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Assessment of Various Retreatment File Systems: Impact on Canal Centering and Transportation in Endodontic Retreatment Procedures - an in vitro CBCT study

[1]Tanvi Deepak Shah,[2]Sindhu Ramesh

Department of Conservative Dentistry and Endodontics,Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences,Saveetha University,Chennai, India
Mail Id : tanvis20597@gmail.com
Professor, Department of Conservative Dentistry and EndodonticsSaveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences,Saveetha University,Chennai, India
Mail Id: sindhuramesh@saveetha.com

Corresponding Author:Sindhu Ramesh

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Abstract
Background: Advances in endodontic retreatment methods and file systems have increased the procedure's efficiency and accuracy. The purpose of this study was to evaluate canal centering, transportation, and debris removal in teeth obturated utilizing several procedures, notably matched taper single cone (MTSC), downpack backfill (DBF), and cold lateral compaction (CLC).
Methods: Fifty-four freshly removed mandibular premolars with single straight canals were split into three groups according to obturation procedures. Before endodontic treatment and after retrieval of gutta percha, cone beam computed tomography (CBCT) scans were performed. Protaper Universal Retreatment (Group 1), Coltene Micromega Hyflex Remover (Group 2), and Neoendo Retreatment File (Group 3) were used to execute retreatments. Gambill et al. developed a method to measure canal centering and transit.The researchers discovered substantial variations in canal centering and conveyance across the three obturation strategies. The greatest variance was seen in Group 2 (DBF), followed by Group 1 (MTSC) and Group 3 (CLC). However, no statistically significant differences were found across the groups at various canal levels. All groups had residual filling material, with the lateral condensation approach having less leftover material than single cone obturation and downpack backfill.
Conclusion: The impact of obturation technique and file system on retreatment outcomes is highlighted in this study. While current rotary file systems are efficient, they may not remove all root filling materials completely. The study emphasizes the need of using adjunctive treatments like H-files and endodontic solvents to guarantee comprehensive canal cleaning and disinfection.
Keywords: Endodontics, retreatment, rotary files, obturation techniques, canal centering, transportation, debris removal, cone beam computed tomography

Introduction

Endodontic retreatment has prompted significant advancements in rotary file design and functioning.[1] Due to bacterial persistence, post-treatment sickness, or complications with the first root canal therapy, retreatment procedures are commonly necessary. In response to these limits, modern retreatment rotary files have evolved to increase their efficacy and precision.[2] Among the advancements are file design, metallurgy, and surface treatments. Improved file geometry allows for more successful negotiation of challenging canal anatomies, as well as improved capacity to remove obturation materials and residual debris.[3] Improved metallurgical properties give increased flexibility and cyclic fatigue resistance, minimizing the risk of file separation during retreatment procedures. Furthermore, sophisticated surface treatments help in debris removal and friction reduction, ultimately improving overall cutting efficiency and reducing the chance of iatrogenic errors.[4]

Proper canal centering and avoiding transportation are key criteria when utilizing rotary files in endodontic procedures.[5] Canal centering preserves the natural canal anatomy, reducing the likelihood of iatrogenic dentinal wall damage.[6] Transportation or deviation from the original canal channel might result in obturation concerns, broken seals, and treatment failure.[7] Variable tapers and asymmetric cross-sections are two examples of innovative design features seen in current rotary file systems. These characteristics contribute to increased flexibility, dirt removal capability, and torque during instrumentation. These advancements significantly reduce the probability of transportation while maintaining the structural integrity of the root canal by carefully following the canal's natural contour. The application of these design elements not only improves overall procedural efficiency, but also ensures the durability and efficacy of endodontic treatments.[8][9]

The development of retreatment rotary files indicates the ongoing commitment to refining endodontic operations, ensuring successful retreatment outcomes, and ultimately improving endodontic patient care.[10], [11] As a consequence, the purpose was to assess residual dentin, canal centering ability, and retreatment file transportation on teeth with diverse obturations and retreatment files.

Materials And Methods

This research was done with the approval of the institutional ethical committee (SRB/SDC/ENDO-2101/23/051) and in accordance with the PRILE 2021 guidelines.[12]

Sample Selection

We gathered 54 freshly removed mandibular premolars. Included were teeth with single straight canals and patent up to the apex. Teeth having additional canals or roots, as well as extreme curvatures. Internal or external resorption, as well as cavities, were not considered. The teeth were scaled and preserved in Normal Saline (JoinHub Pharma, India) till the experiment began.

Sample Preparation

All of the chosen teeth were decoronated to a constant length of 16mm. An Endo-Z bur (Dentsply, Maillefer) was used to alter the access aperture. Working length and glidepath were established using 10K and 15K files (Dentsply Maillefer, Ballaigues, Switzerland), followed by root canal shaping with Protaper Gold Rotary files (Dentsply Maillefer, Ballaigues, Switzerland). The canal was prepared up to size F2 and utilized according to the manufacturer's specifications. Irrigation with 3% sodium hypochlorite (Prime Dental, India), 17% EDTA (Cerkamed Medical Company, Poland), and Saline (JoinHub Pharma, India), as well as sonic activation with EndoActivator (Dentsply Maillefer), was extensive. After that, the teeth were sorted into three groups of 18 samples each.

Obturation Techniques

The teeth were obturated using three distinct techniques: matched taper single cone (MTSC), downpack backfill (DBF), and cold lateral compaction (CLC). Prior to this, the canals were dried with absorbent paper points and sealed with an AH plus resin-based sealant.

The MTSC method employed a single F2 size ProTaper Gutta Percha cone. The DBF technique employed an F2 gutta percha cone that was sheared off up to the apical third before being backfilled with thermoplasticized gutta percha (Gutta-Smart, Dentsply Maillefer, Ballaigues, Switzerland). Finally, the CLC approach employed no. 25 gutta percha with a 2% taper that was laterally compressed with additional 2% cones. Cavit G (3M Espe, India) was employed as a temporary infill material after further gutta percha was sheared off. Prior to analysis, the obturation quality was assessed by collecting radiographs in the mesio-distal and bucco-lingual directions. Teeth were kept in 100% humidity at 37 degrees Celsius for one week to verify that the resin-based sealant had completely set.

Cone Beam Computed Tomography Analysis following the Endodontic Treatment

The samples were implanted in a transparent self cure resin mold on a regular basis, and a preoperative CBCT scan was performed. The ORTHOPHOS XG 3D CBCT SYSTEM (Sirona--The Dental Company) was used to scan the samples. The scanning settings were 64 kVp, 8 mA current, and 900 projections across the whole rotation with a resolution of 150 m. The FOV encompassed an area similar to an 8 cm diameter and height cylinder.

Gutta-Percha Removal

The samples in each group were further subdivided into 3 groups

- Protaper Universal Retreatment File (Group 1)
- Coltene Micromega Hyflex Remover (Group 2)
- Neoendo Retreatment File (Group 3)

All the files were used sequentially with copious irrigation using saline. Retreatment of the canal was considered to be over when there was no debris evident on the flutes of the retreatment file. Each file was used for only one sample and discarded. Final saline rinse followed by drying the canal with absorbent paper points (Dentsply Maillefer, Ballaigues, Switzerland). The samples were now processed for the final CBCT scan.

Measurement of Canal Centering and Canal Transportation

The mean centering ratio demonstrates the instrument's capacity to remain centered within the canal. The CA of the instrument was calculated using a method devised by Gambill et al. using the third (apical), fifth (middle), and seventh (coronal) mm from the apex of the root.

Canal Centering ability $=(X1- X2) / (Y1- Y2)$ or $(Y1- Y2) / (X1- X2)$

Where X1 and X2 are the smallest distances from the root's edge to the canal's edge, while Y1 and Y2 are the greatest lengths. The capacity of the instrument to maintain the central location of the root canal was found to be lowest when the values neared 0 (zero), and highest when they approached 1 (one).

The amount and direction of canal transportation may be estimated by measuring the distance from the edge of the uninstrumented canal to the edge of the tooth in both the longest and shortest directions and comparing it to the measurement obtained from the instrumented images.Canal transit was calculated using the Gambill formula as follows:

Canal Transportation $= [(X_1-X_2)-(Y_1-Y_2)]$

where $T = 0$ denotes no transportation, $T > 0$ denotes transportation toward the mesial aspect of the root canal, and $T < 0$ denotes transportation toward the distal aspect of the root canal.

Statistical Analysis

With the aid of the Statistical Package for the Social Sciences (SPSS) software program, version 23.0 (IBM, Chicago, Illinois), statistical analysis was carried out. A value of $P < 0.05$ was considered statistically significant. The mean and standard deviation for each group were determined, one-way analysis of variance (ANOVA) was used to compare the outcomes of the various groups.(Fig 1 and 2)

Figure 1: Extracted teeth arranged in a clear acrylic resin to mimic the mandibular arch.

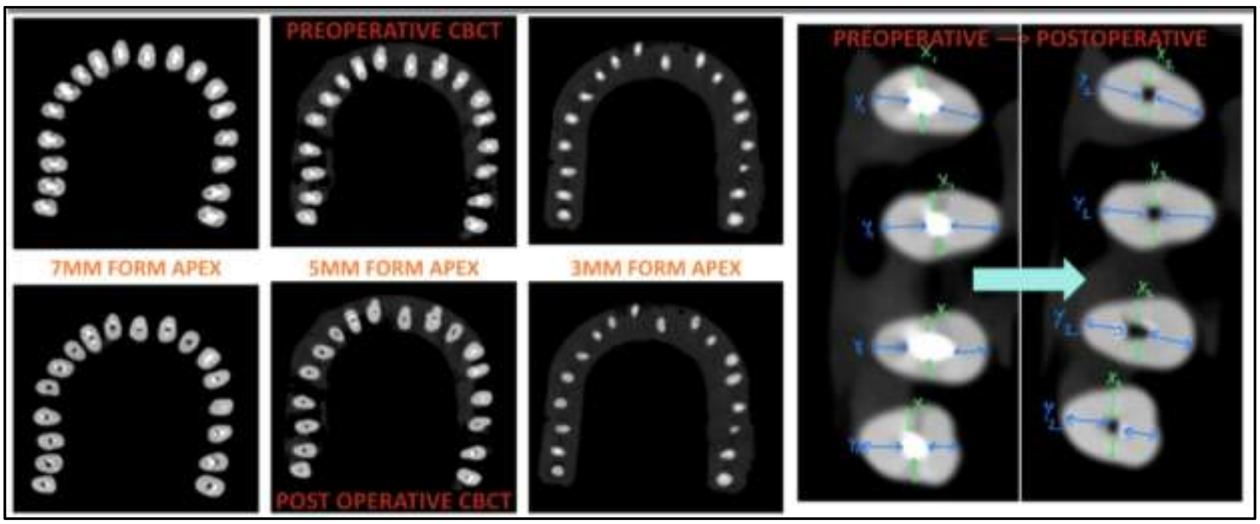

Figure 2: CBCT images at slices of 3mm, 5mm and 7mm from apex showing preoperative and postoperative data. Image on the right shows calculations performed on slices to measure transportation and centering ratio.

Results

File	Parameter	3mm (Mean ± Sd)	5mm (Mean ± Sd)	7mm (Mean ± Sd)
Group 1	Transportation	0.011 ± 0.032	0.197 ± 0.070	0.020 ± 0.055
	Centering ratio	0.614 ± 0.352	0.643 ± 0.305	0.673 ± 0.349
Group 2	Transportation	0.045 ± 0.023	0.245 ± 0.054	0.034 ± 0.067
	Centering ratio	0.853 ± 0.139	0.698 ± 0.396	0.784 ± 0.234
Group 3	Transportation	0.009 ± 0.012	0.134 ± 0.028	0.010 ± 0.006
	Centering ratio	0.427 ± 0.075	0.469 ± 0.046	0.379 ± 0.026

Table 1: showing values for Canal Centering and Transportation of all 3 Groups at 3 levels of the canal

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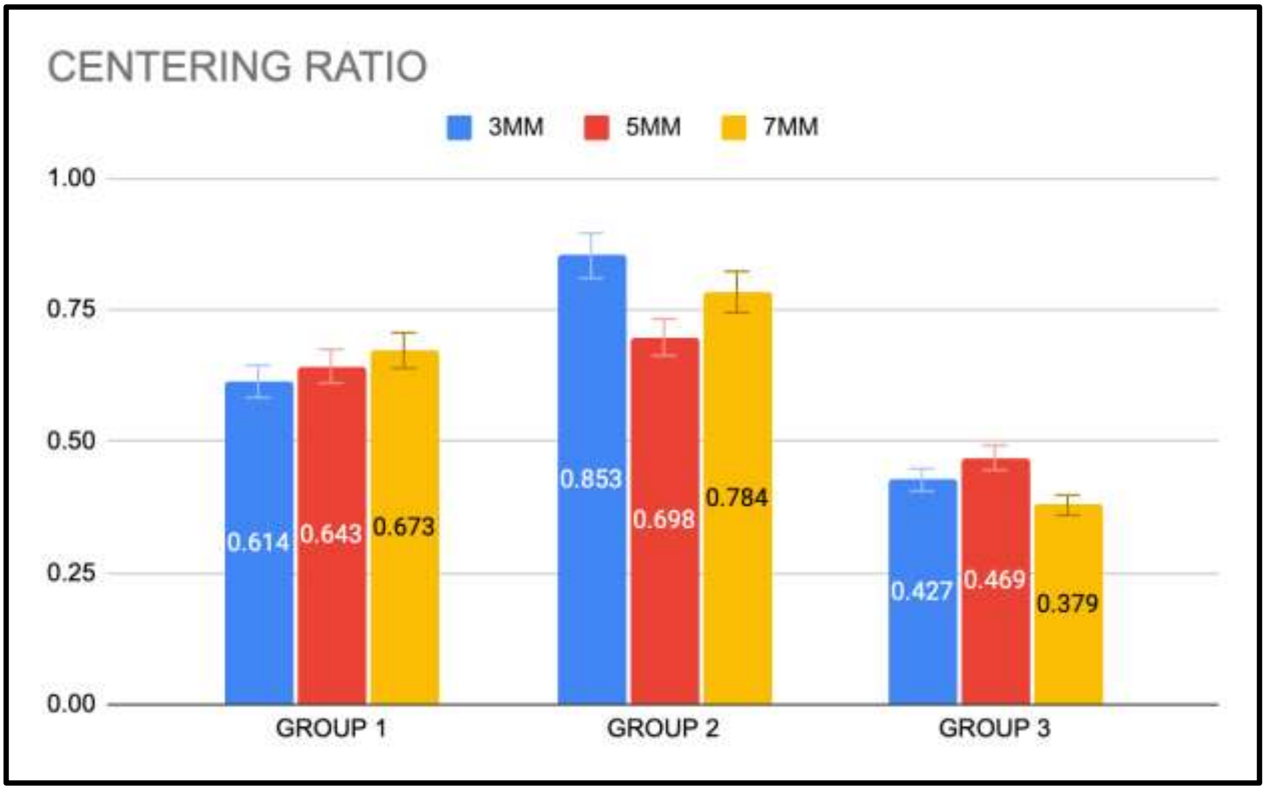
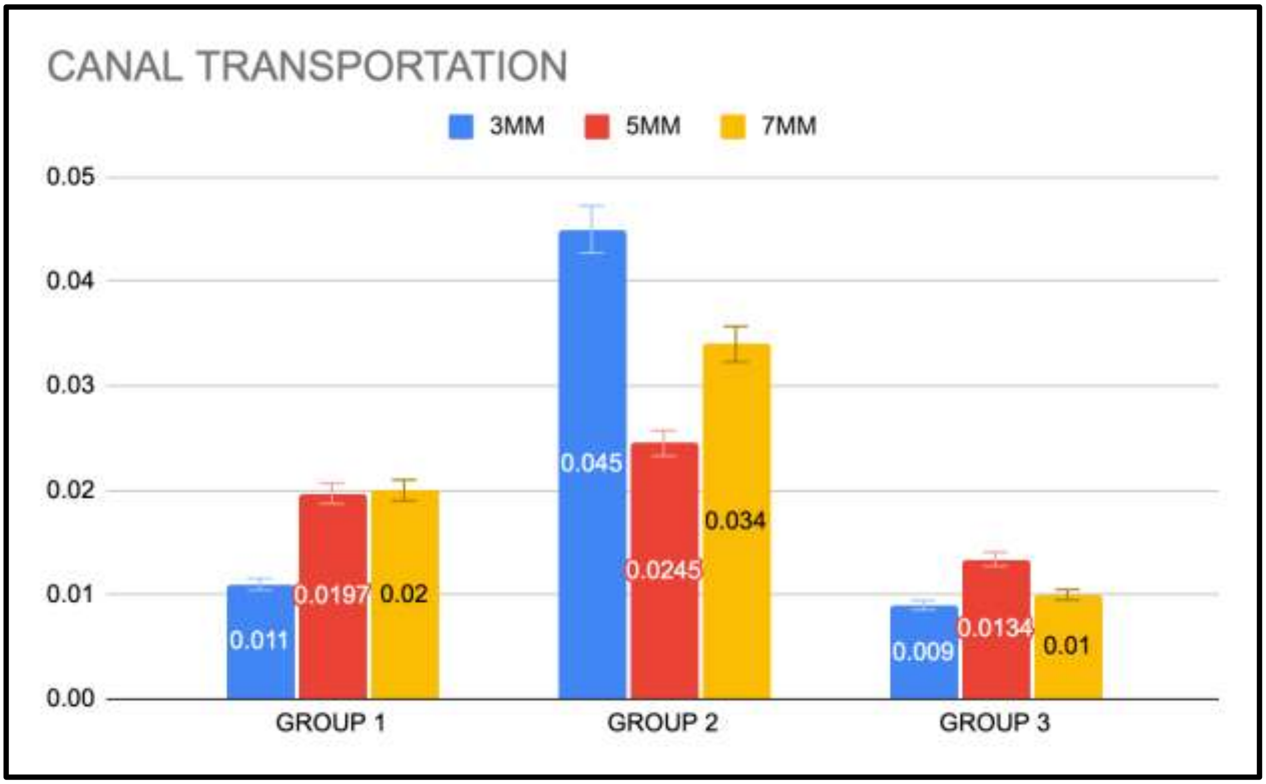


Graph 1: Canal Centering ability was noted in a bar graph for all 3 groups are 3mm,5mm and 7mm from the apex



Graph 2: Canal Transportation was noted in a bar graph for all 3 groups are 3mm,5mm and 7mm from the apex

The results (Graph 1) reveal that there is a considerable variation between all groups in terms of canal centering, with group 2 having the greatest deviation, followed by groups 1 and 3. Canal transit (Graph 2) was greatest in group 2, followed by groups 1 and 3. There was no statistically significant difference between the groups at different canal levels. However, group 2 had the greatest degree of deviation at the 3mm level from the apex. All of the samples included some leftover filling material. When compared to single cone obturation and downpack backfill approach, root canals obturated using lateral condensation technique had less leftover filling material. The findings also reveal that there is no statistically significant difference in deviation across obturation strategies.

Discussion

Gutta-percha removal has typically been accomplished using H-files, which is time consuming and prone to iatrogenic errors. By eliminating operator and patient fatigue, rotary NiTi technology offers the potential to accelerate and simplify the procedure.[1]

The ability of the instrument to stay centered inside the canal is critical for providing enough extension without inducing significant root tissue deterioration.[6] These surgeries, however, run the danger of causing iatrogenic issues such as perforation, ledge development, canal straightening, or changed canal morphology. To decrease the possibility of iatrogenic mistakes during the examination, we chose teeth with a mean curvature of less than 20° apically.[13,14]

For many years, lateral compaction of Gutta-percha has been used as a classic root canal filling technique and has been acknowledged as a gold standard in contrast to other procedures.[15] Thermafil obturation method resulted in denser, better-adapted obturation in curved canals, according to radiographic examination.[16,17] The single cone method with matching taper is the least sensitive, quickest, and offers the finest apical seal. It is also the most extensively used method.[18]

The efficiency of removing root canal debris has been tested using a number of approaches, according to published studies. With the advancement of the CBCT and CT scan, it is now able to explore the whole root canal system in three dimensions. CBCT uses significantly less effective radiation than CT and allows for 3D analysis. CBCT allows for detailed examination of morphologic characteristics such as root canal networks without causing damage to tooth specimens.[19,20]

Until recently, the gold standard was ProTaper retreatment (ProTaper R) (Dentsply Maillefer, Baillagues, Switzerland). D1 has an active cutting tip for early filling material penetration, whereas D2 and D3 have non-cutting tips for removing gutta-percha from the middle and apical thirds, respectively. [21,22]

Retreatment procedures must be selected primarily on the basis of case-specific factors such as the technical quality of the root filling and a personal evaluation of risks and monetary expenditures.[23–25] Another new unique rotating system is the NeoEndo retreatment file system. These files should be handled with care, never pushed, and at the right speed and torque settings, according to the manufacturer's specifications. This method consists of three files: N1, N2, and N3 for coronal third preparation, middle third preparation, and apical third preparation. N1 and N2 are 16 mm and 18 mm long, respectively, while N3 and N4 are 22 mm and 25 mm long, respectively.[26],[27,28]

In recent years, NiTi retreatment devices created with heat treatment, such as the HyFlex Remover file (Coltene/Whaledent AG, Altstätten, Switzerland), have been available. The HyFlex Remover, which was utilized for One Curve (Micro-Mega), was made from C-wire[29], The HyFlex Remover system employs a single tool to remove canal filling materials up to three millimeters short of the apex, whereas the ProTaper Universal Retreatment system, D-RaCe, and R-Endo use two to four instruments to remove root canal filling materials. [30]

Because of the superior surface treatment to the file and modified cross section of the Hyflex Remover, it is safe to say that it should be recommended for retreatment of endodontically treated teeth to minimize iatrogenic errors while also increasing patient and clinician comfort.

While the rotational systems increased in efficiency, none of them entirely eliminated the root filling materials, highlighting the importance of obturating processes for retreatment. As a result, further cleaning of the canal using H-files and endodontic solvents is advised.

Conclusion In this study, the efficiency of multiple endodontic retreatment procedures was studied, with a focus on obturation methods and the use of various rotary files. Traditional H-file processes are successful but time-consuming and error-prone, whereas contemporary rotary NiTi technology has increased efficiency and safety. It is worth noting that the obturating approach had no effect on the efficacy of retreatment by these file systems. However, none of the rotational procedures completely eliminated all root canal filling materials. The study emphasizes the need of personalizing treatment options based on parameters such as root filling quality, hazards, and costs. The HyFlex Remover stands out among the rotary systems assessed because of its exceptional design and safety features. Overall, this study shows continued attempts to improve endodontic treatments, emphasizing the need of combining methods like H-files and solvents to enable comprehensive root canal cleaning. Further research will improve these procedures, ultimately improving endodontic patient care.

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