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In Vitro Comparison of Gutta-Percha Removal Using XP Endo Finisher and ProTaper With or Without Organic Solvent by Scanning Electron Microscope

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ABSTRACT

Introduction: Non-surgical endodontic retreatment is highly dependent on the removal of previous root filling material, bacteria and necrotic tissue. Various techniques and instruments have been used for endodontic retreatment. Recently, the XP-endo Finisher has been introduced in endodontic treatment to clean highly complex morphologies and difficult to reach areas.
Aims: a) To compare the effectiveness of XP-endo Finisher and ProTaper universal retreatment system with or without organic solvent in removing gutta-percha. b) To compare the amount of apically extruded debris between the groups. Methods: 24-human- extracted, single-rooted teeth were divided into three groups of 8. The groups were classified as follows: Group I: using a ProTaper universal retreatment system with chloroform. Group II: using a ProTaper universal retreatment system without chloroform. Group III: using a ProTaper universal retreatment system followed by XP-endo Finisher without chloroform. The apically extruded debris was collected during the retreatment and weighted. The roots were split longitudinally. The degree of dentinal tubules patency was evaluated by scanning electron microscopy.
Results: The most intensely clear dentinal tubules were observed in group III, followed by group II and group I, respectively. Group I resulted in a debris extrusion, significantly less, as compared with the other groups ($P < 0.05$). While there was no notable difference between group II and group III ($P > 0.05$).
Conclusion: Under the conditions of the present study, out of all the retreatment techniques that were used, the XP-endo Finisher was the most effective in the removal of the gutta-percha in cervical, middle and apical thirds. The use of solvent during retreatment can decrease the amount of the apically extruded debris.

1. Introduction

Root canal treatment is known as a non-surgical procedure, which is used to treat two certain endodontic disease entities: (1) an irreversibly inflamed vital pulp or (2) a non-vital pulp which is associated with apical periodontitis [1]. Nowadays in modern dentistry, a non-surgical root canal therapy is considered a routine procedure. Post-treatment failure is hereby related to the persistence of microorganisms in the root canal system, this could be due to some causes such as untreated canals, insufficient cleaning, iatrogenic events, inadequate filling, or recolonization of the root canal space by bacteria, as following a coronal or apical micro-leakage [2,3]. After endodontic failures, the preferred treatment option is retreatment of the previously filled root; it thus aims to the improvement of the root canal system disinfection, by the complete removal of root canal obturation material to eliminate the remaining necrotic tissues and bacteria that could potentially be responsible for periapical failure and inflammation [4].

In order to achieve this goal, various methods have been followed; these include H-files, rotary files, solvents [4–6], Gates Glidden burs, heat, ultrasonic instruments [7], and laser [8]. The gutta-percha is the most popular root canal filling material although its removal by using hand files with or without solvent can be a complicated procedure and a time-consuming process, more so, when the root filling material is well-compacted [5]. Therefore, the use of NiTi rotary instruments in root canal retreatment is faster and more efficient than Hedstrom hand files and might decrease patient and operator fatigue [9–11].

As of recent, XP-endo Finisher (FKG Dentaire, La Chaux de Fonds, Switzerland) was introduced to use as the final supplementary step for the enhancement of cleaning the root canal during its treatment. The file displays a core diameter of ISO 25 and zero tapers (25\.00) they produced using an exclusive FKG alloy, the highly flexible NiTi MaxWire (Martensite-Austenite-electropolish-fleX) that reacts at various levels of temperature. At regular room temperature, the file is straight in its M-phase. Whereas within the root canal system the file is thus exposed to the body temperature and accordingly adjusts its shape to A-phase that has a C-shape of 1.5mm depth in the final 10 mm of length. Chloroform is one of the most widely used solvents, as it dissolves the gutta-percha quickly and moreover has a long history of clinical use [12], but due to its potential carcinogenicity, its use should be limited, if not avoided, if possible.

Moreover, several studies concluded that the use of a solvent has an exceedingly reduced apically extruded debris as compared to the results of the non-solvent group [13]. It is therefore desirable to exercise a reduction in debris extrusion during a canal debridement, as the apical extrusion of foreign material is found to be strongly related to periapical inflammation, flare-ups, postoperative pain, and a delayed periapical healing [14–17].

The purpose of the following study is to compare XP-endo Finisher and proTaper universal retreatment system effectiveness, with or

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without an organic solvent in removing gutta-percha by scanning electron microscopy.

2. Materials and Methods

Specimen selection and preparation

An in vitro study was done on 24 human-extracted single-rooted teeth. All teeth were radiographed by using a digital radiography system[2] to confirm the absence of stones, sclerosis, internal and external root resorption, fully-formed apices, and root curvature less than 30 degrees according to Schnieder criteria [18]. Teeth with more than one canal, fractures and cracks were excluded from this study. Teeth were cleansed from visible blood and gross debris with an ultrasonic cleaner and stored in a fresh 1:10 solution of diluted sodium hypochlorite. The teeth were divided into three groups of 8. Then, the samples were decoronated using a fine needle bur leaving the root length to be approximately 18 mm determined by a caliper.

Root canal procedures

Access cavity was done for all teeth by diamond round bur followed by a long fine needle. Then, a #15 k-file[3] was inserted 1mm beyond the apex to confirm apical patency. Working length was established 1mm short from the point #15 K-file was visualized at the apex. A crown down technique was done using a proTaper universal system[4] with a torque of 2.5 Ncm and speed of 250 rpm in the following sequence: SX, S1, S2, F1, F2, and F3. During treatment, each file was used four times then discarded. A 5.25% solution of sodium hypochlorite (NaOCL) as irrigation was used after each file with a 5 ml syringe using a 27-gauge needle for 1minute placed 2mm shorter than the working length. A 5 ml of sterile saline was used as a final rinsing. A sterile paper point was used to dry the canals. The canals were obturated using lateral condensation technique and AH Plus sealer[5]. The teeth were stored at a temperature of 37 C^{o} and a humidity of 100% in an incubator for two weeks to ensure that the sealer has completely set.

Retreatment procedures

The teeth were divided randomly into three groups for root canal retreatment procedures as the following:

Group I, removal of gutta-percha was performed with a proTaper universal retreatment system[6] with a torque of 2.5 Ncm and speed of 500 rpm (Figure1) and chloroform.

Figure 1: proTaper universal retreatment system.

The D1 file (30\.09) was used to create a small reservoir for chloroform and remove gutta-percha in coronal one-third of the canal. D2 file (25\.08) and D3 file (20\.07) were used to remove gutta-percha from middle and apical one-third of the canal, respectively. The solvent was refreshed when needed. Retreatment deemed complete when there were no remnants of the gutta-percha or the sealer were observed on the surface of the last instrument, and the canal walls were smooth. During retreatment, each instrument was used three times then discarded. The irrigation was done as in treatment procedures.

Group II, the removal of gutta-percha was done by the same procedure as a group I except that no chloroform was used in this group.

Group III, the removal of gutta-percha was done by the same procedure as a group I with the addition of XP-endo Finisher [7] (Figure2).

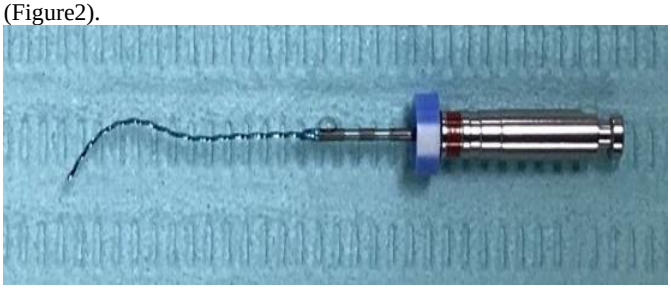

Figure 2: XP-endo Finisher.

A cup of water with 37 C^{o} temperature to stimulate the body temperature was used before using this file. By this way, the C-curvature shape would be created at the end of the file. The instrument was placed in a contra-angle handpiece and removed from the plastic tube in a rotation mode, applied by a lateral movement. Each of the canals, filled with 1 mL of 5.25% NaOCl and the XP-endo Finisher file, was then inserted into it with no rotation. Furthermore, the rotation was initialized (800 rpm and 1 Ncm), and the instrument activated for one minute by using gentle and slow 7–8 mm lengthwise movements onwards the working length. The instrument was pressed against the canals' side walls throughout the procedure. Finally, each root canal was then irrigated with 5 mL of 5.25% NaOCl by using a 1 mm shorter syringe from the working length. Each XP-endo instrument was used in two canals then discarded.

Debris collection

The apically-extruded debris was then collected into twenty-four resin tubes that have been pre-weighed. Then the tubes were stored in the incubator for five days in order to obtain the final dry weight. The amount of apically extruded debris was calculated by subtracting the tube's initial weight from its final dry weight [19].

Scanning electron microscope evaluation

After retreatment, a groove was done on buccal and lingual surfaces of each tooth by a diamond fine needle and split it longitudinally using a diamond disk, the half with the most visible part of the apex was selected while the other half was discarded. Following that, each specimen was grooved to three parts from the root apices by using a diamond bur to divide the root into coronal, middle, and apical thirds [20]. The specimens were gently air dried, dehydrated in ascending grades of ethanol (35%, 50%, 75%, 95%, 100%) then dried to the critical points by immersion of the dehydrated samples in 1-2 ml of hexamethyldisilazane (HMDS) for 10 minutes. Decantation of the HMDS from the sample vial was carried out. Then the sample vial was left with the other samples in a desiccator to air-dry overnight at room temperature. This particular method was used to minimize the specimen distortion due to drying tensions. Following the desiccating procedure, the specimens were observed under an SEM, Model INSPECT S50 FEG (Field Emission Gun) with accelerating voltage 30 K.V., magnification X14 up to 1000000 and resolution for Gun.1n. FEI company, Netherlands.

The analysis of the photomicrographs was carried out by 2 examiners, an oral biologist and an endodontist and they were blind to group status. For descriptive analysis of patent and clear dentinal tubules in the cervical, middle and apical thirds of all groups, the variable "degree of dentinal tubule patency" (0: intensely clear; 1: moderately clear; 2: slightly clear; 3: completely blocked) was used.

2 GENDEX expert DC, Chicago, USA
3 MANI, Tochigi, Japan
4 Dentsply Maillefer, Ballaigues, Orbe, Switzerland.
5 Dentsply Maillefer, Ballaigues, Orbe, Switzerland.
6 Dentsply Maillefer, Ballaigues, Orbe, Switzerland.
7 FKG Dentaire SA.

Statistical analysis

In order to perform a statistical analysis, a one-way ANOVA and post hoc Scheffe's test were used for the comparison of the apically extruded debris amidst the groups. SPSS software (version 20) was used with a level of significance at (P=0.05). The agreements between the 2 examiners regarding the degree of dentinal tubules patency and surface remnants scores were evaluated with Cohen kappa.

3. Results

Scanning electron microscope evaluation

Group I (ProTaper universal retreatment system with chloroform) showed slightly clear dentinal tubules and less surface remnants in cervical and middle thirds and completely

blocked dentinal tubules in the apical thirds (Figures 3&4, a-c).

Group II (ProTaper universal retreatment system without chloroform) showed moderately clear dentinal tubules and less surface remnants in cervical and middle thirds and completely blocked dentinal tubules in the apical thirds (Figures 3&4, d-f).

Group III (ProTaper universal retreatment system with XP-endo Finisher without chloroform) showed intensely clear dentinal tubules and less surface remnants in the cervical, middle, and apical thirds (Figures 3&4, g-l).

By comparing each group with the other groups, the most intensely clear dentinal tubules were observed in group III (ProTaper universal retreatment system with XP-endo Finisher without chloroform), followed by group II (ProTaper universal retreatment system without chloroform), followed by group I (ProTaper universal retreatment system with chloroform), respectively.

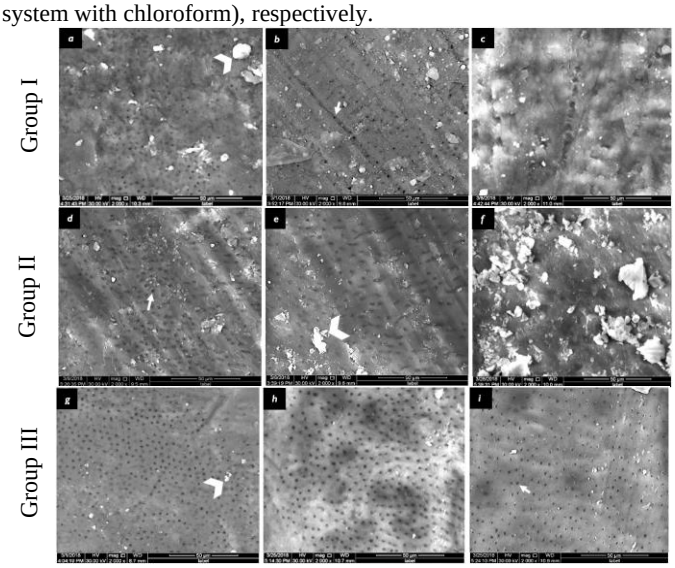

Figure 3: scanning electron microscope images for each group represents cervical, middle and apical thirds, respectively. Group I (a-c), group II (d-f), group III (g-i). Arrows represent the dentinal tubules and arrowheads represent the surface remnants, Original magnification x 2000.

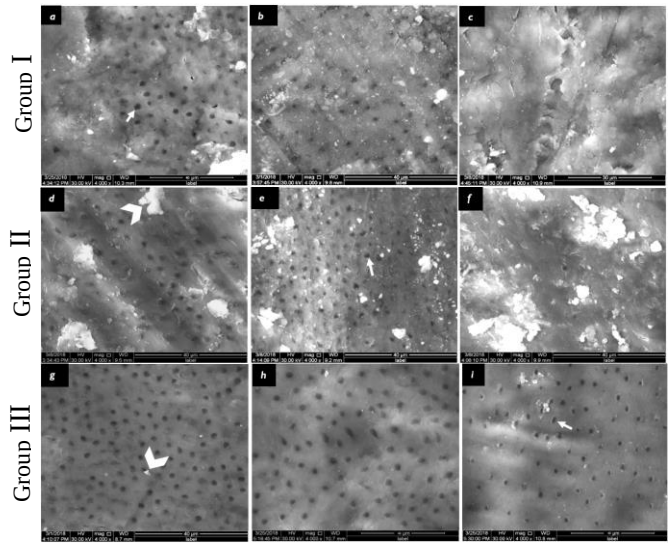

Figure 4: higher magnification of the previous figure. Note the intensely clear dentinal tubules (arrows) in Group III in all thirds as compared to the other groups. Original magnification x 4000.

Statistical results

All the specimens were associated with apical debris extrusion. The mean value and standard deviation (M ±SD) of extrusion for each group were presented in table (1) and figure (5).

Table1: Mean and standard deviation of apically extruded debris between Group I, Group II, and Group III.

Apically extruded debris	Group I	Group II	Group III	F (P Value)
	M ±SD	M ±SD	M ±SD	16.541(0.000)***
	.590 ± .125	.757 ± .088	.870 ± .074	

M: Mean.

SD: Standard deviation.

***The mean difference is significant at the 0.05 level.

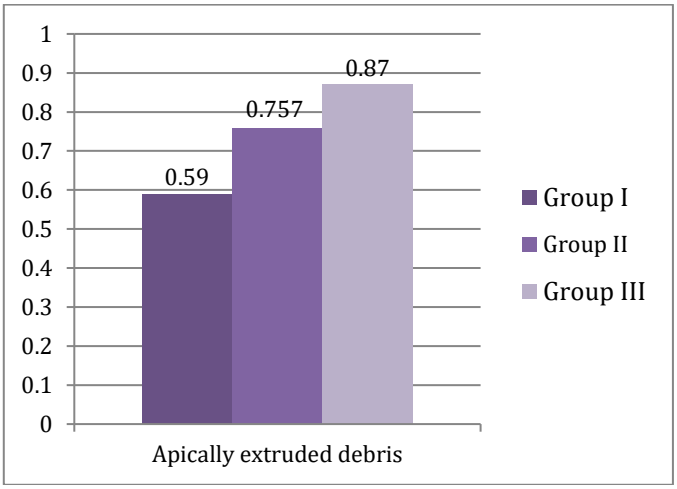

Figure 5: Mean of apically extruded debris between Group I, Group II and Group III

Group I (ProTaper universal retreatment system with chloroform) produced significantly less debris than group II (ProTaper universal retreatment system without chloroform) and an extremely significant difference with group III (ProTaper universal retreatment system with XP-endo Finisher without chloroform). While no significant difference was found between group II (ProTaper universal retreatment system without chloroform) and group III (ProTaper universal retreatment system with XP-endo Finisher without chloroform) Table (2).

Table 2: Significant difference of apically extruded debris between the groups.

Group I vs Group II	0.01*
Group I vs Group III	0.000***
Group II vs Group III	0.095•

The mean difference is significant at the P< 0.05 level.

(*) Significant difference. (*******) Extremely significant difference. (•)Non-significant difference

4. Discussion

In order to avoid and thus eliminate any possible interfering factors, we were concerned with carrying out the standard procedures, and carefully performed them by a single operator. Different methods have been used to detect the residual filling materials after canal retreatment including stereomicroscope [10],[21] a postoperative radiograph [22] and micro-CT device [23].

In the present study, a scanning electron microscope was chosen to evaluate the degree of dentinal tubule patency and surface remnants. Utilizing NiTi rotary instruments in a root canal retreatment is more efficient and effective than using Hedstrom hand files [9–11]. This could be due to the heat generated by friction of the engine-driven files, potentially plasticizing the gutta-percha and facilitating its removal [24].

In the present study, Group I (ProTaper universal retreatment system with chloroform) and group II (ProTaper universal retreatment system without chloroform) showed more patent and clear dentinal tubules in cervical and middle thirds than in apical thirds (figures 3&4, a-f). Our results are consistent with Preetam et al. 2016 who reported

that NiTi files are proven to be more efficient in the filling material removal at the cervical and middle thirds, this is possibly attributed to the greater taper of the files at these areas (.09 and .08 respectively) thus engaging more of the filling materials during the cleaning process. More surface remnants in the apical thirds were found, which could be due to the smaller core diameter of the file used for apical filling removal (ISO 20) as compared with the file used in initial preparation (ISO 30). Moreover, the loss of tactile sensation of engaging the filling material as provided by hand instrument may result in a higher amount of filling material in the apical third [22].

In root canal retreatment, solvents as chloroform are often used as an aid for gutta-percha removal [25,26]. A study using scanning the Electron microscope added that solvents led to more remnants of the gutta-percha and sealer on the walls of the root canal and dentinal tubules [27]. In the present study, group I (ProTaper universal retreatment system with chloroform) showed the highest amount of surface remnants compared with group II (ProTaper universal retreatment system without chloroform without chloroform) and group III (ProTaper universal retreatment system followed by XP-endo Finisher without chloroform) (figures 3&4, a-i). This could be due to the dissolution of the filling material by the solvent thus penetrating the dentinal tubules and being difficult to be removed [11].

In the present study, Group III (ProTaper universal retreatment system followed by XP-endo Finisher without chloroform) showed intensely clear dentinal tubules after using XP-endo Finisher file (figure 4). Which could be due to their exceeding flexibility, and the uniqueness of the sickle shape at the apical half; the file can expand up to 6mm in diameter to easily reach and clean such areas that are otherwise extremely difficult to approach by using standard instruments [23], and by improving the flow and distribution of irrigation solution within the root canal system [20].

A study evaluated the effectiveness of XP-endo Finisher in removing residual root filling material from canals with straight oval-shapes, revealed an effective but incomplete removal of gutta-percha from the root canal system [23]. Moreover, other studies presented superior results of the XP-endo Finisher when utilized as the final irrigation step procedure on debris and smear layer removal [20], as well as in the removal of calcium hydroxide paste from root canal [28].

Therefore, it is found that a reduction in debris extrusion during the canal debridement is recommended as the apical extrusion of foreign material is found to be strongly related to periapical inflammation, flare-ups, postoperative pain, and a delayed periapical healing [14–17]. The amount of debris would vary according to the technique used for preparation, as well as the instrument's cross-sectional design [17]. The ProTaper retreatment files resulted in less apical debris extrusion than hand files; potentially due to the retreatment files triangular's cross-section that reduces the area of contact between the dentin walls and the instrument [29].

In the present study, Group I (ProTaper universal retreatment system with chloroform) produced significantly less apical debris extrusion than Group II (ProTaper universal retreatment system without chloroform) (table 2 & figure 5). This could be due to softening and removal of the bulk of the filling material in a coronal direction [13].

No significant difference was found between group II (ProTaper universal retreatment system without chloroform) and group III (PoTaper universal retreatment system with XP-endo Finisher without chloroform) (table2 &figure5). This could be explained by the high flexibility of the file thus removing the filling material without cutting dentine, and the zero-taper reducing the area of contact between the instrument and the dentin walls [23].

Moreover, the quantitative values of the extruded debris could be affected by possible crystallization of the irrigation solution which was used in this study. The sodium hypochlorite irrigation solution was used during endodontic retreatment, the sodium crystals couldn't be separated from the debris and may have an adverse effect on the experimental methodology reliability [30].

5. Conclusion

Under the conditions of this study, out of all the retreatment techniques that were used, the XP-endo Finisher without chloroform was the most effective in the removal of the gutta-percha in cervical, middle and apical thirds. The use of solvent during retreatment can decrease the amount of the apically extruded debris.

6. Recommendations

Further studies are needed to evaluate the effectiveness of XP-endo Finisher with and without solvent in a larger sample. Moreover, SEM attached with EDX Unit is needed for image analysis.

7. Ethical approval

This study was done in vitro on human-extracted single-rooted teeth collected from orthodontic clinics. The ethical approval was provided by UQUDEN-Institutional Review Board number 62-17.

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