DOI: 10.7860/JCDR/2023/59885.17622

Original Article

Dentistry Section

Comparative Evaluation of Different Retreatment Files for Gutta-percha Removal from Curved Root Canals Accessed with Novel Ultra-conservative Opening: An In-vitro Study

CHINTAN JOSHI[1], MUSTAFA HAJOORI[2], AASHRAY PATEL[3], MONA SOMANI[4], SWEETY THUMAR[5], ANKITA KHUNT[6], DRITALI PATEL[7], NEELAM DESAI[8]

ABSTRACT

Introduction: In endodontic retreatment, gutta-percha removal must be done correctly in order to assure a successful outcome following failed procedures. The goal of this study was to compare the effectiveness of stainless-steel hand files with three different nickel-titanium rotary instrument systems for removing gutta-percha using ultra-conservative access opening in curved canals.

Aim: To compare the efficacy of different rotary instruments for removing obturating material from root canals with Ninja access in mandibular mesiobuccal moderately curved canals measured radiographically using Cone-beam Computed Tomography (CBCT).

Materials and Methods: An in-vitro study was conducted in the Conservative and Endodontics Department, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India in the time period of June 2022 to July 2022. Forty extracted human mandibular molar teeth were accessed through Ultraconservative opening (Ninja Access). After preparing the root canals, they were sealed using gutta-percha and AH Plus sealer through lateral compaction. The teeth were then stored for one week. The samples were divided into four groups according to the rotary file used: Group I- Hedstrom Files; Group II- ProTaper Universal Retreatment (PTUR) Files; Group III- Neoendo Retreatment Files; Group IV- R-Endo Retreatment. The amount of remaining filling material after the retreatment procedure was checked with CBCT. The statistical analysis was performed using R statistical analysis software version 4.1.0 for windows.

Results: In sagittal section, there was significant difference of residual filling material between the four file systems in middle third only (p=0.048) while significant difference was seen only in apical third in the coronal section (p=0.011). However, the three rotary retreatment files left significantly less remnants than Hedström files during removal of the gutta-percha. The time taken for retreatment was significantly higher for Hedström files (398.90±20.717) sec followed by R-endo retreatment files (274.30±14.407).

Conclusion: H file was the least effective in removing gutta-percha from the canals when compared to the other three file systems. The Neo-Endo rotary retreatment system was faster.

Keywords: Endodontic retreatment, Hedstrom files, Protaper universal rotary files

INTRODUCTION

The long-term success of endodontic treatment depends on thorough cleaning of the root canal system and proper filling of the canal in three dimensions [1]. The persistence of the bacteria mainly Enterococcus faecalis within the intricate root canal system is the main cause of root canal therapy failure [2]. The anatomical intricacy of the root canal system and certain tooth-specific characteristics may both have an impact on the prognosis for success of root canal therapy [3]. Due to its effectiveness and capacity to protect dental structures, non surgical endodontic retreatment is typically the first treatment recommended for endodontically treated teeth displaying persistent apical periodontitis [4].

Multiple studies have shown that using nickel-titanium (NiTi) rotary instruments is an effective and safe method for removing root canal filling material during endodontic retreatment [5-8]. Traditional endodontic cavities have prioritised straight-line paths into root canals in order to maximise preparation efficiency and reduce technical issues [9]. There are concerns that Traditional Endodontic access Cavity (TECs) may weaken the tooth due to the extensive removal of tooth structure during the whole deroofing of the pulp chamber. This could potentially make the tooth more prone to fracture under the forces of mastication [10,11].

With the least invasive trend and increasing use of magnification in dentistry, an alternative to this traditional procedure, named conservative endodontic cavities, was proposed [12-14].

Preserving the pericervical dentin could perhaps increase the resistance to fracture since, it distributes stress. This strategy was put up by Clark D and Khademi J on the theory that removing dental hard tissues for clinical convenience, such as the pericervical dentin, the oblique ridges, and thinning the marginal ridges, may increase the risk of tooth breakage [11]. Various retreatment files system is available but the most commonly used file system is ProTaper Universal. Recently, a new retreatment file system NeoEndo has been introduced. The ProTaper Universal rotational retreatment file system is used in the order listed as given below: D1 with taper 30/09 and length 16 mm for coronal one third removal, D2 with taper 25/08 and length 18 mm for middle one third removal and D3 with taper 20/07 and length 22mm for apical one third removal [15]. NeoEndo retreatment file system is another recent innovation in rotary technology. This system includes three files: N1 (size 30/0.09 taper) for coronal one-third preparation, N2 (size 25/0.08 taper), for middle one-third, and N3 (size 20/0.07 taper) for apical one-third [16].

The R-Endo instruments (Micro-Mega, Basancon, France) are a set of instruments with sizes Rm, Re, R1, R2, and R3. The Rm (size 25, 4% taper) is used to clear the way for the other instruments. The Re (size 25, 12% taper) is used for the first 2-3 mm of filling material removal, followed by R1 (size 25, 0.08 taper), R2 (size 25, 0.06 taper), and R3 until the working length is reached [17].

Various researches have been done on different retreatment file systems comparing the efficacy of hand files, rotary files with or without the use of solvent [5,6]. At present there is scarcity of data on the effectiveness of NeoEndo retreatment files, which was recently introduced when compared to other rotary retreatment systems that are available at present. There is very limited research available [18] for retreatment in ultraconservative access opening using rotary retreatment files, thus the aim of this in-vitro experiment is to compare the effectiveness and time needed to fully remove filling material using three different rotary file systems: Neoendo, R-Endo and Protaper Universal Retreatment files with the use of H files as a reference.

MATERIALS AND METHODS

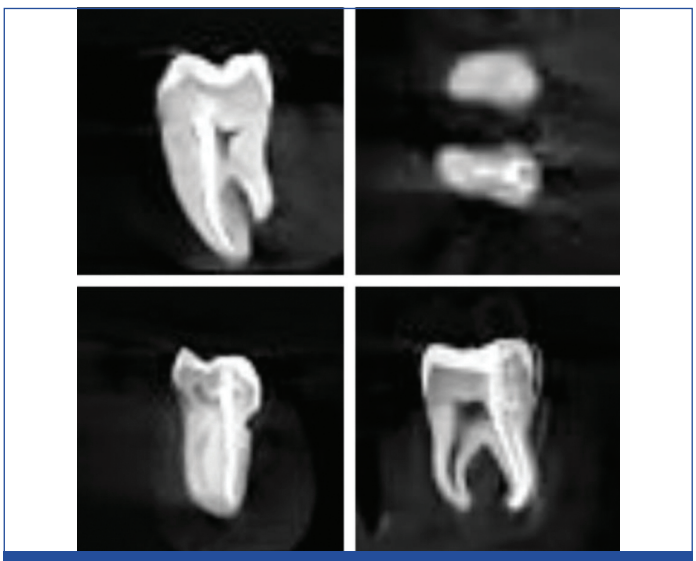
The present in-vitro study was conducted in the Conservative and Endodontics Department, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India in the time period of June 2022 to July 2022. The synopsis and study design was presented in front of ethical committee of the university. No ethical issues were found the study was approved and exempted for ethical clearance due to in-vitro nature of the study.

Forty mandibular molars were selected for this study. Intact tooth without caries or restoration with fully formed root with separate mesial and distal canals. The tooth surface was cleaned for debris and were stored in 0.9% saline at 4°C and used within six months.

Study Procedure

In order to provide alternatives for magnification and coaxial lighting during endodontic access preparation, access preparation was carried out under high magnification utilising a Dental Operating Microscope (DOM). The access cavity was done as a rounded cavity which was performed over the mesio-buccal pulp horns of the tooth by placing the small round bur parallel to the long axis of the tooth in a high-speed handpiece with water cooling. The working length was determined by inserting a size 10 K-file (Dentsply, Maillefer, OK US) into the access cavity. The mesio-buccal canals of all the teeth were prepared using ProTaper rotary instruments (Dentsply, Maillefer, US) in a specific sequence starting with the SX file and continuing with the S1, S2, F1, and F2 files until the entire working length was reached. During the shaping process, the canals were flushed with 2mL of 2.5% sodium hypochlorite (NaOCl) after each instrument was used. The root canals were then sealed with Dia-proseal sealer (Diadent, South Korea) and size F2 ProTaper single cone after being dried with paper points (Dentsply, DeTrey, Germany).

Radiographic confirmation of the calibre and apical extension of root canal fillings was made [Table/Fig-1]. For two weeks, teeth were kept at 37°C with 100% humidity to allow the sealer to fully set. Four sets of ten samples each were formed from three groups of teeth at random. In order to make the gutta-percha soft during retreatment, xylene was utilised as a solvent. Following each instrument swap, 2.5% sodium hypochlorite was used to irrigate the canals. Retreatment was considered complete when no evidence of gutta-percha or sealer was visible on the instruments being used or in the irrigation fluid. The retreatment time from the start of retreatment till completion was calculated with a stopwatch and the time taken was recorded in seconds.



[Table/Fig-1]: CBCT images of obturated teeth prior to gutta-percha removal.

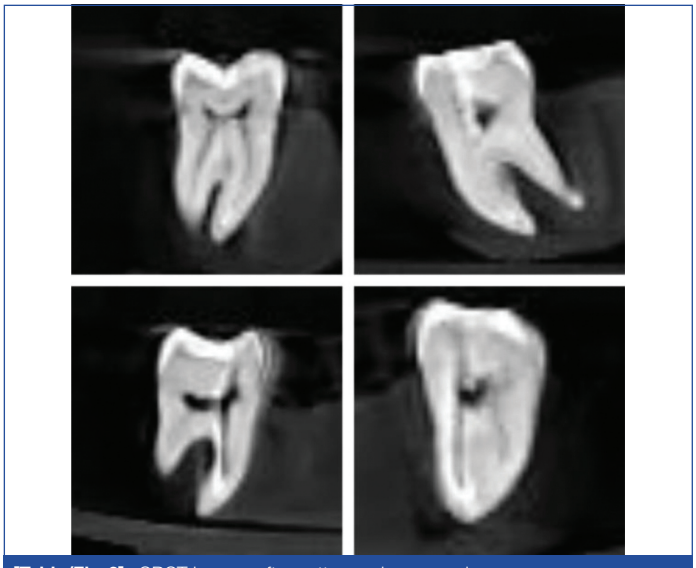
Group I- Hedstrom files: Using Gates Glidden drill sizes 2 and 3, gutta-percha was eliminated from the canal's coronal section. The root fillings from the middle and apical regions of the canal were removed using Hedstrom files (Dentsply Maillefer, Ballaigues, Switzerland) in a circumferential quarter turn push pull motion until the original working length had been attained.

Group II- ProTaper Universal Retreatment Files (PTUR): The root canals were instrumented using a brushing motion. According to the manufacturer's instructions, the rotational speed was set at 500 rpm. To get to the predetermined working length, D1, D2, and D3 were applied in that sequential order.

Group III- Neoendo retreatment files: Following the manufacturer's instructions, neoendo retreatment files were employed sequentially with a gentle apical pressure at 350 rpm. Using the crown down approach, The Neoendo retreatment files were used in a specific order, with N1 used for the coronal third of the root canal, N2 used for the middle third, and N3 used for the apical third.

Group IV- R-endo retreatment files: According to the manufacturer's instructions, the files were used with a back and forth motion at 300 rpm. First the Rm file was used followed by Re instrument to remove the first 2-3. R1, R2 and R3 were used for progressive removal of the gutta-percha till the estimated working length.

Each sample was reshaped and finished with ProTaper Universal rotary files (S1, S2 and F1, F2) after using all the retreatment files, following the manufacturer's instructions until the F2 file reached the working length. The final diameter of the root canal at the apex was 0.25 mm [Table/Fig-2].



[Table/Fig-2]: CBCT Images after gutta-percha removal.

CBCT Evaluation

The effectiveness of removing filling material from the inside walls of the root canal was evaluated by CBCT using PAPAYA 3D PLUS imaging machine keeping the image protocols as Field of view: 5*10 cm, voxel size: 0.18 mm, kilo voltage: 80-90 kvp and milliampere: 5-15 Ma.

For viewing TRIANA software version 2.5.11.2 was used [Table/Fig-2]. After scanning, the area with the greatest amount of filler material was assessed on axial, coronal, and sagittal sections.

On the coronal and sagittal sections, the canal's surface area and residual filling material were determined.

The following equation was used to determine the percentage of filling material still present on the canal walls [19]:

$$APRFM^{*}=\frac{\text{area of remaining filling material}}{\text{area of canal wall}}=100$$

***(APRFM=Area Percentage of the Remaining Filling Material)**

The amount of filling material left in the coronal, middle, and apical sections of each canal was evaluated according to the following criteria [20]:

- No or slight presence (0-25% debris on the dentinal surface)
- Mild presence (25-50% debris on the dentinal surface)
- Moderate presence (50-75% debris on the dentinal surface)
- Heavy presence (more than 75% debris on the dentinal surface).

Note that the debris was not distinguished between filling material and sealer remnants.

STATISTICAL ANALYSIS

Mathematical data was presented as mean and Standard Deviation (SD) values. The data was analysed using the Kolmogorov-Smirnof and Wilcoxon tests, which showed that the data followed a normal Gaussian distribution. The t-test was used to compare the data between groups. The results were considered statistically significant if the p-value was less than or equal to 0.05. The statistical analysis was performed using R statistical analysis software version 4.1.0 for windows.

RESULTS

The gutta-percha in the canals could not be completely removed by any of the files. The mean values and SD of the grades of leftover filler material in each group are displayed in [Table/Fig-3,4]. Data analysis revealed that in sagittal section, there was significant difference of remaining filling material between the four file systems in middle third only (p=0.048) while significant difference was seen only in apical third in the coronal section (p=0.011). The Hedstrom file group, followed by the Protaper and NeoEndo retreatment files, showed the biggest area of filling material residues in the coronal and middle. In the apical third, the least amount of filler material remains was in Protaper retreatment file group [Table/Fig-3,4].

Area	H-files	ProTaper	NeoEndo	R-Endo	F-test	p-value
Coronal	2.20±0.63	1.90±0.74	1.70±0.67	1.70±0.67	1.204	0.322
Middle	2.40±0.51	2.00±0.67	1.90±0.57	1.80±0.63	1.930	0.142
Apical	3.10±0.74	2.10±0.74	2.20±0.63	2.30±0.67	4.303	0.011

[Table/Fig-3]: Mean values and Standard Deviations (SD) of residual filling material in each group in coronal section.
*One-way ANOVA test

Area	H-files	ProTaper	NeoEndo	R-Endo	F-test	p-value
Coronal	2.50±0.53	2.20±0.63	1.90±0.74	1.80±0.63	2.466	0.078
Middle	2.80±0.79	2.00±0.67	2.20±0.63	1.90±0.87	2.9100	0.048
Apical	3.20±0.79	2.40±0.70	2.50±0.71	2.50±0.71	2.589	0.068

[Table/Fig-4]: Mean values and Standard Deviations (SD) of residual filling material in each group in Sagittal Section.
*One-way ANOVA test

Significant difference was seen when residual filling material was compared between Hedstrom files and all the other file systems [Table/Fig-5], while Neo-Endo, R-Endo, and the ProTaper retreatment file did not differ significantly from one another (p>0.05) [Table/Fig-6,7].

[Table/Fig-8] lists the amount of time each group spent retreating in seconds. R-Endo and H file took a lot longer than Protaper and Neo-Endo. The H file took the longest time, taking longer than all the other groups combined.

Section	H-files	ProTaper	Mean difference	95% CI of mean difference	t-value	p-value
Coronal	7.70±0.82	6.00±1.15	1.70	(0.75,2.64)	3.791	0.001
Sagittal	8.50±1.18	6.60±1.17	1.90	(0.79,3.00)	3.612	0.002
NeoEndo						
Coronal	7.70±0.82	5.80±1.47	1.90	(0.77,3.02)	3.556	0.002
Sagittal	8.50±1.18	6.60±1.17	1.90	(0.79,3.00)	3.612	0.002
R-Endo						
Coronal	7.70±0.82	5.80±0.42	1.90	(1.28,2.51)	6.496	0.001
Sagittal	8.50±1.18	6.20±1.32	2.30	(1.12,3.47)	4.116	0.001

[Table/Fig-5]: Comparison of overall residual filling material in H-files with ProTaper, Neoendo and R-Endo file in the coronal and sagittal sections (mean±standard deviation).
*Student t-test

Section	ProTaper	NeoEndo	Mean difference	95% CI of mean difference	t-value	p-value
Coronal	6.00±1.15	5.80±1.47	0.20	(-1.04,1.44)	0.338	0.740
Sagittal	6.60±1.17	6.60±1.17	0.00	(-1.10,1.10)	0.000	1.000
R-endo						
Coronal	6.00±1.15	5.80±0.42	0.20	(-0.62,1.01)	0.514	0.613
Sagittal	6.60±1.17	6.20±1.32	0.40	(-0.77,1.57)	0.717	0.482

[Table/Fig-6]: Comparison of residual filling material in ProTaper, with NeoEndo and R-Endo file in the coronal and sagittal sections (mean±standard deviation).
*Student t-test

Section	NeoEndo	R-Endo	Mean difference	95% CI of mean difference	t-value	p-value
Coronal	5.80±1.47	5.80±0.42	0.00	(-1.02,1.02)	0.000	1.000
Sagittal	6.60±1.17	6.20±1.32	0.40	(-0.77,1.57)	0.717	0.482

[Table/Fig-7]: Comparison of residual filling material between NeoEndo and R-Endo (mean±standard deviation).
*Student t-test

Group	Mean	SD	Min	Max	Chi-square	p-value
H-files	398.90	20.717	362	424	36.565	0.001
ProTaper	185.70	7.528	174	197		
NeoEndo	155.90	9.492	139	167		
R-Endo	274.30	14.407	247	295		

[Table/Fig-8]: Time taken in seconds for retreatment.
*Chi-square test

DISCUSSION

The present study focused on ability of, Protaper universal, R-Endo and Neoendo retreatment files to remove gutta-percha and sealer from root canals in retreatment cases as quickly as possible. The present study found that no retreatment files was able to completely remove gutta-percha, but there was significant difference between H files and rotary files both in terms of time taken and efficiency of gutta-percha removal.

In the event that endodontic therapy is unsuccessful, retreatment is seen as a respectable substitute for extraction. One of the main objectives of the non surgical endodontic retreatment method is the arduous task of completely removing the root filling material [20]. Complete removal of the root canal filling material was advised during non surgical retreatment to ensure retreatment success. Due to their intricate architecture, well-filled curved canals present particular difficulties for this technique, endangering the cleaning process and raising the possibility of mishaps. Previous research has found that rotary instruments are less time consuming, safer, and less labour-intensive than traditional hand instruments [21]. To determine the amount of leftover root canal filler material in the canals after retreatment, previous studies have used a number of

techniques. These procedures included radiographic inspection, stereomicroscope evaluation, CBCT, Scanning Electron Microscopy (SEM), clearing techniques, and micro-CT. Digital pictures were also taken when teeth were split longitudinally. Only two-Dimensional (2D) information of a three-Dimensional (3D) structure is provided by radiographic images of the sample. Magnification and distortion are two things that can happen to radiographs. Remaining filling material is lost when teeth are divided longitudinally using digital imaging method. The most accurate method for this evaluation to far is micro-CT, although it takes a lot of time. In order to analyse any remaining root canal filling material, 3D CBCT imaging, which is more promising and easily accessible to researchers, was chosen for the current investigation [22,23].

Previous research has suggested that after using retreatment files, the root canals should be reprepared with size 25 finishing files to ensure thorough cleaning due to the limited cleaning action of the size 20 D3 ProTaper Universal retreatment file, which is designed to reach all the way till working length but does not allow for complete cleaning. Same could be seen with Neoendo, where N3 (size 20) and R-Endo where last file used had size and taper of size 25/0.04 taper. To ensure maximum removal of gutta-percha this protocol was followed [15,24]. The effectiveness of single cone obturation has been the subject of numerous researches in the past [25]. For example, when multiple writers analysed the quality of the obturation in root canals filled with single-cone procedures, they came to the conclusion that single cone produced better outcomes. Bi-directional radiography and the mechanism of fluid conveyance were used by Hörsted-Bindslev P et al., to assess the obturation quality in curved root canals [26]. They found that the root canal curvatures of the single-cone and lateral condensation procedures and obturation were comparable. The gutta-percha in the study has been softened using solvent. It is debatable whether or not to use solvents during the retreatment process because doing so could accidentally remove gutta-percha and leave a layer on the canal walls. With its capacity to quickly disintegrate gutta-percha, chloroform is one of the most preferred solvents for gutta-percha removal. It has been classified as a class 2B carcinogenic substance, and as its use is debatable, it has been now been advised to substitute xylene, orange oil, or eucalyptol oil as solvents [27]. The gutta-percha solvent in the current study was xylene. Xylene, as opposed to liquidised gutta-percha, slowly dissolves gutta-percha and improves gutta-percha excretion [28].

The preservation of tooth structure, which has an impact on the survival of endodontically treated teeth, is a crucial aspect of conservative endodontic treatment. There isn't much evidence to back up the advantages and potential disadvantages of the Conservative Endodontic Access (CEC) cavity idea. The basic components of root canal therapy include thorough cleaning, disinfecting, and filling the canals with biologically acceptable materials. Black gave the concept of "extension for prevention" which states the removal of additional tooth structure in order to prevent mishaps which is in contrast to the principle of conservation. This modification of the principles, which include the outline form, the convenience form, and the removal of the carious dentin, has been tried. Different conservative cavity designs were developed to address the issue of maintaining tooth structure, particularly pericervical dentin [13,29]. A study by Corsentino G, found that the use of UltraConservative Access (Ninja Access) does not significantly improve the fracture strength of endodontically treated teeth compared to CEC and TEC techniques [30].

On the other hand, Reddy NG et al., concluded that minimal invasive endodontic access cavities such as CEC and Ninja access not only showed greater fracture resistance than TEC but also had an almost same root canal filling efficacy as TEC [31]. Protaper Retreatment files' design may be responsible for their cutting effectiveness. D1, D2, and D3 have lengths and taper that progress. They feature a triangular cross-section that is convex. The gutta-percha usually follows the ProTaper universal retreatment files into the flutes and into the canal opening. Additionally, these engine-driven files generate frictional heat that may cause gutta-percha to plasticise and make removal easier [32]. Gutta-percha removal on pulling motion is facilitated by the positive rake angle of H-files. Hand files being more rigid and stiffer than rotary files, and using them all the way to the working length might result in procedural problems such as ledges, transportation, orand canal perforation. In their investigation, Khalilak Z et al., found that Protaper retreatment files outperformed H files at removing gutta-percha. This is so that more filler material can be removed. Protaper files D1, D2, and D3 have bigger cross-sections and larger taper than H-files which have a taper of just 2% [33].

The cross-section of the Neoendo files is parallelogram-shaped, and the rake angle is positive. This type of cross-section allows only one or two point contact. In turn, this will lessen binding and ensure that there is little to no wedging in, improving cutting and effectiveness. The additional volume guarantees improved debris removal around the instrument. Additionally, it contains an active cutting tip for simple initial penetration [34]. The R-Endo instruments, which include Rm hand file and four NiTi rotary files, are specifically made for retreatment. They have an active tip and consist of a triangular cross-section with equally spaced cutting edges that lack radial angles. The files are centred within the canal, particularly at the apical third, and have enhanced flexibility as a result of having a smaller core structure ProTaper universal instrumentation was found to be more effective than R-Endo devices, according to Das S et al., The ProTaper Universal Retreatment File has a triangular cross-section with a convex shape, which provides a larger inner surface area for the removal of filling material, was said to be the reason for its success [35].

The results of this study was found in agreement with Tasdemir T et al., who also found ProTaper to leave less gutta-percha while complete removal was not observed with any file [36]. According to various studies, Ni-Ti rotary instrument are faster than hand files in retreatment cases for gutta-percha removal. The mechanically plasticised gutta-percha gives less resistance to the subsequent instrumentation's activity. Because of this, it was probably simpler to achieve the working length using Ni-Ti tools than with hand files [37-39]. comparative evaluation of the present study with previously published study has been done in [Table/Fig-9] [15,32,33,35,36,39].

S. No.	Author's name and year	Place of study	Sample size	File systems compared	Conclusion
1.	Das S et al., 2017 [35]	North Bengal Dental College and Hospital, Darjeeling, India	60	ProTaper retreatment files, Mtwo retreatment files, and R-Endo files	ProTaper and Mtwo retreatment file systems, were found to be effective in the removal of root canal filling material
2.	Preetam CS et al., 2016 [32]	Madha Dental College, Chennai, Tamil Nadu, India	30	ProTaper Retreatment files and RaCe System compared to hand instrumentation with Hedstrom files	The use of both rotary and hand instrumentation for effective removal of gutta-percha for retreatment.
3.	Mittal N and Jain J 2014 [39]	Banaras Hindu University, Varanasi, Uttar Pradesh, India	40	ProTaper retreatment system and hand retreatment system with/without solvent	ProTaper retreatment system with solvent was better in gutta-percha removal

4.	Khalilak Z et al., 2013 [33]	Islamic Azad University, Tehran, Iran	40	ProTaper and Hedström files with/ without chloroform	ProTaper Ni-Ti instruments were more efficient in the removal of gutta-percha compared to Hedström File in canals with no or slight curvature
5.	Giuliani V et al., 2008 [15]	University of Florence, Florence, Italy	42	ProTaper Universal System rotary retreatment system and Profile 0.06 and hand instruments (K-file)	ProTaper Universal System for retreatment files left cleaner root canal walls than the K-file hand instruments and the ProFile Rotary instruments
6.	Tasdemir T et al., 2008 [36]	Karadeniz Technical University, Trabzon, Turkey	60	ProTaper, R-Endo, Mtwo and Hedström files	ProTaper left significantly less gutta-percha and sealer than Mtwo instruments
7.	Present study	Karnavati University, Gandhinagar, Gujarat, India.	40	Hedström files, Protaper Universal retreatment file, NeoEndo retreatment file, R-Endo retreatment files	All the rotary retreatment files performed better then hand Hedström files. There was no significant difference among the rotary files but R-Endo files left a smaller amount of residual material, While ProTaper left less gutta-percha in the apical third.

[Table/Fig-9]: Comparative evaluation of previously published studies [15,32,33,35,36,39].

Limitation(s)

The limitation of the present study was that the study was done in-vitro without considering the patient related factors such as post instrumentation pain and apical debris extrusion.

CONCLUSION(S)

No file system included in this study was able to entirely eliminate gutta-percha from the canals However, ProTaper Universal Retreatment files performed better than NeoEndo, R-Endo and H-files in gutta-percha removal from the apical third of the root. R-Endo retreatment files had less overall residual filling compared to Protaper Universal and NeoEndo retreatment files, but the result was not significant. H Files took significantly more time for gutta-percha removal followed by R-endo retreatment files. Further in-vivo studies are necessary to evaluate presence of any postoperative complication and pain.

REFERENCES

[1] Li GH, Niu LN, Selem LC, Eid AA, Bergeron BE, Chen JH, et al. Quality of obturation achieved by an endodontic core-carrier system with crosslinked gutta-percha carrier in single-rooted canals. J Dent Sci. 2014;42(9):1124-34.
[2] Nasiri K, Wrbas KT. Elimination of Enterococcus faecalis in the root canal during the SARS-CoV-2 pandemic. J Dent Sci. 2022;17(4):1829-30.
[3] Oliveira MA, Venâncio JF, Pereira AG, Raposo LH, Biffi JC. Critical instrumentation area: influence of root canal anatomy on the endodontic preparation. Br Dent J. 2014;25:232-36.
[4] Alakabani TF, Faus-Llácer V, Faus-Matoses I, Ruiz-Sánchez C, Zubizarreta-Macho Á, Sauro S, et al. The efficacy of rotary, reciprocating, and combined non surgical endodontic retreatment techniques in removing a carrier-based root canal filling material from straight root canal systems: A micro-computed tomography analysis. J Clin Med. 2020;9(6):1989.
[5] Akpınar KE, Altunbaş D, Kuştarcı A. The efficacy of two rotary NiTi instruments and H-files to remove gutta-percha from root canals. Medicina Oral, Patologia Oral Y Cirugia Bucal. 2012;17(3):e506.
[6] Peters OA, Schönenberger K, Laib A. Effects of four Ni–Ti preparation techniques on root canal geometry assessed by micro computed tomography. Int Endod J. 2001;34(3):221-30.
[7] Tejaswi S, Singh A, Manglekar S, Ambikathanaya UK, Shetty S. Evaluation of dentinal crack propagation, amount of gutta-percha remaining and time required during removal of gutta-percha using two different rotary instruments and hand instruments- An In-vitro study. Niger J Clin Pract. 2022;25(4):524-30.
[8] Patel A, Parekh V, Kinariwala N, Johnson A, Somani M. Forensic identification of endodontically treated teeth after heat-induced alterations: An in-vitro study. Eur Endod J. 2020;5(3):271-76.
[9] Patel S, Rhodes J. A practical guide to endodontic access cavity preparation in molar teeth. Br Dent J. 2007;203:133-40.
[10] Schroeder KP, Walton RE, Rivera EM. Straight line access and coronal flaring: Effect on canal length. J Endod. 2002;28:474-76.
[11] Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am. 2010;54:249-73.
[12] Tang W, Wu Y, Smales RJ. Identifying and reducing risks for potential fractures in endodontically treated teeth. J Endod. 2010;36:609-17.
[13] Shabbir J, Zehra T, Najmi N, Hasan A, Naz M, Piasecki L, et al. Access cavity preparations: Classification and literature review of traditional and minimally invasive endodontic access cavity designs. Journal of Endodontics. 2021;47(8):1229-44.
[14] Anjum SA, Hegde S, Mathew S. Minimally invasive endodontics-A review. J Dent Orofac Res. 2019;15(2):77-88.
[15] Giuliani V, Cocchetti R, Pagavino G. Efficacy of ProTaper universal retreatment files in removing filling materials during root canal retreatment. J Endod. 2008;34(11):1381-84.
[16] Sagare SV, Chandra P, Kaur T, Ganorkar O, Khade A, Mehta SD. A comparative study of the efficacy of WaveOne and NeoEndo retreatment file system for the removal of gutta-percha from the root canal. J. Pharm. Bioallied Sci. 2021;13(Suppl 2):S1682.
[17] Fenoul G, Meless GD, Perez F. The efficacy of R-Endo® rotary NiTi and stainless-steel hand instruments to remove gutta-percha and Resilon. Int Endod J. 2010;43(2):135-41.
[18] Fatima K, Nair R, Khasnis S, Vallabhaneni S, Patil JD. Efficacy of rotary and reciprocating single-file systems on different access outlines for gutta-percha removal in retreatment: An in-vitro study. J Conserv Dent: JCD. 2018;21(4):354.
[19] Madhu K, Karade P, Chopade R, Jadhav Y, Chodankar K, Alane U. CBCT Evaluation of gutta-percha removal using ProTaper and Mtwo retreatment files, waveone, and hedstrom files: an ex-vivo study. Front dent of surgical and nonsurgical endodontic retreatment cases. J Endod. 1989;15(6):261-66.
[20] Azarpazhooh A, Sgro A, Cardoso E, Elbarbary M, Lighvan NL, Badewy R, et al. A scoping review of 4 decades of outcomes in nonsurgical root canal treatment, nonsurgical retreatment, and apexification studies—Part 2: Outcome measures. J Endod. 2022;48(1):29-39.
[21] Aung NM, Myint KK. Diagnostic accuracy of CBCT for detection of second canal of permanent teeth: A systematic review and meta-analysis. Int J Dent. 2021;2021:1107471.
[22] Alsofi L, Rajkhan W, Al-Habib M, Ashe H, Alnowailaty Y, Balto K. Characterization of the differential efficacy of austenitic vs martensitic NiTi rotary files in non surgical root canal retreatment: A micro-CT analysis. Front Biosci. 2021;26(9):465-74.
[23] 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;41:288-95.
[24] Huang X, Ling J, Gu L. Quantitative evaluation of debris extruded apically by using ProTaper Universal Tulsa Rotare System in endodontic retreatment. J Endod. 2007;33:1102-05.
[25] Zare S, Shen I, Zhu Q, Ahn C, Primus C, Komabayashi T. Micro-computed tomographic evaluation of single-cone obturation with three sealers. Restor Dent Endod. 2021;46(2):e25.
[26] Hörsted-Bindslev P, Andersen MA, Jensen MF, Nilsson JH, Wenzel A. Quality of molar root canal fillings performed with the lateral compaction and the single-cone technique. J Endod. 2007;33(4):468-71.
[27] Vajrabhaya LO, Suwannawong SK, Kamolroongwarakul R, Pewklieng L. Cytotoxicity evaluation of gutta-percha solvents: Chloroform and GP-Solvent (limonene). Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;98(6):756-59.
[28] Dotto L, Sarkis-Onofre R, Bacchi A, Pereira GK. The use of solvents for gutta-percha dissolution/removal during endodontic retreatments: A scoping review. Journal of Biomedical Materials Research Part B: Applied Biomaterials. 2021;109(6):890-901.
[29] Mishra A, Sedani S. Comparative evaluation of remaining dentinal thickness in three different conservative access preparation techniques in mandibular molars using CBCT. AMHSR. 2021;11:106-09.
[30] Corsentino G. Influence of access cavity design on fatigue resistance of reciproc blue: Conservative vs. Truss access. Int J Oral Dent Health. 2021;7:125.
[31] Reddy NG, Naga SG, Kumar MM, Srinivas NH, Mettu S, Animireddy D. Influence of access cavity design on the fracture resistance and root canal filling efficacy in simulated young permanent molars using cone-beam computed tomography: An in-vitro study. Endodontology. 2020;32(3):130.
[32] Preetam CS, Chandrashekhar M, Gunaranjan T, Kumar SK, Sahib SAM, Kumar MS. A comparative evaluation of two rotary Ni-Ti instruments in the removal of gutta-percha during retreatment. J Int Soc Prev Community Dent. 2016;6(Suppl 2):S131.
[33] 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.
[34] Baranwal HC, Mittal N, Garg R, Yadav J, Rani P. Comparative evaluation of retreatability of bioceramic sealer (BioRoot RCS) and epoxy resin (AH Plus) sealer with two different retreatment files: An in-vitro study. J Conserv Dent. 2021;24(1):88-93.
[35] Das S, De Ida A, Das S, Nair V, Saha N, Chattopadhyay S. Comparative evaluation of three different rotary instrumentation systems for removal of gutta-percha from root canal during endodontic retreatment: An in-vitro study. J Conserv Dent. 2017;20(5):311-16.

[36] Taşdemir 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.
[37] Zmener O, Pameijer CH, Banegas G. Effectiveness in cleaning oval-shaped root canals using anatomic endodontic technology, ProFile and manual instrumentation: A scanning electron microscopic study. Int Endod J. 2005;38(6):356-63.
[38] Betti LV, Bramante CM. Quantec SC rotary instruments versus hand files for gutta-percha removal in root canal retreatment. Int Endod J. 2001;34(7):514-19.
[39] 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.

PARTICULARS OF CONTRIBUTORS:
1. Professor and Head, Department of Conservative Dentistry and Endodontics, Karnavati University, Gandhinagar, Gujarat, India.
2. Postgraduate, Department of Conservative Dentistry and Endodontics, Karnavati University, Gandhinagar, Gujarat, India.
3. Assistant Professor, Department of Conservative Dentistry and Endodontics, Karnavati University, Gandhinagar, Gujarat, India.
4. Associate Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.
5. Associate Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.
6. Assistant Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.
7. Postgraduate, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.
8. Senior Lecturer, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Gandhinagar, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Aashray Patel,
37, Swagat Bunglows, Ramosana Jakat Naka, Mehsana-384002, Gujarat, India.
E-mail: aashray@karnavatiuniversity.edu.in

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 05, 2022
- Manual Googling: Dec 20, 2022
- iThenticate Software: Jan 04, 2023 (12%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 27, 2022**
Date of Peer Review: **Oct 14, 2022**
Date of Acceptance: **Jan 05, 2023**
Date of Publishing: **Mar 01, 2023**