COMPARATIVE EVALUATION OF ROOT CANAL FILLING REMOVAL EFFICACY OF RECIPROCATING AND CONTINUOUS ROTARY INSTRUMENTS USING CBCT: AN IN VITRO STUDY

[1]Nandini Tripathi, [2]Shubhra Malik, [3]Sonali Taneja

[1]Department of Conservative Dentistry and Endodontics, ITS-CDSR Muradnagar, Uttar Pradesh

[2]Department of Conservative Dentistry and Endodontics, Santosh Deemed to be University Ghaziabad, Uttar Pradesh

[3]Department of Conservative Dentistry and Endodontics, ITS-CDSR Muradnagar, Uttar Pradesh

Corresponding Author: Dr. Shubhra Malik

Professor, Department of Conservative Dentistry and Endodontics Santosh Deemed to be University, Sector 12, Block H, Pratap Vihar, Ghaziabad, Uttar Pradesh 201009

ABSTRACT

This present-day study aimed to evaluate and compare the efficacy of manual, rotary, and reciprocating retreatment systems when removing gutta-percha root fillings from root canals using cone-beam computed tomography (CBCT). Forty human mandibular premolars with curvature ranging from 10-20 degrees were selected. Canals were prepared using hand Protaper instruments and obturation was done by using the cold lateral condensation technique. Obturated samples were randomly divided into four groups (n=10). Removal of root canal filling material was done using (Group I) Hedstrom files, (Group II) Protaper universal retreatment files, (Group III) Mani Gutta percha removal (GPR) files, and (Group IV) RECIPROC blue files respectively. The duration of the procedure including the required time to reach the working length was recorded. It was observed that Reciproc blue took least amount of time to completely remove the root canal filling filling material and reach the working length followed by Protaper universal retreatment group and Mani GPR ($p<0.001$). H-files had the maximum amount of remaining filling material and took significantly more time for the entire procedure compared to other file systems. It was concluded that RECIPROC Blue files performed best followed by Protaper Universal retreatment files and Mani GPR.

Keywords: Cone-beam computed tomography, Protaper universal retreatment files, RECIPROC Blue files, Gutta percha, Mani Gutta percha removal files, Hedstrom files.

Introduction:

Through advancements in recent years, there has been a tremendous rate of success in root canal therapy. It can be achieved by thorough cleaning and total three-dimensional filling of the root canal systems. Failure to achieve these goals eventually results in root canal failure. Failures of initial endodontic therapy could occur due to many reasons like persistence of bacteria, inadequate filling of the canal, overextensions of root filling materials, improper coronal seal, untreated canals, iatrogenic procedural errors such as poor access cavity design, and complications of instrumentation (ledges, perforations, or

separated instruments).[1]

The treatment options for post-treatment disease include surgical retreatment (Apical endodontic surgery) and non-surgical retreatment (orthograde retreatment). The first choice to eliminate or reduce microbial infection is non-surgical root canal retreatment being less invasive and relatively have lower risk than surgical retreatment procedures. So far, no retreatment system has been developed that is successful to remove filling material completely. [2,3]

Regaining access to the apical area is a major difficulty faced by endodontists in conventional root canal retreatment, as the filling material act as a barrier and often requires time and effort to be removed. Various methods can be used to remove the root canal filling material, including stainless steel hand files, nickel-titanium (Ni-Ti) instruments, ultrasonic systems, laser systems, and chemical solvents.

In recent years, there has been an increased use of nickel-titanium (Ni-Ti) rotary instruments in order to remove root-filling material along with root canal retreatment has been widely investigated as a promising approach. An important aspect of this method is that it eliminates the use of solvents which reduces the formation of a thin film of the root canal filling material on the walls. Other advantages of rotary instruments include: non-utilization of potential carcinogenic products and the reduction of apical extrusion of gutta-percha by the excessive dissolution of this material.[4]

To improve safety preparation and prepare the intended shapes, new file designs with cutting tips, radial lands, varying taper and rake angles, and varying pitch lengths have been developed.[5]

The ProTaper universal retreatment have progressive tapers, along with a convex triangular cross-section. This file system includes three files (D1, D2, D3) with diameters at the tip (size 30, 0.09 taper, size 25, 0.08 taper, size 20, 0.07 taper). D1 file consists of an active tip that allows swift movement of subsequent files. D2 and D3 consist of non- active tips that tend to reduce the incidence of ledge formation, perforation, and stripping during the removal of filling materials.[2]

A newer rotary file system for gutta-percha removal, namely the NRT GPR has been manufactured by Mani Inc., has been introduced. It comprises of helical grooves along the working section. It is available in four sizes; 1S (size 70, 16 mm length, 0.04 taper) and 2S (size 50, 18 mm length, 0.04 taper) are used for gutta-percha removal from the cervical and middle third of the canal and are made of stainless steel. The 3N (size 40, 21 mm length 0.04 taper) and 4N files (size 30, 21 mm length, 0.04 taper) are used till the working length and are Ni-Ti files.[6]

Reciprocating motion is a more rapid method when compared to hand or rotary instruments for the removal of root canal-filling materials. Reciproc Blue (VDW, Munich, Germany) with a reciprocating motion—are manufactured from thermally treated blue wire which makes the file more flexible, with a lower risk of fracture and pre-bending potential.[7]

Multiple techniques have been developed to evaluate effectiveness in the removal of root filling materials after retreatment among which the most commonly used are the longitudinal sections or transverse [8] of the roots, clearing the tooth [9], or analysis of radiographic images for analyzing the area of the remaining filling material through a software package called

AutoCAD 2000.[10] However, these methods have certain disadvantages and it is difficult to quantify the volume of remaining filling material.

Cone beam computed tomography (CBCT) is a technique introduced in endodontic research which is a non-destructive method that allows visualization of the all the morphological features of the root canal in detail, least invasive/destructive, and allows three-dimensional visualization of treatments performed within the root canal system.[11]

Therefore, the aim of this present-day study was to evaluate and compare the efficacy of manual, rotary, and reciprocating retreatment instruments when removing gutta-percha root fillings from root canals using CBCT.

In the present study, the null hypothesis tested was:

1. There is no significant difference in the efficacy of the Hedstrom files, Mani GPR files, ProTaper Universal retreatment files, and RECIPROC Blue system in the removal of root canal filling material.
2. There is no significant difference in the time taken for the removal of the entire root canal filling material among all four file systems.

MATERIALS AND METHODS

Specimen Preparation:

Forty human mandibular premolars with intact roots were selected for the study. The teeth were stored in 10% formalin and access cavities were prepared. Teeth were radiographed in buccolingual and mesiodistal direction with a size 10 k file in place. The degree of curvature was analysed by using Schneider's method (AUTOCAD software, Autodesk Inc., San Rafael, CA, USA). Teeth with curvatures ranging from 10-20 degrees were selected. The coronal part of the tooth was sectioned to obtain the final dimension of 14 mm. Canals were prepared using hand Protaper instruments (Dentsply) under constant irrigation with a standardized volume of 5% NaOCl and 17% EDTA followed by rinsing with a standardized volume of normal saline. AH plus sealer and gutta-percha points were used for obturation by cold lateral compaction technique. The coronal access cavity is sealed by temporary filling material (3M ESPE Cavit-G). The teeth were stored at 100% humidity and 37 degrees Celsius for two weeks. Primary cone beam computed tomographic scans were performed on Carestream 9300 Premium CBCT scanner.

Retreatment Procedure:

For the retreatment procedure teeth samples were randomly divided into four groups (n=10). All the groups were re-instrumented using (Group I) Hedstrom files, (Group II) Protaper universal retreatment files, (Group III) Mani Gutta percha removal (GPR) files, and (Group IV) RECIPROC blue files respectively. All instruments were used according to the manufacturer's instructions under constant irrigation with 5% NaOCl. Preparations were deemed complete when no filling material/ sealer was covering the instruments and when the irrigation solution coming out of the canals was clear of debris.

Evaluation:

Volume analysis

Volume analysis was done after obturation (V1) and retreatment (V2), using DICOM data sets from the CBCT scans and analyzed by volume calculation tool of the software – In vivo 5.2 licensed software (Anatomage, San Jose, CA,USA. It was

calculated in mm^3. The percentage of volume reduction of root canal filling material was quantified by dividing the total volume of remaining filling material over the total volume of filling material present in the canal before preoperatively.

Time required to remove the material:

Stopwatch was used to calculate the total time (including change of instruments and irrigation) required to reach the working length (T1) and also for complete removal of filling material with last instruments used (T2) was recorded in seconds.

RESULTS:

Table 1 shows the means values for time and percentage values of residual filling materials and standard deviations. On comparing the mean values for time taken to reach working length and time taken for removing entire filling material for different groups it was observed that Reciproc blue took significantly less time followed by Protaper universal retreatment group and Mani GPR ($p<0.001$). It was found that H-files took significantly more time for entire procedure and had maximum amount of remaining filling material. Mean values of remaining filling material in RECIPROC blue files after retreatment is significantly less on comparison with all the other groups ($p<0.001$). Protaper Universal retreatment files when compared to H- files and Mani GPR files had significantly less volume of remaining filling material.

Statistical Analysis:

All the data was collected and analyzed. The statistical software SPSS 16.0 is used for analysis of data. The descriptive statistics like mean, median, Standard deviation and frequency distribution of data was calculated. The normality of data was tested by Shapiro Wilks test. The 95% C.I. and 5% level of significance was used for analysis of data.

DISCUSSION:

Complete removal of gutta-percha from root canal walls, re-establishing working length, promoting disinfection, and re-obturating the root canal is the main goals of non-surgical retreatment to re-establish healthy periapical tissues and obtain predictable success. [12]

We used CBCT scanning as a non-invasive method that allows the visualization of morphological features in detail. This method is simple, efficient, and sensitive enough to identify small areas of residual filling materials on the canal walls. This method offers reproducible data and allows the assessment of endodontic retreatment by comparing the amount of obturating material inside the root canals before and after retreatment procedures.[13]

In the current study, AH Plus sealer has been used, it is a gold standard hydrophobic epoxy resin-based filling material.[14] Epoxy resin-based sealers have high dimensional stability and a positive rate of polymerization which may influence the difficulty to remove material from the walls.[15]

To our knowledge, no studies have been reported in the literature that included a 3-D volumetric evaluation to compare the efficiency of root canal filling removal systems RECIPROC blue files, Protaper Universal retreatment files, Mani GPR files, and Hedstrom files in moderately curved canals.

Both the null hypotheses of the present study were rejected as the results of the present study indicate a significant difference amongst the groups for removal of root canal filling material and also in the

time needed for removal of the entire root canal filling material.

In the current study, there was presence of some amount of residual filling materials in all specimens, irrespective of the retreatment technique used. Similar results have been reported in previous literature. [9,16,17]

When mean of time taken (both to reach the working length and to remove the entire filling material) by Group I (H-files) was compared with Group II (MANI GPR), Group III Protaper Universal retreatment (PTUR), and Group IV (RECIPROC blue), it was found that H-files took significantly more time for the entire procedure. The reason behind this could be the greater speed of all the other motor-driven instruments. This result was in accordance with previous literature [8,12,19] where H-files took longer time for retreatment compared to other groups.

A study by Unal et al (2009) had contradictory results in which manual instruments were significantly faster than Protaper UR files. This might be because they used k- files along with H-files which may have decreased the total working time.[20]

When the mean time taken by Group II (MANI GPR) files to reach the working length was compared with the mean time taken by Group III (Protaper UR files), Group III showed lesser values and the result was significant. This might have occurred because Protaper UR files have an active cutting tip of the first file D1 and a negative cutting angle but the MANI GPR files have non- cutting tips and limited cutting efficacy. This result was in accordance with the study done by Joseph et al in 2016.[6]

The mean time taken by Group IV (RECIPROC blue) for retreatment was found to be less in comparison to all the other groups and with statistically significant value. The ability of RECIPROC Blue system is probably associated with its design, which is characterized by, larger chip space, positive cutting angle, "S"- shaped cross section with two sharp cutting edges and greater removal capability. The instrumentation of root canals during retreatment may require more time, but reciprocating systems are still expected to be faster because they are single-file systems. According to studies done by Burklein et al and Plotino et al, the cutting efficiency of an instrument is greatly influenced by its cross-sectional design. Therefore, it can be assumed that S-shaped cross-section of RECIPROC Blue instrument is responsible for its efficiency. [8,21]

In a study by De deus et al (2019) [22] it was possible to regain apical patency in all specimens from both M -Wire RECIPROC and RECIPROC Blue groups, this observation highlights the well-reported scoutability of these instruments, which allow them to naturally follow the root canal path down to the canal terminus in an effective way. No difference was found in the removal efficacy of these two file systems.

Protaper Universal retreatment files have better performance when compared to H-files and Mani GPR files in both time taken and percentage volume of remaining filling material. This finding is in accordance with those reported by Bramante et al. The authors reported the performance of Protaper Universal retreatment instruments due to their greater taper along with metallic core. Such design causes increase in the heat release that leads to rapid softening of gutta-percha. [23]

When the mean of remaining filling material retreated with Group I (H files) was compared to all the other groups, the values were significantly larger. These findings were supported by other observations of Gu et al (2008) [8], K fir et al (2012) [18]

Conclusion:

Within the limitation of this in-vitro study, it was deduced that, regarding cleaning efficiency and treatment duration, RECIPROC Blue files performed best followed by Protaper Universal retreatment files and Mani GPR. Hedstrom files took maximum time and had the maximum amount of remaining filling material left after retreatment. However, the findings of the study are to be interpreted with caution as the present study employed an in-vitro model and the future randomized controlled trials will definitely generate better evidence.[24]

Groups	Mean±SD		
	Time (sec)		Volume (%)
	Time to reach working length (T1)	.Time for complete removal of filling (T2)	V2/V1*100
I (Hedstrom files)	149.70±5.79	419.50±33.12	30.48±3.09
II (Mani GPR files)	118.10±3.90	299.20±13.24	24.89±1.75
III (Protaper Universal Retreatment files	107.00±3.09	235.50±6.20	15.92±2.18
IV (Reciproc Blue files)	94.00±2.67	172.90±6.44	10.85±2.44

Table 1: Mean values and standard deviation for the Time taken for retreatment and volume (%) of remaining filling materials in four experimental groups.

REFERENCES

1. Tabassum S, Khan FR. Failure of endodontic treatment: The usual suspects. Eur J Dent, 2016;10(1):144-147.
2. Rios Mde A, Villela AM, Cunha RS, Velasco RC, De Martin AS, Kato AS, Bueno CE. Efficacy of 2 reciprocating systems compared with a rotary retreatment system for gutta-percha removal. J Endod, 2014;40(4):543-6.
3. Gomes NN, de Carvalho GM, Júnior ECS, Garcia LDFR, Marques AAF, de Carvalho FMA. Filling Material Removal with Reciprocating and Rotary Systems Associated with Passive Ultrasonic Irrigation. Eur Endod J, 2017; 2(1):1-7.
4. Fariniuk LF, Westphalen VP, Silva-Neto UX, Carneiro E, Baratto Filho F, Fidel SR, Fidel RA. Efficacy of five rotary systems versus manual instrumentation during endodontic retreatment. Braz Dent J, 2011; 22(4):294-8.
5. Simsek N, Ahmetoglu F, Keles A, Bulut ET, Er K. 3D analysis of D-RaCe and self-adjusting file in removing filling materials from curved root canals instrumented and filled with

different techniques. ScientificWorldJournal. 2014; 2014:836513.
6. Joseph M, Ahlawat J, Malhotra A, Rao M, Sharma A, Talwar S. In vitro evaluation of efficacy of different rotary instrument systems for gutta percha removal during root canal retreatment. J Clin Exp Dent, 2016; 8(4):e355-e360.
7. Zuolo AS, Mello JE Jr, Cunha RS, Zuolo ML, Bueno CE. Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. Int Endod J, 2013; 46(10):947-53
8. Plotino G, Giansiracusa Rubini A, Grande NM, Testarelli L, Gambarini G. Cutting efficiency of Reciproc and waveOne reciprocating instruments. J Endod, 2014; 40(8):1228-30.
9. 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.
10. Barletta, FB. Lagranha, SB. Comparative analysis of different techniques in root canal retreatment. Endodoncia 2002; 20:189-96.
11. 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):532-7.
12. Somma F, Cammarota G, Plotino G, Grande NM, Pameijer CH. The effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling materials. J Endod, 2008; 34:466-9.
13. Dall'Agnol C, Hartmann MS, Barletta FB. Computed tomography assessment of the efficiency of different techniques for removal of root canal filling material. Braz Dent J, 2008; 19(4):306-12.
14. Zhou HM, Shen Y, Zheng W, Li L, Zheng YF, Haapasalo M. Physical properties of 5 root canal sealers. J Endod, 2013; 39(10):1281-6.
15. Simsek N, Keles A, Ahmetoglu F, Ocak MS, Yologlu S. Comparison of different retreatment techniques and root canal sealers: a scanning electron microscopic study. Braz Oral Res, 2014; 28:S1806-83242014000100221.
16. 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; 41:191-196.
17. Silva EJ, Sá L, Belladonna FG, Neves AA, Accorsi-Mendonça T, Vieira VT, De-Deus G, Moreira EJ. Reciprocating versus rotary systems for root filling removal: assessment of the apically extruded material. J Endod, 2014; 40:2077-2080.
18. Kfir A, Tsesis I, Yakirevich E, et al. The efficacy of five techniques for removing root filling material: microscopic versus radiographic evaluation. Int Endod J, 2012; 45:35e41.
19. Mollo A, Botti G, Prinicipi Goldoni N. Efficacy of two Ni-Ti systems and hand files for removing gutta-percha from root canals. Int Endod J, 2012; 45:1–6.
20. 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
21. Bürklein S, Hinschitza K, Dammaschke

T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J, 2012; 45(5):449-61.

22. De-Deus G, Belladonna FG, Zuolo AS, Simões-Carvalho M, Santos CB. Effectiveness of Reciproc Blue in removing canal filling material and regaining apical patency. Int Endod J, 2019; 52(2):250-257.
23. Bramante CM, Betti LV. Efficacy of Quantec rotary instruments for gutta-percha removal. Int Endod J. 2000; 33:463.
24. Mittal N, Goyal M, Mittal PK. Understanding and Appraising Systematic Reviews and Meta-Analysis. J Clin Pediatr Dent. 2017;41(5):317-326.