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Smear Layer Removal and Apical Extrusion Evaluation Among Different Irrigating Techniques and Solutions (In vitro Comparative study)

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Abstract

Objectives: The aim of the present study was to compare the effectiveness of Endovac, Vibringe and needle with different irrigation solutions on removal of smear layer and apical extrusion of irrigating solution.

Methods: Seventy-two sound human premolar teeth were used and divided into three experimental groups (n=24) according to the type of irrigation technique used: In-group 1 irrigation was performed with Vibringe. In-group 2 irrigation was performed with a 30-gauge side-vented irrigation needle. In-group 3 irrigation was performed with Endovac. Instrumentation was performed by using the ProTaper files. Each main group divided into three sub-groups (n=8) according to irrigation solution used: In sub-group 1 Irrigation was performed with 5.25% Sodium hypochlorite (NaOCL). In sub-group 2 Irrigation was performed with 17% Ethylene Diamin Tetra Acidic Acid (EDTA). In sub-group 3 Irrigation was performed with 5.25% NaOCL and 17 % EDTA. The amount of extruded irrigating solution was then measured by subtracting the weight before final irrigation from the weight after final irrigation using the electronic balance. The cleanliness of smear layer removal was evaluated using scanning electron microscopy.

Results: The results showed that the group that resulted in more irrigation extrusion was as follow from highest to lowest: side-vented >Vibringe> Endovac. The difference among all groups was significant. As for cleaning results, smear layer collection in both EndoVac and Vibringe groups were less than side-vented group and these differences were significant. When the three irrigating solutions compared the differences among all the groups were significant and combination of (5.25% NaOCL and 17 % EDTA) resulted in more smear layer removal.

Conclusion: In conclusion, the EndoVac irrigation system extruded significantly less irrigant solution than both the Vibringe and needle irrigation systems. Smear layer collection was least in the apical third regarding the EndoVac irrigation system and resulted in more Smear layer removal. And combination of NaOCL and EDTA group was more effective on smear layer removal than other two groups.

Keywords: Endovac, EDTA, Smear layer, ProTaper

Introduction

Chemomechanical debridement is an important part of endodontic treatment. Elimination of pulpal tissue, microbiota and their by-products, and organic and inorganic debris removal by using instruments and intracanal irrigants are objectives of this important phase of treatment. Sodium hypochlorite along with EDTA is able to achieve the goal of chemical debridement (1).

It has been demonstrated that debris accumulation is a potential side effect of root canal instrumentation and that accumulated debris certainly has a negative impact on the sealing ability of root canal fillings. Traditionally, irrigation during root canal treatments involved placement of an end-port or side-port needle into the canal and expressing solution out of the needle to be suctioned coronally this creates a positive pressure system with force created at the end of the needle, which may lead to solution being forced into the periapical tissues (2)

The Vibringe is the first endodontic irrigation device to combine manual delivery of the solution with the patented micro-processor controlled sonic technology, which called the sonic flow technology. This enables delivery and activation of the irrigation solution in one step (3). Endovac system is a commercially available negative pressure irrigation system that is designed to deliver irrigating solution to the apical end of the canal system and remove debris via a negative pressure mechanism (4).

According to researcher's knowledge no studies have been performed to evaluate the efficiency of different technique on smear layer removal during root canal treatment so this study designed to Compare and evaluate the efficiency of (conventional irrigation system side-vented needle), sonic irrigation system (Vibringe) and apical negative pressure (EndoVac irrigation system) in removing of dentin debris at three levels of root canal, and apical extrusion of irrigating solutions, and lastly to compare the effect of different irrigating solutions (EDTA, NaOCL, and combination of both) on smear layer removal.

Materials and Methods

Seventy two sound human premolar teeth extracted for orthodontic reason age between 15-35 years Fully formed roots with mature apices and no sign of abnormal defects (fractures, cracked roots) or open apices as described by Rathke et al (2009) (5) were used. A standard endodontic access cavity preparation was made occlusaly into the pulp chamber using carbide bur. Working length (WL) was established by introducing a size 10 K-file into the root canal until the tip of the instrument was visible at the apical foramen. Working length (WL) was then established by subtracting 1 mm from the length of the file (Demiryurek et al, 2009) (6) length of all teeth standardized at (21±1mm). Each tooth was then rigidly fixed and secured with a clear cold acrylic resin in a clear plastic collecting vial with rubber top to collect the extruded irrigation solution as depended by (Desai and Himel, 2009) (7)

The samples were used and divided into three experimental groups (n=24) according to the type of irrigation technique used as shown in (Fig.1): In group 1 irrigation was performed with Vibringe. In group 2 irrigation was performed with a 30 gauge side-vented irrigation needle. In group 3 irrigation was performed with Endovac. The

teeth were prepared with rotary system and proTaper nickel titanium files.

Each main group divided into three sub-groups (n=8) according to irrigation solution used: In sub-group 1 Irrigation was performed with 5.25% Sodium hypochlorite (NaOCL). In sub-group 2 Irrigation was performed with 17% Ethylene Diamin Tetra Acidic Acid (EDTA). In sub-group 3 Irrigation was performed with 5.25% NaOCL and 17 % EDTA. The amount of extruded irrigating solution was then measured by subtracting the weight before final irrigation from the weight after final irrigation using the electronic balance. The cleanliness of smear layer removal was evaluated using scanning electron microscopy.

Cleanliness Evaluation

The method of cleanliness evaluation was performed depending on Al-Hadlaq et al (2006) (8) Teeth were removed from the collecting tubes and sectioned into two halves by using a carborundum disk to create longitudinal grooves on the buccal and lingual surfaces without entering into the canals. The teeth were then splitted using a chisel. The part which showed most visible part of the canal was taken, then it was divided into three main parts (coronal, middle, and apical) by creating two horizontal grooves using a tapered fissured carbide bur perpendicular to the canal then observed by SEM at 700 X.

SEM pictures were evaluated by two calibrated evaluators using a standard scoring system depending on Vineet and Sonali (2012) (9) as outlined below:

Score	Description
0	Root canal surface free of smear layer leaving the openings totally exposed.
1	Root canal surface covered with smear layer only at the opening of dentinal tubules.
2	Root canal surface with a thin covering of residue on the dentinal tubules with visible tubules in few regions.
3	Surface covered with smear layer with no dentinal tubule openings visible

Statistical Analysis

The statistical analysis was performed using the SPSS software package (Version 20, SPSS Inc., Chicago, Illinois, USA). Descriptive analysis for the sample, mean values, range and standard deviation were calculated and using One-Way ANOVA analysis and LSD Test (Less Significant Difference)..The level of statistical significance was set at $p < 0.05$. And highly significance set at $P<0.001$.

Result

The Extruded Irrigating Solution:

The results showed that the group that resulted in more irrigation extrusion was as follow from highest to lowest: side-vented >Vibringe> Endovac. The difference among all groups was significant as described in the table (1) from the table it was observed that the mean weight difference of the extruded irrigant for the three experimental groups was most for the side-vented group (0 .192225) followed by Vibringe group (0.099321) and least for the EndoVac group (0.016567) (table 1) (Figure 3). A One-Way ANOVA analysis among the three different experimental groups showed statistical significant difference between them at ($P \leq 0.05$) (Table 1).

Effect of different irrigating techniques on smear layer removal

As for cleaning results, smear layer collection in both EndoVac and Vibringe groups were less than side-vented group and these differences were significant. The Endovac cleaned

and least smear layer remained (1.5555) than both the vibringe (1.7500) and syringe scoring (2.3333) (table 2) (Figure 4). Endovac and vibringe performed better than the Syringe group and statistically a significant difference was seen among Endovac and Syringe at P=0.005, also the difference among Vibringe and Syringe was significant at P=0.035. While the difference among Endovac and Vibringe was statistically not significant and P value was 0.476.

Effect of different irrigating solutions on smear layer removal

When the three irrigating solutions compared the differences among all the groups were significant and combination of (5.25% NaOCL and 17 % EDTA) resulted in more smear layer removal. Results of effects of different irrigation solutions are illustrated in table 3 and figure 5.

Discussion

Irrigating solution extrusion

Results obtained from the present in vitro study showed that the method of activation and delivery of irrigating solution into the apical third play a role in the amount of extrusion into the apical tissues. (10). The results of this study confirmed that the EndoVac irrigation system extruded a minimal irrigant solution that could be considered insignificant and most of the samples recorded no extrusion at all when compared with side-vented irrigating needle, as the electronic balance that was used in this study is very sensitive to record any additional weight. The results of this study are in agreement with Neilsen and Baumgartner (11), and Desai and Himel (7), who concluded that negative pressure irrigation is a controlled effective method to deliver irrigants into the apical third of the canal system.

EndoVac group extruded significantly less irrigant than the side-vented group, which supports Lambriandis et al (12), confirming that irrigation with positive pressure resulted in apical extrusion. And when Vibringe was used apical extrusion of irrigating solutions was more than that of Endovac and statistically the difference was significant, and resulted in less extrusion than side-vented syringe that was statistically highly significant and this in agreement with (Desai and Himel, (7) as they found that apical extrusion of water was significantly reduced when using sonic or apical negative pressure devices compared with syringe and side-port needle or passive ultrasonic irrigation (PUI) with continuous irrigant flow .

This is an in vitro study conducted on extracted teeth. So it should be known that the extrusion results of this study may be different if they were applied to vital teeth with the presence of periapical tissue that may resist the apical extrusion of irrigants and smear layer in vivo (13).

Effect of different irrigating techniques on smear layer removal

Both Endovac and Vibringe performed better than Side-vented Needle. The Endovac system showed least amount of smear layer remaining among all groups but statically, no significant difference found between the Endovac system and Vibringe system., Endovac removes smear layer better than conventional needle irrigation as shown by previous studies Siu and Baumgartner (14); and Shin et al (15). The explanations for these results might be related to the depth of the irrigation needles; in the conventional needle irrigation group, we limited the depth of needle

penetration to 2 mm from WL, similar to clinical use of needle irrigation.With the Endovac, irrigant is pulled into the canal and removed by negative pressure at working length; the microcannula was inserted to WL. Increased conventional needle penetration depth closer to WL has been correlated to increased debris reduction (Sedgley et al, 2005) 2. The volume of irrigant delivered to the canal apically by the Endovac system was significantly higher than the volume delivered by conventional syringe needle irrigation during the same time period (11).

The superior efficiency of the Vibringe group in removing dentin debris is in agreement with Rodig et al (16). They found that the Vibringe System performed significantly better than conventional syringe irrigation in the apical part of the root canal. In spite of the Vibringe and conventional groups used the same type and gauge needles (maxi-I-probe gauge 28 which equivalent to ISO size 40) and the Vibringe system only activated at the final irrigation. However, the Vibringe show superior removal of dentin debris because of the oscillation amplitude of the sonically activated irrigation needle, resulting in an increased fluid velocity and increasing the capacity of sodium hypochlorite to dissolve organic tissue and removing of debris. While the limitations of positive-pressure irrigation (conventional irrigation) alone, particularly at the apical third, might be related to the presence of gasses in the apical region forming a vapor lock into which further fluid penetration is difficult (17, 18).

Effect of different irrigating solutions on smear layer removal

NaOCL (2-25% - 5.25%) is a most commonly used irrigant in endodontic therapy it has not shown to effectively remove the smear layer but effectively dissolves organic tissue. EDTA (17%) is an inorganic solvent and chelating agent. EDTA is effective in removal of smear layer on the dentinal wall. To accomplish the ability of root canal irrigant to remove smear layer and debris an alternate use of NaOCL and EDTA has been tried. A number of studies showed that smear layer may be removed to achieve successful union of obturant and root canal walls (19)

An ideal root canal irrigant should have the property of dissolving both organic and inorganic components of smear layer with a microbicidal property. The chelating action of EDTA results in a wide opening of the dentinal tubules in the root canal walls, sometimes also completely destroying the intertubular dentin in the region. (20).

In this study the specimens irrigated with EDTA (group 2) alone scored (1.7916). Partial removal of smear layer it has the capacity to dissolve inorganic components of smear layer only. NaOcl is a reducing agent which is the most commonly used root canal irrigant in concentration from 1.0% to 5.25%. It has the ability to remove loose superficial debris and dissolve organic debris by release of hypochlorous acid which reacts with insoluble protein to form soluble peptides. But it failed to remove the inorganic component of smear layer completely. NaOCL (group 1) during or after instrumentation produces superficially clean canal walls with the smear layer present (Kennedy et al, 1986). When group 3 (Combined) was compared with other two groups, the NaOCL and EDTA combination showed the ability to deminiralize inorganic component of smear layer and dissolve organic component. The solution when compared with other two groups the

results of this study indicate that sodium hypochlorite did not remove the smear and this is in agreement with studies done by many researchers (20, 21)

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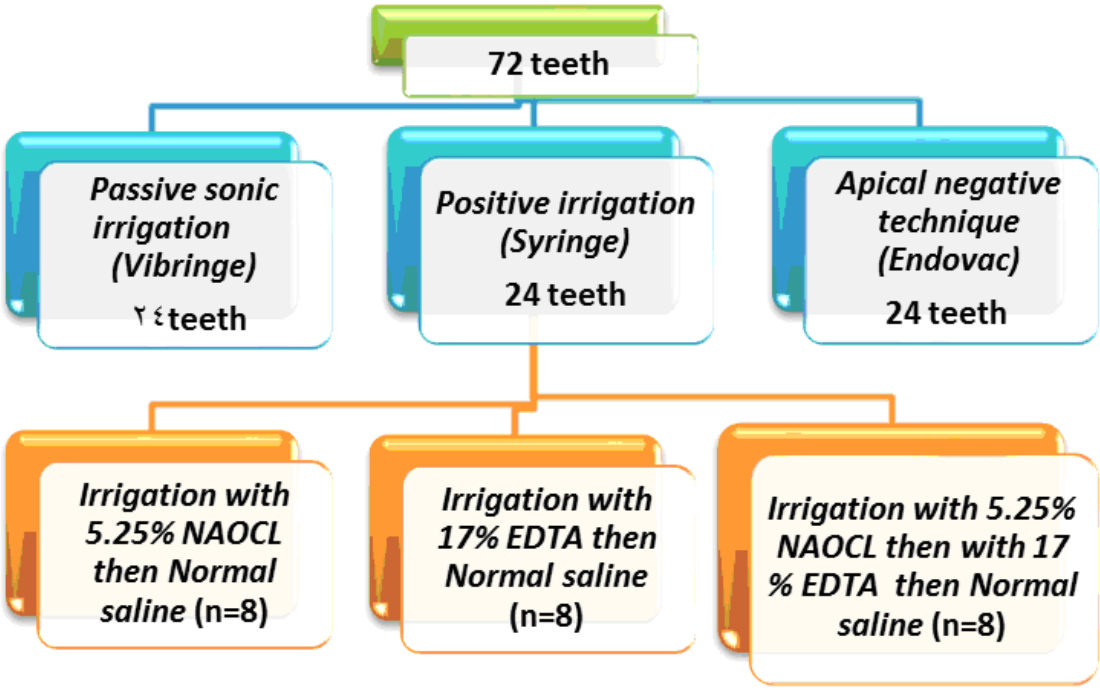

Figure 1: sample grouping

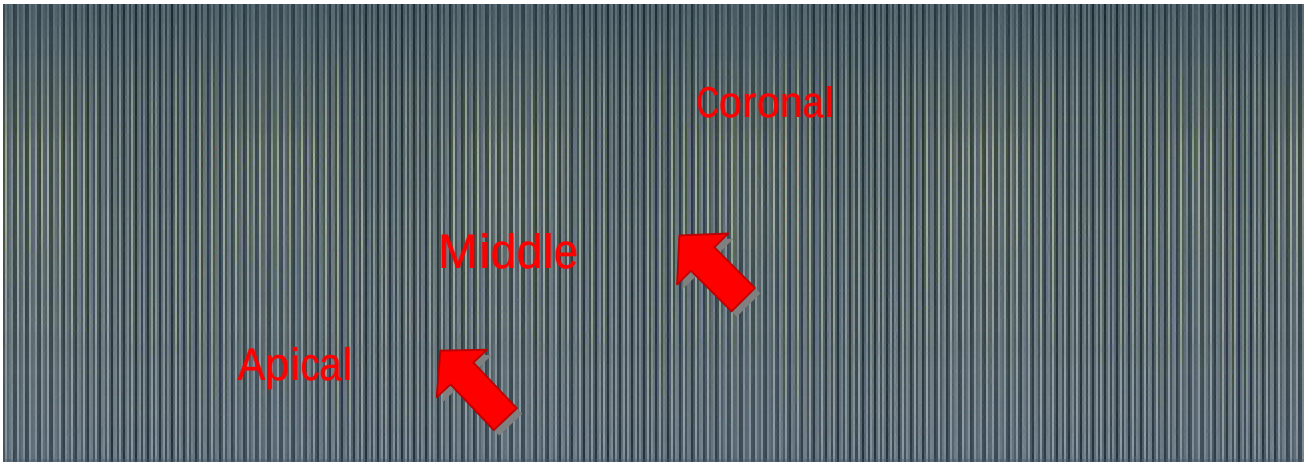

Figure 2: Sample preparation for SEM

Table 1: One-Way ANOVA Test Descriptive statistical Comparison of Mean Weight Difference of Extruded Irrigation among the Three Experimental Groups (LSD)

g	N	Mean of Wigh	Std. D.	g	N	Mean of Wigh	Std. D.	Sig
g1	24	.0993	.0446	g2	24	.1922	.0240	.026*
g1	24	.0993	.0446	g3	24	.0165	.0197	.047*
g2	24	.1922	.0240	g3	24	.0165	.0197	.000**

* Significant at p<0.05 ** Highly Significant

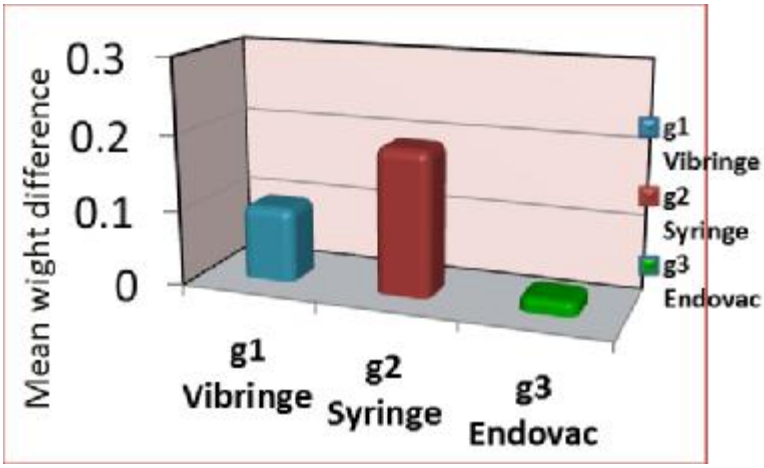

Figure 3: Apical extrusions of different irrigating techniques

Table 2: One Way ANOVA Comparison of different techniques on smear layer removal

group	N	Mean	Std. D.	group	N	Mean	Std. D.	Sig
g1	24	1.7500	0.9890	g2	24	2.3333	0.8164	.035
g1	24	1.7500	0.9890	g3	24	1.5555	1.0000	.476
g2	24	2.3333	0.8164	g3	24	1.5555	1.0000	.005*

*. The mean difference is significant at the 0.05 level

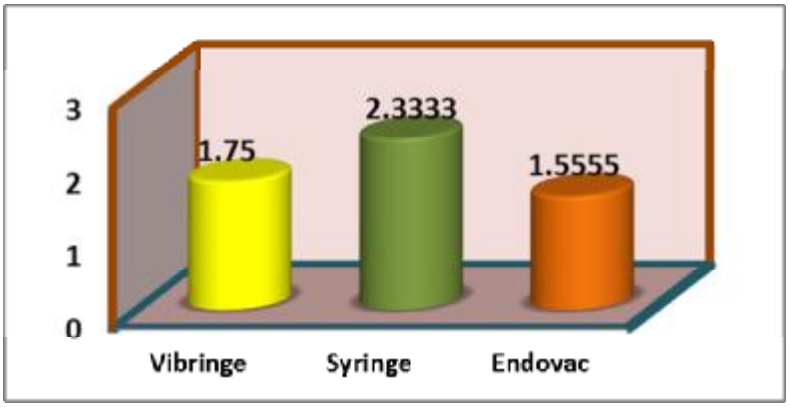

Figure 4: Scores of smear layer remained after irrigation with different techniques

Table 3: Effect of different irrigating solution on smear layer removal One Way ANOVA test

group	n	Mean	Std. D.	group	n	Mean	Std .D.	Sig
g1 NaOCL	24	2.4166	0.8297	g2 EDTA	24	1.7916	1.1787	.035*
g1 NaOCL	24	2.4166	0.8297	g3 Comb.	24	1.1388	0.9776	.000**
g2 EDTA	24	1.7916	1.1787	g3 Comb.	24	1.1388	0.9776	.028*

* The mean difference is significant at the 0.05 level

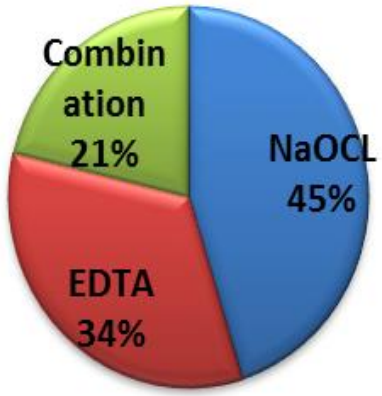

Figure 5: A pie chart of the percentage of debris remained of each irrigating solution