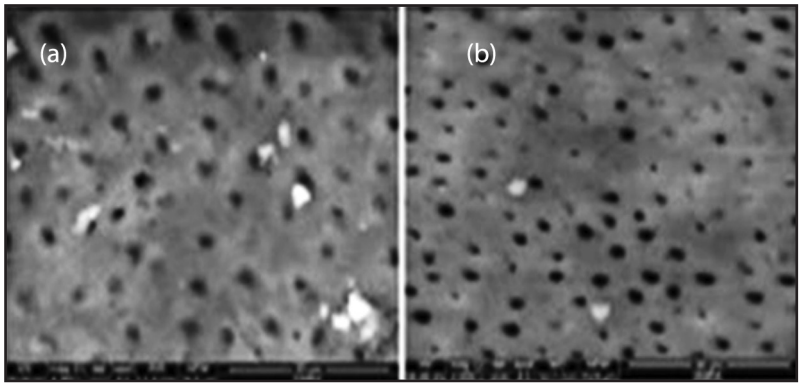

Figure (2) A scanning photomicrograph of the apical level of a root canal rinsed with Apple vinegar by conventional irrigation (A) and XP Endo Finisher file (B).

DISCUSSION

There is no irrigating solution acts simultaneously on the two component of the smear layer (organic and inorganic). Sodium Hypochlorite combined with EDTA has been used for efficient removal of smear layer [26-28]. Searching for chelating agent that is more efficient and biocompatible than EDTA has resulted in various solutions being researched over the last few years. Accordingly, apple vinegar was used in the present study due to its biocompatibility, chelating capacity, antimicrobial potential and its cost-effectiveness [4,6,13].

A volume of 5 ml 17% EDTA and commercial apple vinegar was used as final rinse after irrigation with NaOCl, for 1 minute. Since it has been reported that irrigation with 5 ml 17% EDTA for 1 min contact time was efficient in smear layer removal [29.30]. Similarly, it has been showed that irrigation with apple vinegar applied for 1 minute was efficient in smear layer removal [4,6].

Irrigating needle is the most well-known method used in irrigation. It is proved that this method has less efficiency in the apical level [15]. The apical third of the curved root canal is not able to be cleaned due

to the apical third size is small that interfere with the action of the irrigating solutions [15,31]. Therefore, XP-endo Finisher file was used in this study after final rinse to remove the debris and smear layer in root canals after biomechanical instrumentation by using SEM. Several studies have shown that XP-endo Finisher file is powerful in smear layer removal [18,22].

Effect of irrigant on smear layer scores:

In this study, no statistical significant difference in the median smear layer scores produced by 17% EDTA and Apple vinegar at all root canal levels.

Samples treated with Apple vinegar showed lower median smear layer score in the middle third compared to that treated with 17% EDTA. These results might be attributed to that apple vinegar has acids in its constitution, and the malic acid is the main component which is responsible for the therapeutic property of the apple vinegar [32]. These results were in agreement with previous study that reported the more efficacy of Apple vinegar to remove smear layer [13].

The lower median smear layer score with apple vinegar reported in this study was in disagreement with previous study, which revealed that the apple vinegar was not able to clean the canal wall, with significant difference between EDTA at the coronal third. These discrepancies might be attributed to differences in the selected teeth, where they used less volume of apple vinegar (3ml) and less volume of NaOCl irrigation [33].

Effect of irrigating techniques on smear layer scores:

Samples treated with XP Endo Finisher file recorded lower median smear layer scores compared to that recorded with conventional irrigation at the apical level regardless the type of irrigant. However, no statistically significant difference between two irrigating techniques (conventional irrigation and XP Endo Finisher file) when Apple vinegar used as final rinse.

The results of this study attributed to the specific design of XP-endo Finisher file that can reach inaccessible parts of the canal and provide better cleaning. Its Small diameter (ISO 25) and the fact that it can change its shape during rotation in the canal (M and A phase) allow this file to reach inaccessible areas of the canal wall and efficiently remove dentin debris and smear layer. Due to its highly flexible proprietary without taper which with efficient irrigation in instrumented canals can remove smear layer and dentin debris from inaccessible areas [17].

Results of this study was in agreement with previous studies reported that XP-endo Finisher file was more effective for removing smear layer in comparison to different irrigation regimens [18,19,24].

The results of the current study showed that no statistical significant difference between the two irrigating techniques (conventional irrigation and XP Endo Finisher file) at the coronal and middle levels regardless the type of irrigant.

The results of the current study can be explained by tha easy reach of the coronal and middle thirds which have larger diameter of dentinal tubules orifices by instruments and chemical solutions [13].

In this study, the results was in agreement with another study reported that coronal and middle thirds was less challenging for smear layer removal by XP-endo Finisher file comparing to other root canal levels [24]

Effect of root level on smear layer scores:

In this study, results showed that, there was a statistically significant difference between the all root levels in the median smear layer scores. The apical level showed the statistically significantly highest median smear layer score compared to the middle and coronal levels. However, there was no statistical significant difference between the middle and coronal levels.

It has been reported that, coronal and middle levels have less challenge in smear layer removal in comparable with the apical level. That is due to the size of the canal in these thirds is larger than in the apical which enhance the irrigating solution efficiency [14].

At apical level, in general, it has been proved that there was a definite decline in the efficiency of irrigating solution in the apical third. This could be due to the fact that dentin is more sclerosed in the apical level and there is reduction in root canal and dentinal tubules diameter, which impairs the access of irrigant, with consequent reduction in its flow [34].

These results of were in agreement with other studies reported that low effectiveness of irrigants in cleaning the apical third [35,36].

On the other hand, results of this study was in disagreement with another study reported that, EDTA produced efficient smear layer removal from all root thirds. This could be clarified by the large size of apical diameter as the canal was prepared to a size F5 ProTaper Universal file. Increase the apical size facilitates exposure of dentin to larger volumes of irrigants which improve the efficiency of the irrigant [37].

CONCLUSIONS

1. Apple vinegar presented similar smear layer removal efficiency from intraradicular dentin compared to 17% EDTA when used as final rinse.
2. The irrigation methods may affect the smear layer removal efficiency of Apple vinegar when used as final rinse.
3. XP-Endo Finisher file is an effective root canal agitation system for smear layer removal from intraradicular dentin when using Apple vinegar or 17% EDTA as final rinse.

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