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Quantification of Apical Extrusion of Debris Using Five Different Retreatment Files, With and Without Solvent: An *In-Vitro* Study

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KEYWORDS

Apical extrusion of debris, Retreatment, Guttapercha solvent, Retreatment files

ABSTRACT:

Introduction: The objective of this study was to evaluate the efficacy of five different Retreatment files with and without gutta percha (GP) solvent, by quantifying the apical extrusion of endodontic debris during retreatment procedure.

Methods: 45 extracted human mandibular premolars were collected and prepared by performing root canal treatment and stored at 37 ^{0}C at 100% moisture were fixed inside the eppendorf tube to suspend the roots within the tubes. Samples were divided into nine groups, from Group 1 using H files with xylene as control and groups. Group 2 to 5 with subgroups a & b, with and without solvent using ProTaper, Mtwo group,D-Race group and R-ENDO system respectively. The samples were weighed before and after retreatment to determine the weight of apical extrusion of debris using analytical weighing balance. The results were statistically analysed and tabulated. ($p<0.05$).

Results: Debris extrusion was significantly higher in group 5b (R-ENDO Retreatment file system without the use of solvent) ie. 0.47±0.447mgs. All the other test groups extruded some amount of debris apically with the range from 0.11±0.003 to 0.15±0.065 mgs. with no statistical significant difference among them.

Conclusion: All the experimental retreatment file systems extruded some amount debris through apical foramen with no significant difference with file systems tested when used with or without the solvent and R-ENDO retreatment file with solvent. But R-ENDO rotary file when used with solvent, extruded least amount of debris among the experimental retreatment files, when used without the solvent.

1. Introduction

Owing to the simplicity and non-radical approach to the periapical pathology, non-surgical option of endodontic

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retreatment is still considered the most preferred treatment option in case of failed previously root canal treated cases.[1] Most of the instrumentation techniques are concerned with removal of root canal filling materials, bacteria, organic tissue remnants and the debris which can get extruded apically and cause periapical inflammation in the host immune system.[2,3] There have been various studies published to determine the factors which influence the success/failure of non-surgical endodontic therapy.[4-15] One of the factors which proves to be critical for the good outcome of the non-surgical root canal retreatment could be periapical extrusion of the debris during the root canal retreatment. Debris extrusion brings about periapical inflammation contributing towards the failure of the retreatment.[16] The amount of debris extrusion can dictate the prevalence and level of occurrence of periapical inflammation as well. [17,18] Studies have concluded that greater mass of debris is extruded in the instrumentation techniques that involve a push and pull motion rather than the ones possessing any rotational motion.[19-23] The quantity of debris extruded through apical foramen may differ depending on the design of NiTi rotary instruments, methods of use, cross-sectional shapes etc.[23.]

Various NiTi rotary systems for retreatment are available in the market. Numerous studies have been conducted to evaluate and compare the effectiveness of various retreatment files.24 The ProTaper Universal retreatment system (Dentsply Maillefer, Ballaigues, Switzerland) comprises of a set of 3 rotary instruments i.e., D1, D2 and D3. They have triangular and convex cross sections with different lengths and tip diameters. The file tips, which are size 30(9% taper), size 25(8% taper) and size 20(7% taper) and lengths 16 mm (D1), 18 mm(D2) and 22 mm(D3) to be used at a speed of 500rpm. D1 tip facilitates initial penetration into the root canal obturation.[24]

Bramante et al found that ProTaper universal retreatment system, performed the best, in terms of time needed for complete retreatment.[25] however, Giuliani V et al proposed that these files were most efficacious among the test groups. They remove large amount of gutta percha with negative cutting angles and the lack of radial land. Thus, these file systems have dual action of initially softening gutta percha and cutting it at the later stages of rotation motion.[26]

The Mtwo system, comprises of 2 files with cutting tips at a helical angle that remains constant. R1 file comes with size and taper, 15/.05, R2 with size 25 and taper 0.05, with a length of 21 mm, to be used at 250 to 300 rpm as specified by manufacturer for absolute efficacy and affectivity. They have positive rake angles like that of hand H files. [27]

D-RaCe Retreatment instruments (FKG Dentaire, Switzerland) comprises of two retreatment instruments i.e., DR1 and DR2, with triangular cross section and alternate cutting edges. Rotary instrument, DR1, has an active working tip, facilitating penetration in to the obturating material initially.[28] It is specifically designed for initial penetration into the obturating material and can clean the coronal third while DR2 has a blunt tip possessing a non-cutting action and is designed for removing obturating material from the apical third.

The R-ENDO retreatment system (Micro-Mega, France) comprises of a hand file and a set of 4 NiTi files. They have triangular cross sections. The cutting edge are at three regular intervals and does not have radial land and comprises of tips that are inactive. Re (size 25, 12% taper) permits flaring of the coronal surface while remaining 3 files i.e. R1, R2 and R3 are designed for each third of root canal respectively.[29,30] It consists of inactive tip and no radial land. It is designed for a better strength and flexibility. It has also proven to be faster than the other rotary retreatment systems in various in vitro experiments.[31]

A variety of gutta percha solvents are used clinically nowadays including tetrachloroethylene, xylene, chloroform, refined orange oil, halothane etc. The amount of extrusion of debris from the apical end during retreatment has been measured and compared for different solvents and results have concluded that the use of solvents causes less extrusion of debris apically.[32] But these chemicals may have deleterious effects on the radicular dentin, which may affect the outcome of the treatment.

Several studies have evaluated various techniques and various instruments used during retreatment procedures and tried to quantify the amount of debris extruded through the apical formen. [17,31-33] However, very few studies have measured the amount of debris extruded through apical foramen during retreatment along with solvent. Hence the present study was planned to quantify

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and determine the amount of debris extrusion apically, during root canal retreatment, with five different retreatment file systems, with and without the gutta percha solvent.

2. Methods

Ethical committee clearance was obtained before the commencement of the study from the Institutional Ethical Committee. A total of 45 extracted mandibular premolars with Vertucci's Type 1 canal anatomy, extracted due to orthodontic reasons or periodontal conditions were included in the study. The total sample of 20 subjects achieved 88% power to detect differences among the means versus the alternative of equal means using an f test with a 0.05000 significance level. The size of the variation in the means is represented by their standard deviation which is 92.34. The common standard deviation within a group was assumed to be 100.00.

Inclusion Criteria: Freshly extracted human mandibular premolars consisting of single root, single canal system (Type1 Vertucci's), Mature apex, Root canal with curvature less than 20 degrees value according to Schneider'classification.[46]

Exclusion Criteria: Teeth with open apex, severe root curvature (≥20 degrees according to Schneider's classification)[46], calcified canals, restorations, Dental caries extending over the root surfaces.

Standardisation and canal preparation

Forty Five human mandibular premolars with Type 1 canal anatomy extracted for orthodontic or for periodontal reasons with mature apex and a root canal curvature of less than 20 degrees angle according to Schneider's classification**.** Radiographs were taken in buccal and proximal directions to ensure absence of resorption, calcification, fracture or crack. Soft tissue remnants and calculi on the external surface were removed using hand and ultrasonic devices.

To standardize the specimen length, a diamond disc (Strauss dental) was used for all teeth to shorten them up to 20 mm by making the occlusal surface flat enough to facilitate and a coronal access cavity preparation using a high-speed endo access no. 2 bur. The working length (WL) of specimen root canals was determined, 1 mm short of the length of #10 K-file (Dentsply Maillefer) which was seen through the apical foramen under 2.5X magnification.

Instrumentation, irrigation and obturation:

Canal was instrumented using conventional step-back technique with MAF (Master Apical File) equal to #30 K-file. It was stepped back to size # 60, using 5 ml 5.25% NaOCl. Smear layer and debris removal was done with 2 ml of 17 % EDTA and 2 mL 5.25% NaOCl followed by 2 ml of normal saline. No. #30 paper points were used to dry the canals. The master cone of no. #30 GP was placed till the working length and Gutta percha was laterally condensed into the root canal using # 15 lateral cones. AH plus sealer was used. Access cavities were then, temporarily sealed with Zinc Oxide eugenol temporary cement and teeth were incubated at 37◦C with 100% humidity for 8 weeks to allow complete setting of the sealer.

Preparation of teeth-vial system:

All teeth were fixed in individual eppendorf tubes that had been pre-weighed 3 times using an analytical weighing balance with an accuracy of 10^{-3}. Holes were created in the eppendorf tube caps using a hot instrument. One root canal treated tooth was inserted through the top under pressure and fixed at the cementoenamel junction in eppendorf tubes using cyanoacrylate. The apical part of the root was suspended within the vial, which also acted as a collecting container for the apical material extruded through the foramen of the root. A 25- gauge needle was placed through the cap to equalize the air pressure inside and outside the tube. The specimen samples were randomly divided in to 9 groups as described below:

Group 1: Retreatment was performed with H files and solvent.

No #3 and #2 GG drills were used in a crown down technique to remove the gutta percha from coronal part. #15 H-file was used in the canal till it reached the working length. Then Xylene was added in the space length to remove the gutta-percha and sealer, canals were instrumented up to size 40. Retreatment was considered complete when no more filling materials or sealer was seen on the last instrument under 2.5x magnification.

Group 2a: Retreatment with ProTaper Universal files with solvent.

#3 and #2 GG drills were used in a crown down technique to remove GP from coronal part. Then ProTaper Universal retreatment files i.e. D1, D2 and D3

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sequentially, were used in a gentle push and pull motion till it reached the working length. Then xylene was added in the space length and canals were further instrumented. Retreatment was deemed complete when no more filling materials or sealer was seen on the last instrument. (Fig 1)

Group 2b: Retreatment with ProTaper Universal files without solvent.

#3 and #2 GG drills were used in a crown down manner to remove gutta percha from coronal portion of the root. Then ProTaper Universal retreatment files D1, D2 and D3 were used in a gentle in and out motion till it reached the working length for GP removal. Retreatment was complete when no more filling materials or sealer was seen on the last instrument.

Group 3a: Retreatment with Mtwo files with solvent.

The same procedure as in group 1 was carried out using Mtwo Retreatment file along with addition of xylene.

Group 3b: Retreatment with Mtwo files without solvent.

Same procedure as in group 1 was followed using Mtwo Retreatment files without xylene.

Group 4a: Retreatment with D-RaCe files with solvent.

Same procedure as in group 1 was followed using D-RaCe Retreatment files i.e., DR1 and DR2 along with xylene.

Group 4b: Retreatment with D-RaCe files without solvent.

The same procedure as in group 1 was followed using D-RaCe Retreatment files i.e DR1 and DR2 without the use of xylene.

Group 5a: Retreatment with R-ENDO files with solvent.

The same procedure as in group 1 was followed using R-ENDO Retreatment files, Rm, Re, R1, R2, R3 along with addition of xylene.

Group 5b: Retreatment with R-ENDO files without solvent

The same procedure as in group 1 was followed using R-Endo retreatment files, without the use of solvent (xylene).

Fig 1 - Instrumentation to remove canal contents during retreatment procedure.

Final Preparation for weighing the debris:

After retreatment, the apical part of the tooth along with extruded debris that adhered to the eppendorf tube was washed with 1 ml. distilled water and collected in new set of preweighed eppendorf tubes and stored in dry bath at 80 degrees centigrade for one hour to evaporate any moisture before weighing the dry debris. (Fig 2) Tubes that included dry extruded debris were weighed in the same manner as during the initial measurement. The weight of the extruded debris was determined by subtracting the weight of the preweighed empty eppendorf tubes from the weight of the tubes containing dried debris.

Fig 2 - Dry bath with eppendorf tubes and wet debris.

Statistical analysis

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Data was analyzed statistically with the use of SPSS 17.0 version. All the data collected were tabulated and descriptive statistics were calculated. Intergroup comparison was done using One way ANOVA along with post hoc tukey test. The p value was set at ≤ 0.05.

3. Results

The weight of samples, in pre- retreatment stage and post retreatment stage along with the weight of debris extruded in milligrams are given in Table 1. The mean weight of apically extruded debris using, hand files with gutta percha solvent which was used as control is 0.14 ± 0.101, Protaper universal system along with solvent is 0.11 ± 0.003, which is the least amount of debris extruded among all the groups. R Endo without solvent extruded maximum amount of debris, which is 0.47 ± 0.447. (Table 1)

Table 1

	Pre retreatment sample weight (in mg)			*Post retreatment sample weight (in mg)*			
Groups	Min	Max	Mean S.D	Min	Max	Mean S.D	Amount of Debris
1	4.40	4.57	4.50 ± 0.69	4.47	4.79	4.64 ± 0.14	0.14±0.101
2a	4.32	4.43	4.38 ± 0.04	4.44	4.55	4.49 ± 0.04	0.11±0.003
2b	4.30	4.54	4.44 ± 0.09	4.43	4.66	4.56 ± 0.09	0.12±0.006
3a	4.30	4.42	4.36 ± 0.04	4.42	4.53	4.49 ± 0.04	0.12±0.013
3b	4.33	4.41	4.36 ± 0.02	4.47	4.60	4.51 ± 0.05	0.15±0.065
4a	4.35	4.57	4.41 ± 0.08	4.47	4.74	4.54 ± 0.11	0.13±0.021
4b	4.28	4.53	4.40 ± 0.10	4.40	4.65	4.53 ± 0.10	0.12±0.014
5a	4.31	4.49	4.37 ± 0.06	4.43	4.60	4.49 ± 0.06	0.11±0.006
5b	4.35	4.57	4.43 ± 0.08	4.51	5.48	4.90 ± 0.42	0.47±0.447

Table 1: Intergroup Descriptive Analysis

One way ANOVA shows there is significance difference among the values, with a significance level of 0.018. (Table 2)

Intergroup comparison with post hoc Tukey's test for multiple comparison showed significant difference when compared to other groups in the study. (Table 3)

Table 2

	Sum of Squares	dF (Degree of freedom)	Mean Square	F value	P value
Between Groups	0.525	8	0.066	2.737	0.018
Within Groups	0.863	36	0.024		

Table 2: Amount of debris collection between and within group comparison based on One Way Analysis of Variance

The difference of mean weight of samples in pre and post retreatment stage gives us the amount of debris extrusion in each group. The amount of debris extruded apically is significantly more in group 5b i.e 0.47±0.447 where retreatment is done using R-Endo retreatment system without the solvent. (Table 3) There is no statistically significant difference found regarding amount of apically extruded debris in other groups with or without solvents.

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Table 3

Multiple Comparisons						
(I) group	**(J) group**	**Mean Difference (I-J)**	**Standard Error**	**P value**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
1	2a	.026	.097	1.00	-.29	.34
	2b	.020	.097	1.00	-.30	.34
	3a	.018	.097	1.00	-.30	.34
	3b	-.011	.097	1.00	-.33	.31
	4a	.009	.097	1.00	-.31	.33
	4b	.012	.097	1.00	-.31	.33
	5a	.022	.097	1.00	-.30	.34
	5b	**-.33000***	**.097**	**.042**	**-.65**	**-.0071**
2a						
	2b	-.006	.097	1.00	-.32	.31
	3a	-.008	.097	1.00	-.33	.31
	3b	-.037	.097	1.00	-.35	.28
	4a	-.017	.097	1.00	-.33	.30
	4b	-.014	.097	1.00	-.33	.30
	5a	-.004	.097	1.00	-.32	.31
	5b	**-.35600***	**.09795**	**.022**	**-.6789**	**-.0331**
2b						
	3a	-.002	.097	1.00	-.32	.32
	3b	-.031	.097	1.00	-.35	.29
	4a	-.011	.097	1.00	-.33	.31
	4b	-.008	.097	1.00	-.33	.31
	5a	.002	.097	1.00	-.32	.32
	5b	**-.35000***	**.09795**	**.025**	**-.6729**	**-.0271**
3a						
	3b	-.029	.097	1.00	-.35	.29
	4a	-.009	.097	1.00	-.33	.31
	4b	-.006	.097	1.00	-.32	.31
	5a	.004	.097	1.00	-.31	.32
	5b	**-.34800**	**.09795**	**.027**	**-.6709**	**-.0251**
3b						
	4a	.020	.097	1.00	-.30	.34
	4b	.02300*	.097	1.00	-.29	.34

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	5a	.033	.097	1.00	-.28	.35
	5b	**-.31900**	**.09795**	**.055**	**-.6419**	**.0039**
4a						
	4b	.00300*	.097	1.00	-.31	.32
	5a	.01300	.097	1.00	-.30	.33
	5b	**-.33900**	**.09795**	**.034**	**-.6619**	**-.0161**
4b						
	5a	.010	.097	1.00	-.31	.33
	5b	**-.34200**	**.09795**	**.031**	**-.6649**	**-.0191**
5a						
	5b	**-.35200**	**.09795**	**.024**	**-.6749**	**-.0291**

Table 3: Within group comparison based on Tukey test.

Discussion

There is direct link between the amount of debris extrusion and the severity of periapical tissue reaction according to the study done by Al-Omari et al. who quantified the apical extrusion of debris[47] Therefore, we planned to evaluate the amount of debris extrusion with routinely used obturating material, gutta percha and sealer in root canals.

Different methods to measure the apically extruded debris have been employed so far,[35,38] but weighing the amount using a precision microbalance is a precise method which is less technique sensitive. Hence in our study we used precision analytical microbalance to measure the amount of extruded debris. We used Schneider's criteria[46] for selection of samples to standardize them.

All the retreatment systems used in this study irrespective of rotary or manual motion, produced some amount of debris extrusion apically in our study, which agrees with a number of studies presented available in the literature. [17,18,33,35,38,39,41]

According to the results of present study, R-ENDO retreatment system without the solvent (Group 5B) extruded the maximum amount of debris apically (0.47±0.447) which was significant when compared to all other groups. (Table 4) This could be due to non-use of solvent and faster cutting action and aggressive cutting design of R-ENDO which has led to increased apical extrusion than other rotary retreatment systems which were tested. [29,43] When R-ENDO is used with solvent, the debris extrusion (0.11±0.006) was significantly reduced. This shows R-ENDO retreatment system has to be used in conjunction with GP solvents to reduce the debris extrusion. Similar results were found in the study done by Canakci and Dincer *et al* which concluded that the use of solvent, generally reduces the debris extrusion apically from the root canals during retreatment procedure, hence they suggested the use of sealer specific solvent.[43] The action of solvent is to increase the solubility of the sealer and the obturating material, which in turn leads NiTi rotary files to penetrate into the obturating material with minimum resistance and pulling it coronally, thereby preventing pushing of the debris apically.[48] It also could be due to the action of solvent causing conformational change that occurred in the structure of gutta percha. [50] Post softening usually gutta percha hardens, shrinks and tends to separate out from the root canal wall, gathering in the centre of the canal system.

Although Canakci, Dincer *et al* [43] and Shenoi *et al* [49] have supported the idea of using sealer specific solvent, these solvents reduce the micro-hardness of the sealer to a greater degree. However xylene was the choice of solvent in our experiment due to its well established highly potent GP solvent action as mentioned in the literature repeatedly.[24,34,36,50] Bhagavaldas MC *et al* found the presence of solvent can result in incomplete removal of gutta percha since the obturating material tends to become more viscous and stick in the irregularities present inside the root canal walls.[45] In our study, we quantified the extrusion of the debris and not checked for the amount of gutta percha remaining in the canal.

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In contrary to the present study, Mollo et al [30] found that R-endo retreatment files without any solvent have shown significantly lesser debris extrusion when compared to the rest of the instrument types used in their study. But they quantified apical extrusion of debris only by visual means. Hence their study cannot be considered momentous due to lack of standard method to measure the amount of debris.

The rotary retreatment files such as D-Race, MTwo and Protaper universal used with or without GP solvent and R- Endo with GP solvent, extruded significantly minimal amount of debris compared to R-Endo without solvent in the present study. (Table 2) Results of the present study agree with the previous studies for their efficacy in removing debris extrusion apically. [27,37,51] But none of these retreatment rotary files have proved to be gold standard in retreatment, since there are no studies proved any of them eliminated the extrusion of debris completely.

D-Race retreatment files provide exit of dentinal debris by creating sufficient space coronally for better removal of filling material and reduction in apical extrusion of the debris. [20] Mtwo files also extruded less debris apically, which could be due to its design consisting of increased depth behind the blades that particularly aids in efficient dentin cutting and gutta percha removal during endodontic retreatment.[27] Protaper universal retreatment files have negative cutting angles and lack radial land. Hence gutta percha is softened and removed from the canals efficiently in large amount from the coronal direction in a spiral fashion. [22]

The results of the present study conclude that rotary retreatment file systems such as D-RaCe, MTwo, ProTaper universal, and hand H-file, if used during retreatment, extrude the minimal amount of debris apically through the apical foramen if they are used with or without GP solvent xylene. Among the experimental rotary retreatment files, R- ENDO retreatment files are better than all other files by extruding minimal debris, when used along with GP solvent xylene. But without solvent, they extrude significantly more quantity of debris beyond the apical foramen. than other experimental files.

Further *in vivo* studies are required to evaluate the clinical outcome and long-term success with various retreatment file systems and techniques to find out the best instrument system for retreatment.

Conclusion

Within the limitations the results of the present study conclude that:

1. All the retreatment file systems cause some amount of apical extrusion of debris during retreatment procedure.
2. R-ENDO rotary file causes more extrusion of debris apically when used without the solvent. But when used with solvent, extruded least amount of debris among the experimental retreatment files.
3. There is no significant difference in amount of apical extrusion of debris of other file systems tested i.e., ProTaper Universal, Mtwo and D-Race retreatment systems, when used with or without the solvent and R-ENDO retreatment file with solvent.

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