# A Comparative Evaluation of Gutta Percha Removal and Extrusion of Apical Debris by Rotary and Hand Files

Dentistry Section

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## ABSTRACT

**Aim:** The aim of this study was to evaluate the efficacy of Protaper retreatment files in comparison with RaCe, K3 and H-files for removal of gutta-percha and apically extruded debris using volumetric analysis.

**Materials and Methods:** Forty extracted single rooted maxillary incisor teeth with straight canals and mature apices were selected for the study. After access cavity preparation, apical patency was confirmed with a size 10 K-file extending 1mm beyond the point at which it was first visible at the apical end. Working lengths were determined with the use of size 15 K-file. The canals were prepared in a step-back technique and the master apical file was size 30 for all teeth. 3% sodium hypochlorite was used as an irrigant after each instrumentation. Before final rinse, size 20 K-file was passed 1mm beyond the apex to remove any dentinal shaving plugs and maintain the apical patency. Then the canals were dried with paper points. The root canal was filled using standard gutta-percha points and zinc oxide eugenol sealer under lateral condensation technique. The teeth were then randomly divided into four groups of ten teeth each

based on the instrument used for gutta percha removal. All the rotary instruments used in this study were rotated at 300rpm. The instruments used were: Group 1 – RaCe Files, Group 2 – ProTaper retreatment Files, Group 3 – K3 Files and Group 4 – H Files. The volume of the obturating material was calculated before and after removal using volumetric analysis with spiral CT. The removal efficacy with each instrument was calculated and statistically analysed.

**Results:** The results of the study show that the ProTaper retreatment files (Group 2) (97.4%) showed the highest efficiency in the removal of obturating material, which was followed by RaCe (95.74%), K3 (92.86%) and H files (90.14%) with the efficiency in the decreasing order. Similarly the mean apical extrusion in H files (0.000  $\pm$  0.002) was significantly lower than all the rotary instruments. However, the difference among the rotary files were not statistically significant (p>0.05).

**Conclusion:** ProTaper retreatment files show significant difference over other groups in removal of obturating material and can be the system of choice in endodontic retreatment procedures.

Keywords: Gutta-percha, Extruded debris, Protaper retreatment file

## **INTRODUCTION**

Non-surgical endodontic retreatment is done mainly to eliminate the persistent infection of the root canal system. *Enterococcus faecalis* have been identified predominantly from the failed root canals. Retreatment requires complete removal of the root canal filling material, followed by further shaping, cleaning, disinfection and re-obturation to reestablish healthy periapical tissues [1,2]. Removal of gutta-percha and sealer is an important factor in root canal retreatment, since this enables thorough chemo-mechanical instrumentation and disinfection of the root canal system [3].

Thermal, mechanical, chemical and a combination of the three methods are used to remove the gutta percha and the sealer [4,5]. These methods while removing the gutta percha and the sealer from the root canal can also cause apical extrusion irrespective of the technique used. This apical extrusion can lead to irritation of periapical tissue, periapical inflammation, post-instrumentation flare-up or even failure of apical healing [6].

The removal of these root canal fillings are performed with hand or rotary NiTi instruments in combination with heat or solvents [7,8]. Recently ProTaper Retreatment rotary NiTi files (Dentsply Maillefer) have been introduced in the market. So far no studies have evaluated the efficacy of ProTaper re-treatment files for the removal of gutta percha in comparison with RaCe, K3 and H-files. The purpose of this study was to evaluate and analyse volumetrically the efficacy of ProTaper retreatment files, RaCe, K3 and H-files for removal of gutta-percha during retreatment and to compare the apical extrusion of the obturated material with the help of spiral CT.

## MATERIALS AND METHODS

Forty extracted single-rooted maxillary anterior teeth with straight canals and mature apices were selected for this study. The tooth was extracted for periodontal reasons and was free of dental caries. Soft tissue and calculus were mechanically removed from the teeth surface and stored in 0.9% w/v saline solution (Fresenius Kabi Pvt. Ltd., Pune, India). After access cavity preparation, apical patency was confirmed with a size 10 K-file extending 1mm beyond the point at which it was first visible at the apical end. Working lengths were determined with the use of size 15 K-file (Dentsply Mallefer) till they were visually seen at the apex. From this length 1.5mm was subtracted and selected as the working length. The canal orifices were enlarged with Gates Glidden drills (Mani, Tochigi, Japan) of sizes 2 and 3. The canals were prepared in a step-back technique and the master apical file was size 30 for all teeth. 3% Sodium hypochlorite (Prime Dental Products Pvt. Ltd., Mumbai, India) was used as an irrigant after successive instrumentation. Before final rinse, size 20 file was passed 1mm beyond the apex to remove any dentinal shaving plugs and maintain the apical patency. Then the canals were dried with paper points. The root canal was then filled using standard gutta-percha points (Dentsply Mallefer) and zinc oxide eugenol sealer under lateral condensation technique. The access cavities were sealed with a temporary filling material (IRM, Dentsply Caulk, Milford, USA) with a minimum thickness of 2mm to serve as a coronal seal. The teeth were then stored in a humidator at 37°C for 2 wk to allow the sealer to set completely. The crowns were then resected with a diamond disc so that each specimen was approximately 16mm in length.

Variable	Group	Mean ± S.D. cm <sup>3</sup>	Overall p-value*	
Volume of Obturating material	I	0.070 ± 0.004	Nil	
	II	0.070 ± 0.007		
	III	0.069 ± 0.006		
	IV	0.071 ± 0.009		
Remaining material in the canal	I	$0.003 \pm 0.002^{a}$	<0.0001 (Sig.)	
	II	$0.002 \pm 0.002^{a}$		
	III	$0.005 \pm 0.003^{\circ}$		
	IV	$0.007 \pm 0.003^{d}$		
Apical extrusion	I	0.010 ± 0.006	<0.0001 (Sig.)	
	II	0.010 ± 0.003		
		0.010 ± 0.004		
	IV	0.000 ± 0.002		

[Table/Fig-1]: Comparison of mean values among different study groups \*One-Way ANOVA was used to calculate the P-value \$ Tukey – HSD procedure was employed to identify the significant groups at 5% level. Superscript: Different alphabet indicates significant differences and same alphabet indicates no significance differences between groups

Groups	Files	% Removed			
Group I	RaCe rotary files	95.74%			
Group II	Protaper Retreatment Files	97.4%			
Group III	K3 Rotary Files	92.86%			
Group IV	H Files	90.14%			
[Table/Fig-2]: Percentage of removed material in the canal					

After this all the teeth were mounted on a platform of modeling wax for the purpose of taking spiral CT. After CT imaging (LightSpeed VCT 64-slice Spiral Computed Tomography Scanner, GE Healthcare, USA), the volume of the obturating material in each tooth was estimated using the Syngo software which uses the radiopacity of the obturating material for the volume analysis.

## PREPARATION

The middle third of the specimens were covered with modeling wax block and these were then mounted on wax sheet to obtain a conical shape and leaving a hollow space surrounding the apical third of root to collect the debris during the retrieval procedure.

## **GUTTA PERCHA REMOVAL**

All the roots had 2mm of filling material removed from the cervical part of the canal using Gates Glidden drills #2 and #3 to create a reservoir for the solvent (tetrachloroethylene; Canal Solve, Amdent, India). The teeth were then randomly divided into four groups of ten teeth each based on the instrument used for gutta percha removal. All the rotary instruments used in this study were used as per the manufacturer's instructions.

The instruments used were:

- Group 1 RaCe (n=10)
- Group 2 ProTaper retreatment files (n=10)
- Group 3 K3 (n=10)
- Group 4 H Files (n=10).

Files were wiped regularly using gauze to remove obturation materials and debris. Gutta-percha removal was judged to be complete when a size 20 K-file reached the working length in each specimen and no more gutta-percha could be seen in the last instrument used in each group.

During the removal of obturating material root canals were constantly irrigated with 5ml of 3% NaOCI for one minute in all samples. After completion of removal of the filling materials the canals were irrigated with 5ml of 17% EDTA for one minute. The canals were finally flushed with 3ml of distilled water and dried with sterile paper point.

A second spiral CT scan was done and the volume of remaining obturating material in each tooth was estimated as before using the same software.

The removal efficacy was calculated by using the formula;

#### (a-b)/a

where 'a' was the volume of obturating material packed in the root canal in cm3 and 'b' was the volume of the obturating material remaining after retrieval in cm3.

The percentage of the obturating material removed was calculated by multiplying the obtained value by 100;

#### [(a-b)/a] 100

Three parameters were evaluated by using spiral CT.

- The volume of obturating materials inside the canal
- The volume of gutta-percha removed from the canal
- Amount of apically extruded debris

The efficiency of different instruments in removing obturating materials was statistically analysed. Statistical analysis was done using one way ANOVA and Tukey-HSD procedure.

## RESULTS

- There is no significant difference in mean volume of obturating material among different study groups (p>0.05).
- The mean volume of remaining material in the canal in Group I (0.003cm<sup>3</sup>) is highly significantly than Group IV (0.007 cm<sup>3</sup>) (p<0.01) [Table/Fig-1]. In addition, the mean remaining material in the canal in Group II (0.002 cm<sup>3</sup>) is significantly lower than Group III (0.005 cm<sup>3</sup>) (p>0.05) and in Group IV (0.07 cm<sup>3</sup>) (p<0.001). However, no other comparisons are statistically significant (p>0.05).
- The percentage removed in Group I (95.74%) and Group II (97.4%) are significantly higher than Group III (92.86%) and Group IV (90.14%) [Table/Fig-2].
- The mean volume of apical extrusion in Group IV ( $0.000 \pm 0.002$  cm<sup>3</sup>) is significantly lower than Group II ( $0.010 \pm 0.004$  cm<sup>3</sup>) and Group I ( $0.010 \pm 0.006$ ) (p<0.05). The mean volume of apical extrusion in Group II ( $0.010 \pm 0.003$  cm<sup>3</sup>) and in Group III ( $0.010 \pm 0.004$  cm<sup>3</sup>) are significantly lower than Group I ( $0.010 \pm 0.006$ ) (p<0.05). However, no other contrasts are statistically significant (p>0.05) [Table/Fig-3-5].

### DISCUSSION

Rotary NiTi instruments have been proposed for the removal of filling materials from root canal walls and various studies reported their efficacy, cleaning ability and safety [9-12] [Table/Fig-1]. Studies have shown that rotary NiTi instruments required less time for gutta-percha removal than hand instruments [7,13-15]. Gu et al., and Mittal & Jain found that ProTaper retreatment files were superior for removal of gutta-percha when compared to H-files and K-flex files [16,17]. Also, Khalilak et al., shows that ProTaper Ni-Ti instruments is more competent and requires less time for removal of gutta-percha when compared to H-File in canals with no or slight curvature [18]. [Table/Fig-6] enumerates the various studies showing removal of gutta-percha with rotary and hand files.

In this study, the instruments evaluated for removal of gutta percha were ProTaper retreatment files (Dentsply Maillefer), RaCe NiTi files (FKG Dentaire), K3 (SybronEndo) and Hedstrom stainless steel files (Mani Inc. Tochigi). Orange oil extract was used as a solvent in our study as it has been reported to be a safe and efficient alternative to chloroform and xylol [19-21]. In this study maxillary central incisors were used, as single rooted teeth are better suited for standardization and evaluation and has minimum degree of curvature. Decoronation was performed to ensure standardization of the length of the specimens.





Previous studies have used different methods to assess the remaining filling material, such as radiographs and digitized images [8,22-24] (which only provides 2-D information for a 3-D object) or clearing techniques and digitized images [7,25]. The clearing techniques with digitized images are time consuming and different chemicals used may disturb the remaining filling materials within the root canals during evaluation process [25]. Other studies have vertically sectioned the roots and then digital imaging was carried out [15,26,27]. This might not be accurate because some remaining filling material might be lost in the process. In the present study we choose volumetric analysis with spiral CT for the evaluation of the removal efficacy of gutta percha because with spiral CT three dimensional measurements are possible without sectioning the specimens and thus avoiding the loss of material during sectioning [28] [Table/Fig-1,2,3].

Spiral or Helical CT scan systems have simultaneous patient translation and x-ray exposure in which x-ray tRaCes a helix/spiral curve on patient's surface due to Slip-ring technology. (It consists of large circumference electrically conducting rings to conduct power to tube via electrical brushes (no cables) which allows the scanner gantry to rotate continuously in one direction. It also transfers data from detectors to computer for reconstruction.) Multi Spiral detector fan beam CT scanners reduces scan time, allows 3D reconstruction with low dose radiation. Increased cycle time per slice (0.625mm)



leads to increased number of slices acquired per breath hold. This non-invasive volume analysis method gives a more accurate measurement than surface area measurement [29,30].

It has been proved that debris extrusion occurs in all instrumentation techniques and therefore every attempt should be made to keep the debris extrusion to a minimum. It was stated from previous studies that rotary files exhibit less extrusion than H-files because they are used in crown-down techniques and the design of the nickeltitanium instruments would facilitate the removal of debris from the canal [31,32]. Hence, along with evaluation of efficacy of gutta percha removal by various instruments, their potential for apical extrusion of debris was also evaluated.

In our study, Group 2 (ProTaper retreatment files) showed the highest efficiency in the removal of obturating material (97.4%), which was followed by Group 1 (RaCe) (95.74%), Group 3(K3) (92.86%) and Group 4 (H-files) (90.14%) with the efficiency in the decreasing order. The increased efficiency of rotary files as compared to hand files may be because rotary files cause the plasticization of gutta percha due to frictional heat generated during instrumentation, which makes the gutta-percha less resistant and easier to be penetrated and removed. This is in accordance with the studies conducted by Gu et al., [16], Só et al., [33], Somma et al., [34] and Unal et al., [35]. When assessing RaCe file with H-file for gutta percha removal, RaCe file exhibits better efficiency than the H-file in our study. This is in agreement with the study conducted by Schirmeister et al., [7], Schirmeister et al., [25] and Kumar et al., [36]. When evaluating K3 file with H-file for gutta-percha removal, K3 file demonstrate better efficiency than the H-file in our study. This is in consensus with the study conducted by Saad et al., [13].

Of the rotary files, Group 2 (ProTaper retreatment files) showed superior performance. This may be attributable to their design, the specific convex triangular flute design and radial land compared to the other two file systems. D1 has a cutting tip for effective penetration into the obturation material in the coronal third, which results in better removal of the gutta-percha material. The number of cutting edges per mm (0.75 per mm) is higher and the taper is varying in the ProTaper retreatment instruments compared to both RaCe & K3 files (0.50 per mm). The RaCe & K3 NiTi files are meant for cleaning and shaping of the root canal system and not specifically designed for retreatment. Though these files have the ability to plasticize gutta-percha with their frictional heat, they lack the ability to pull the obturating material towards the orifice. Thus the plasticized gutta percha could get smeared to the walls of the root canal [25]. This could have been the reason for poor performance of Group 1 (RaCe) and Group 3 (K3) when compared to Group 2

S.No	Author	Year	Files used in Guttapercha removal	Conclusion of the study
1	Mittal N, Jain J [17]	2014 [17]	ProTaper retreatment system and hand retreatment system with/without solvent	ProTaper retreatment system with solvent was better in gutta- percha removal
2	Khalilak Z, Vatanpour M, Dadresanfar B, Moshkelgosha P, Nourbakhsh H [18]	2013 [18]	ProTaper and Hedström files with/without chloroform	ProTaper Ni-Ti instruments are more efficient in the removal of gutta-percha compared to Hedström File in canals with no or slight curvature
3	Unal GC, Kaya BU, Taç AG, Keçeci AD. [35]	2009 [35]	K-files, Hedström files, Profile file, R-Endo and ProTaper Universal rotary retreatment system with solvent eucalyptol.	ProTaper Retreatment and R-Endo instruments were less effective in removing filling material from canal walls than manual and ProFile instruments.
4	Ta demir T, Er K, Yildirim T, Celik D [15]	2008 [15]	ProTaper, R-Endo, Mtwo and Hedström files	Protaper is effective than other files in gutapercha removal
5	Hammad M, Qualtrough A, Silikas N. [28]	2008 [28]	ProTaper retreatment files and K files	Gutta-percha was more efficiently removed by using hand K-files.
6	Somma F, Cammarota G, Plotino G [34]	2008 [34]	ProTaper retreatment files, Mtwo R and Hedström files	All the three systems left remnants of filling material and debris on the root canal walls
7	Gu LS, Ling JQ, Wei X, Huang XY [37]	2008 [37]	ProTaper Universal rotary retreatment system, Hedström files and K files with/without chloroform.	The ProTaper Universal rotary retreatment system proved to be an efficient method of removing GP and sealer from maxillary anterior teeth.
8	Logani A, Shah N [38]	2008 [38]	ProTaper hand, ProTaper rotary and ProFile systems	ProTaper rotary extruded a significantly higher amount of debris than the ProFile.
9	Gergi R, Sabbagh C. [8]	2007 [8]	Protaper and R-Endo	ProTaper and R-Endo rotary instruments doesn't results in the complete removal of filling material from the root canal system.
10	Saad AY, Al-Hadlaq SM, Al-Katheeri NH [13]	2007 [13]	Protaper, K3 and Hedström files	ProTaper and K3 were found to be effective and faster in removing gutta-percha.
11	Bueno CE, Delboni MG, de Araújo RA, Carrara HJ, Cunha RS [3]	2006 [3]	K3 rotary files, K files and Hedström files with chloroform/chlorhexidine.	None of the files removed the gutta-percha completely. Hand files resulting in lesser amount of filling debris than rotary files
12	Schirrmeister JF, Wrbas KT, Meyer KM, Altenburger MJ, Hellwig E. [7]	2006 [7]	FlexMaster, ProTaper, and RaCe rotary instruments and Hedström -files	ProTaper and RaCe instruments required significantly less time for gutta percha removal than FlexMaster and Hedström files
13	Schirrmeister JF, Wrbas KT, Schneider FH, Altenburger MJ, Hellwig E. [25]	2006 [25]	FlexMaster, ProTaper, RaCe rotary instruments and hand files	RaCe system is an efficient and safe device for gutta-percha removal in curved root canals
14	Zarrabi MH, Bidar, Jafarzadeh [31]	2006 [31]	Profile, Race, FlexMaster and hand files	Race system induces less extruded debris than the manual technique and the FlexMaster system.
15	Hülsmann M, Bluhm V [14]	2004 [14]	FlexMaster, GT Rotary, ProTaper and Hedström files with/without eucalyptol	FlexMaster and ProTaper NiTi instrument is efficient in the removal of gutta-percha.
16	Current Study		Protaper retreatment files, K3 endo, Race and Hedstrom files with solvent tetrachloroethylene	ProTaper retreatment files which showed significant difference over other groups in removal of obturating material
Table	/Fig-61: Enumeration of various studies	showing rem	oval of gutta percha with rotary and hand files	

(ProTaper retreatment files) [25,37]. On the other hand, the ProTaper retreatment files tends to pull the obturating material into the file flutes and direct it towards the orifice. However, the ProTaper retreatment

files did not show statistically significant difference in percentage removal of the obturating material as compared to RaCe rotary files. This may be due to the similar designs of negative rake angles and triangular cross-sections in both the files.

Among Group 1 (RaCe) and Group 3 (K3), Group 1 (RaCe) showed superior performance. This can be attributed to an increased torsion resistance due to the electrochemical treatment and the alternating cutting edges in RaCe files which prevent threading [25].

The K3 instruments (Group 3) with their taper-centric shaping ability, radial lands and asymmetrical cross section cleaned canal walls better and took less time than H-files but were inferior to RaCe and ProTaper retreatment files. When evaluating K3 file with H-file for gutta-percha removal, K3 file demonstrate better efficiency than the H-file in our study. This is in consensus with the study conducted by Saad et al., [13].

In our study, the results revealed that the volume of apical extrusion material with Group 4 (H files)  $(0.000 \pm 0.02 \text{ cm}^3)$  was lower than the rotary file systems, Group 2 (ProTaper retreatment files)  $(0.010\pm0.003\text{ cm}^3)$ , Group 3 (K3files)  $(0.010\pm0.004\text{ cm}^3)$  and Group 1 (RaCe files)  $(0.010\pm0.006\text{ cm}^3)$ . These results are in accordance with the study done by Somma et al., [34], in which manual instrumentation showed less apical extrusion than rotary instrumentation [34]. It can be speculated that a faster, aggressive system with its characteristic design features in rotary file systems removes a substantial amount of dentin in a shorter period of time and is unable to coronally displace the debris with the same efficiency as it cuts and hence, poses the risk of increased apical extrusion of debris [38].

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Among the rotary files the least amount of apically extruded debris was seen in Group 2 (ProTaper retreatment files) which was followed by Group 3 (K3 files) and Group 1 (RaCe files), however the differences were not statistically significant.

According to our study, apical extrusion is more in rotary files than in H-file, which is in sharp contrast to other studies [39,40] which stated that, in the rotary technique, debris is blocked in file flutes and moved to the coronal portion. In the push and pull technique used with H files debris goes to the periapical area. Moreover, with rotary instrumentation, the crown down technique coupled with the conical preparation produces a large space for irrigation of debris toward the coronal portion, thereby decreasing the amount of debris extrusion to the periapical area. [Table/Fig-6] enumerates the various studies showing removal of gutta-percha with rotary and hand files.

## CONCLUSION

From the results of this study the following inferences can be made:

- I. ProTaper retreatment files were faster and had greater efficacy for the removal of gutta percha.
- II. RaCe files were better than H-files and K3 files for the removal of gutta-percha.
- III. Apically extruded debris was less in H-files than the other files.

Within the limitations of this study it can be concluded that ProTaper retreatment files which showed significant difference over other groups in removal of obturating material can be the system of choice in endodontic retreatment procedures.

### REFERENCES

- Parekh B, Irani RS, Sathe S, Hegde V. Intraorifice sealing ability of different materials in endodontically treated teeth: an in vitro study. J Conserv Dent. 2014;17(3):234-37.
- [2] Slutzky-Goldberg I, Slutzky H, Gorfil C, Smidt A. Restoration of endodontically treated teeth review and treatment recommendations. *Int J Dent.* 2009;2009: 150251.
- [3] Bueno CE, Delboni MG, deAraújo RA, Carrara HJ, Cunha RS. Effectiveness of rotary and hand files in gutta-percha and sealer removal using chloroform or chlorhexidine gel. *Braz Dent J.* 2006; 17(2):139-43.
- [4] Bodrumlu E, Uzun O, Topuz O, Semiz M. Efficacy of 3 techniques in removing root canal filling material. *J Can Dent Assoc.* 2008;74(8):72.
- [5] Good ML, McCammon A. An removal of gutta-percha and root canal sealer: a literature review and an audit comparing current practice in dental schools. *Dent Update*. 2012;39(10):703-08.
- [6] Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. J Endod. 1985;11:472-78.
- [7] Schirrmeister JF, Wrbas KT, Meyer KM, Altenburger MJ, Hellwig E. Efficacy of different rotary instruments for gutta-percha removal in root canal retreatment. J Endod. 2006;32(5):469-72.
- [8] Gergi R, Sabbagh C. Effectiveness of two nickel-titanium rotary instruments and a hand file for removing gutta-percha in severely curved root canals during retreatment: an ex vivo study. *Int Endod J.* 2007;40(7):532-37.
- [9] Mollo A, Botti G, Prinicipi Goldoni N, Randellini E, Paragliola R, Chazine M, et al. Efficacy of two Ni-Ti systems and hand files for removing gutta-percha from root canals. *Int Endod J.* 2012;45(1):1-6.
- [10] Zmener O, Pameijer CH, Banegas G. Retreatment efficacy of hand versus automated instrumentation in oval shaped root canals: an ex vivo study. Int Endod J. 2006;39:521–26.
- [11] Kosti E, Lambrianidis T, Economides N, Neofitou C. Ex vivo study of the efficacy of H-files and rotary Ni-Ti instruments to remove gutta-percha and four types of sealer. Int Endod J. 2006;39(1):48-54.
- [12] Imura N, Kato AS, Hata GI, Uemura M, Toda T, Weine F. A comparison of the relative efficacies of four hand and rotary instrumentation techniques during endodontic retreatment. *Int Endod J.* 2000;33(4):361-66.
- [13] Saad AY, Al-Hadlaq SM, Al-Katheeri NH. Efficacy of two rotary NiTi instruments in the removal of Gutta-Percha during root canal retreatment. J Endod. 2007;33(1):38-41.
- [14] Hülsmann M, Bluhm V. Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. Int Endod J. 2004;37(7):468-76.
- [15] Tademir T, Er K, Yildirim T, Celik D. Efficacy of three rotary NiTi instruments in removing gutta-percha from root canals. Int Endod J. 2008;41(3):191-96.
- [16] Gu LS, Ling JQ, Wei X, Huang XY. Efficacy of ProTaper Universal rotary retreatment system for gutta-percha removal from root canals. Int Endod J. 2008;41(4):288-95.
- [17] Mittal N, Jain J. Spiral computed tomography assessment of the efficacy of different rotary versus hand retreatment system. J Conserv Dent. 2014;17(1):8-12.
- [18] Khalilak Z, Vatanpour M, Dadresanfar B, Moshkelgosha P, Nourbakhsh H. In Vitro Comparison of Gutta-Percha Removal with H-File and ProTaper with or without Chloroform. *Iran Endod J.* 2013;8(1):6-9.
- [19] Oyama KON, Siqueira LE, Santos M. In vitro study of effect of solvent on root canal retreatment. *Braz Dent J.* 2002;13:208–11.
- [20] Pécora JD, Spanó JCE, Barbin EL. In vitro study on the softening of gutta-percha cones in endodontic retreatment. *Braz Dent J.* 1993;4:43-47.
- [21] Scelza MFZ, Oliveira CRL, Carvalho FB, Faria SCR. In vitro evaluation of macrophage viability after incubation in orange oil, eucalyptol and chloroform. *Oral Surg Med Oral Pathol Oral Radiol Endod*. 2006;102:24-27.

- [22] Cunha RS, De Martin AS, Barros PP, da Silva FM, de Castilho Jacinto R, da Silveira Bueno CE. In vitro evaluation of the cleansing working time and analysis of the amount of gutta-percha or Resilon remnants in the root canal walls after instrumentation for endodontic retreatment. *J Endod*. 2007;33(12):1426-28.
- [23] de Carvalho M AC, Zaccaro Scelza MF. Efficacy of automated versus hand instrumentation during root canal retreatment: an ex vivo study. Int Endod J. 2006;39:779-84.
- [24] Masiero AV, Barletta FB. Effectiveness of different techniques for removing guttapercha during retreatment. Int Endod J. 2005;38:2–7.
- [25] Schirrmeister JF, Wrbas KT, Schneider FH, Altenburger MJ, Hellwig E. Effectiveness of a hand file and three nickel-titanium rotary instruments for removing gutta-percha in curved root canals during retreatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2006;101(4):542-47.
- [26] De Oliveira DP, Barbizam JV, Trope M, Teixeira FB. Comparison between gutta-percha and resilon removal using two different techniques in endodontic retreatment. J Endod. 2006;32(4):362-64.
- [27] Hassanloo A, Watson P, Finer Y, Friedman S. Retreatment efficacy of the epiphany soft resin obturation system. *Int Endod J* 2007;40:633–43.
- [28] Hammad M, Qualtrough A, Silikas N. Three-dimensional evaluation of effectiveness of hand and rotary instrumentation for retreatment of canals filled with different materials. *J Endod.* 2008;34:1370–73.
- [29] Stuart C. White, Michael J. Pharoah, Oral Radiology-Principles and Interpretations, 5<sup>th</sup> edition.
- [30] Jung M, Lommel D, Kilmek J. The imaging of root canal obturation using micro-CT. Int Endod J. 2005;38:617–26.
- [31] Zarrabi MH, Bidar, Jafarzadeh. An in vitro comparative study of apically extruded debris resulting from conventional and three rotary instrumentation techniques. J Oral science. 2006;48:85-88.
- [32] Leonardi Le, Diana M. Atlas Guillermo Raiden Apical extrusion of debris by manual and mechanical instrumentation *Braz Dent J.* 2007;18(1):16-19.
- [33] So' MVR, Saran C, Magro ML. Efficacy of ProTaper retreatment system in root canals filled with gutta-percha and two endodontic sealers. J Endod. 2008;34:1223–25.
- [34] Somma F, Cammarota G, Plotino G. Effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling materials. J Endod. 2008;34:466-69.
- [35] Unal GC, Kaya BU, Taç AG, Keçeci AD. A comparison of the efficacy of conventional and new retreatment instruments to remove gutta-percha in curved root canals: an ex vivo study. *Int Endod J.* 2009;42(4):344-50.
- [36] Kumar NMD, Gokul P, Shivanna V. A comparison of relative efficacy of hand and rotary instrument in the removal of gutta percha from the root canal during retreatment using stereomicroscope- An in vitro study. *Endodontology*. 2009:5-11.
- [37] Gu LS, Ling JQ, Wei X, Huang XY. Efficacy of ProTaper Universal rotary retreatment system for gutta-percha removal from root canals. *Int Endod J.* 2008;41(4):288-95.
- [38] Logani A, Shah N. Apically extruded debris with three contemporary NiTi instrumentation systems: An exvivo comparative study. *Indian Journal of Dental Research.* 2008;19:182-85.
- [39] Bidar M, Rastegar AF, Ghaziani P, and Namazikhah MS, Evaluation of apically extruded debris in conventional and rotary instrumentation techniques. J of CDA. 2004;32(9):665-71.
- [40] Zarrabi MH, Bidar, Jafarzadeh. An in vitro comparative study of apically extruded debris resulting from conventional and three rotary instrumentation techniques. J Oral science. 2006;48:85-88.

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