Full counterclockwise rotary motion kinematics enhances the removal of gutta-percha and bioceramic sealer from root canals: A computed tomographic study

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Abstract

Background and Aim: Complete removal of gutta-percha and sealer is an important step during retreatment. The aim of this study was to assess the efficacy and time taken by full counterclockwise rotary motion of a reciprocating file in the removal of gutta-percha and BioRoot™ RCS bioceramic sealer.

Materials and Methods: Thirty-six extracted human mandibular premolars were instrumented with Mtwo rotary files and obturated using lateral condensation technique with gutta-percha and BioRoot™ RCS bioceramic sealer. The teeth were divided into three retreatment groups (n = 12) based on the kinematics used: Group I, Mtwo retreatment (Mtwo-R) files; Group II, Reciproc files used in reciprocation mode (Reciproc-R); and Group III, Reciproc files used in full counterclockwise motion (Reciproc-CCW). The efficacy of gutta-percha and bioceramic sealer removal was assessed by volume of gutta-percha removed using cone-beam computed tomography and area of remaining gutta-percha and bioceramic sealer using ImageJ software after longitudinal sectioning. Statistical analysis was done by one-way analysis of variance test and Tukey’s multiple post hoc tests.

Results: Reciproc-CCW motion was significantly efficient in the removal of gutta-percha and bioceramic sealer in comparison to Mtwo-R files and Reciproc-R. The time taken for gutta-percha and sealer removal was least for Reciproc-R (325.5 ± 101.68 seconds) and was statistically significant in comparison to the other groups.

Conclusion: Within the limitations of the study, Reciproc-CCW was an effective method of removal of gutta-percha and bioceramic sealer during retreatment.

Keywords: Gutta-percha; reciprocation; removal; retreatment; sealer

INTRODUCTION

The success of endodontic primary root canal therapy of permanent teeth varies between 68% and 98%.[1]

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the apex improving the success of the retreatment procedure.

Gutta-percha removal methods include various conventional techniques and also specially designed retreatment rotary instruments which have increased the efficacy and reduced the time of retreatment.\cite{3,4} Reciprocating instruments were introduced for enlargement of the root canal, but various studies have proved their effectiveness to remove gutta-percha and sealer during retreatment.\cite{5,6} Rossi-Fedele and Ahmed concluded in their systematic review that there was no difference between reciprocating and rotary motion in the removal of gutta-percha and sealer during retreatment. A systematic review by Ahn et al.\cite{8} concluded that though reciprocating instruments have been shown to extrude more dentin debris than the continuous rotating instruments, there are many studies with conflicting results. Moreover, the incidence of postoperative pain after endodontic retreatment is lower with the use of reciprocating instruments and it can be attributed to the instrumentation kinematics (rotary and reciprocation) and number of files used.\cite{9}

Mtwo retreatment (Mtwo-R) files consist of two files (25/0.05 and 15/0.05) which effectively remove gutta-percha and sealer because of their cutting tip design.\cite{10} Reciproc files are available in various sizes and many studies have proved their effectiveness in gutta-percha removal.\cite{11,12} Moreover, Reciproc files were more efficacious than WaveOne during retreatment.\cite{13} Irrespective of technique used for the removal of gutta-percha, a vast majority of the studies indicate that complete removal of gutta-percha and sealer is not possible.\cite{5,6} Thus, an efficient method that can facilitate more complete removal of obturating material during retreatment is essential. Previous literature has shown that continuous rotation has better efficacy in gutta-percha retrieval than reciprocating motion.\cite{14} Reciprocating files are known to have a cutting efficacy in a counterclockwise direction.\cite{15} Therefore, we hypothesize that a novel full counterclockwise rotation mode of instrumentation kinematics of a reciprocating file when compared to a rotary/reciprocation kinematics of instrumentation might act as a conveyor belt and push the debris coronally allowing better removal efficiency of obturating materials.

This study aimed to assess the efficacy and time taken using full counterclockwise rotation motion of a reciprocating file in the removal of gutta-percha and bioceramic sealer using cone-beam computed tomography (CBCT).

**MATERIALS AND METHODS**

**Specimen preparation**

The study protocol was reviewed and approved by the Ethics Committee of Meenakshi Academy of Higher Education and Research, Chennai (MADC/IRB-XX/2018/353). Thirty-six freshly extracted human mandibular premolars with completely formed apices were selected for this study. The teeth were standardized to a length of 21 mm by sectioning the crown of the teeth. All roots were carefully inspected under a dental operative microscope (Labomed Dental Microscope Prima DNT, USA) under ×5 magnification to identify any resorptions and cracks on the teeth. Buccolingual and mesiodistal radiographs were taken to confirm the presence of a single straight canal (<5° according to Schneider’s classification) without calcifications. A single operator performed all initial and retreatment procedures. The teeth were then stored in 0.2% thymol at 5°C before the experimental procedures.

**Root canal treatment**

Endodontic access cavities were prepared using round diamond burs (BR-41, Mani, Utsunomiya, Tochigi, Japan). A size #10 K file (Mani, Utsunomiya, Tochigi, Japan) was used to negotiate the canal. The file was introduced into the root canal until its tip was visible at the apical foramen, and 0.5 mm short of this measurement was recorded as the working length.

All the canals were instrumented using Mtwo (VDW, Munich, Germany) rotary files up to 40/0.04 according to the manufacturer’s instructions in continuous rotation in a X-smart plus endomotor (Dentsply Maillefer, Ballaigues, Switzerland). The canals were irrigated using a 2.5% solution of sodium hypochlorite (NaOCl) (Parcan, Septodont, Delhi, India) with a total volume of 20 ml for each specimen. The final irrigation of the canals was done using 2 ml of 17% ethylenediaminetetraacetic acid, 6 ml of 3% NaOCl followed by 2 ml of sterile saline in a 30-gauge side-vented needle (Maxi-I-probe; Dentsply Sirona Tulsa Dental, York, PA, USA) placed 1 mm short of the working length. The canals were dried using absorbent points (Dentsply Sirona Tulsa Dental, York, PA, USA). Bioceramic root canal sealer (BioRoot™ RCS, Septodont, Saint-Maur-des-Fosses, France) was mixed according to the manufacturer’s instructions and coated on the root canal walls using a Lentulo spiral. The root canals were obturated with cold lateral compaction technique using 40/0.02 gutta-percha (Dentsply Sirona Tulsa Dental, York, PA, USA) point as the master gutta-percha cone and accessory cones. Storage of samples was done at 37°C for 4 weeks to allow complete setting of sealer.

**Postobturation cone-beam computed tomography scan**

A postobturation CBCT (Planmeca, PreXion 3D unit Teracom, San Mateo, Finland) scan was obtained for the prepared samples operating at 90 kVp, 4 mA, a 0.11-mm voxel size field size of 5 cm × 5 cm. CBCT images of the sample were analyzed with CS 3D 9300 imaging software
for the 3D multiplanar reconstructions. The volume of obturation was analyzed using the Horos software (Medical image viewer, HorosTM Project) and is represented as X [Figures 1a and 2b].

Retreatment procedures
The retreatment procedure was initiated by softening the gutta-percha with 3 drops of gutta-percha solvent RC Solve (Prime Dental Products, India). The samples were randomly divided into three groups (n = 12) based on the instrumentation kinematics of the retreatment files used for retrieval.

Throughout the retreatment procedures, a total of 5 ml of 2.5% NaOCl solution was delivered using a 30-gauge side-vented irrigating needle in between instrumentation.

**Group I: Mtwo® retreatment files**
After the use of gutta-percha solvent, size 15/0.05 Mtwo® retreatment instruments (VDW, Munich, Germany) at a speed of 280 rpm and 0.3 Nm torque were used till working length followed by 25/0.05 at a speed of 280 rpm and 1.2 Nm torque as per the manufacturer’s instructions till the working length was established.

**Group II: Reciproc file in reciprocation mode**
Reciproc file (VDW, Munich, Germany) of size 25/0.08 was used at a speed of 300 rpm and 4 Nm torque, in an X-Smart plus Motor in a “Reciproc All mode.” It was introduced into the canal using a pecking motion with a 3-mm amplitude and slight apical pressure till the working length.

**Group III: Reciproc file in full counterclockwise mode (Reciproc-CCW)**
The Reciproc file (VDW, Munich, Germany) of size 25 and taper 0.08 was used in an X-Smart plus Motor (X-mart plus, Dentsply Maillefer, Ballaigues, Switzerland), in a full counterclockwise mode at 300 rpm. It was introduced into the canal using a pecking motion with a 3-mm amplitude and slight apical pressure till the working length. Retreatment was considered complete for all the groups when no residual gutta-percha or sealer could be observed in the instrument’s flutes.6

This study assessed three parameters:
A. Efficacy of motion instrumentation kinematics in the removal of gutta-percha and bioceramic sealer based on volume of gutta-percha removed using CBCT and area of remaining gutta-percha sealer using digital photography
B. The time taken for gutta-percha and bioceramic sealer removal
C. Distortion of file during the retreatment procedure using a stereomicroscope.

**Time calculation**
A second operator timed the removal procedure using a digital stopwatch by measuring the time elapsed from the introduction of the first instrument into the canal to the completion of retreatment procedure. The time required for the irrigation and instrument changes was excluded.

**Distortion**
Each file used for the retreatment procedure was observed under ×10 magnification under a stereomicroscope (Meiji Techno, Lawrence mayo) after every third use to observe for distortion.

**Post-gutta-percha removal scan**
A second CBCT was taken after removal of gutta-percha and bioceramic sealer with the same specifications as that of preoperative CBCT scan and the remaining volume of gutta-percha (Y) was calculated [Figures 1b and 2b].

![Figure 1: CBCT Images of gutta-percha and sealer in the root canal (a) after obturation and (b) after retreatment. CBCT: Cone-beam computed tomography](image1)

![Figure 2: Representation measurement of volume of gutta-percha and sealer calculated via HOROS software: (a) Initial volume after obturation and (b) remaining volume after retreatment](image2)
The efficacy of gutta-percha removal was calculated as follows:

\[
\text{Efficacy of removal} = \frac{(X - Y)}{X} \times 100.
\]

**Surface area**

The samples were later sectioned longitudinally by placing buccolingual grooves with a stainless steel diamond disc (Axis, Sybron Endo) and split into two sections using a sharp instrument to avoid loss of material. The digital images of the sectioned samples were obtained using a digital camera attached to DOM at 16x (Labomed Dental Microscope Prima DNT, USA). The digital images were analyzed using ImageJ (National Institutes of Health, Bethesda, MD, USA, version 2) software to measure the surface areas of residual gutta-percha and sealer. A single trained and blinded operator calculated the volume and surface area of the remaining gutta-percha. The measurements were taken twice at 2 weeks interval to avoid bias.

**Statistics**

The data were analyzed using Statistical Package for the Social Sciences (IBM SPSS Statistics, v22.0; IBM Corp, Armonk, New York, USA). Following descriptive analysis, the mean volume of gutta-percha removed (mean, standard deviation), the surface area of the remaining gutta-percha, and time taken for gutta-percha removal were analyzed. As the variables were normally distributed using the Shapiro–Wilk test, the intergroup comparison was performed using one-way ANOVA test. The post hoc analysis was performed using Tukey’s honestly significant difference (HSD). \( P < 0.05 \) was considered statistically significant.

**RESULTS**

The mean percentage of volume of gutta-percha and sealer removed by Mtwo-R, Reciproc file in reciprocation mode (Reciproc-R), and Reciproc-CCW was 84.4%, 85.12%, and 90.02%, respectively. The mean area of remnant material (gutta-percha and sealer) after removal with Mtwo-R, Reciproc-R, and Reciproc-CCW was 2.8 (1.3) cm\(^2\), 2.2 (0.9) cm\(^2\), and 1.2 (0.3) cm\(^2\), respectively [Table 1]. Full counterclockwise kinematics performed significantly better than Mtwo-R \( (P = 0.0001) \) and Reciproc-R \( (P = 0.001) \) in removing gutta-percha (90% and 1.2 cm\(^2\)). The time taken for the removal of gutta-percha and sealer using the different kinematics is tabulated in Table 1. The Mtwo-R files were significantly slower in the removal of gutta-percha when compared to Reciproc-R \( (P < 0.0001) \) and Reciproc-CCW \( (P < 0.0001) \). The time taken for complete removal of gutta-percha by Reciproc-R and Reciproc-CCW showed no significant difference. The examination of the files under magnification showed that none of the file systems distorted after three uses.

**DISCUSSION**

Files designed for root canal shaping as well as special files designed for retreatment have been used for gutta-percha removal. A systematic review concluded that reciprocating files were as effective as rotary files in the removal of gutta-percha and also in shorter duration.\(^{[10]}\) Rödig et al.\(^{[4]}\) have proven that the efficiency of Reciproc is similar to that of ProTaper universal retreatment files. Mtwo-R and Reciproc systems were selected for this study due to its similarity in cross-section of the file being S shaped and allowing a direct comparison of the motion kinematics of the selected files even though one was a multifile system and the latter was a single-file system.

Bioceramic sealers show good biocompatibility and mineralization capabilities and offer antimicrobial properties and superior bond strength in comparison to conventional root canal sealers. As these sealers set into a hard mass, complete removal may not be possible and can lead to loss of canal patency and apical blockage.\(^{[15]}\) Donnermeyer et al.\(^{[16]}\) compared the retrogradability of three calcium silicate-based sealers compared to an epoxy-based sealer and concluded that it was easier to retreat teeth obturated using bioceramic sealers. Whereas, Kim et al.\(^{[17]}\) reported in their studies that there was no significant differences between the efficacy of removal of epoxy-based resin and bioceramic sealer. Till date, the ease of retrievability of bioceramic sealers remains controversial. Thus, the ability of file kinematics in removing bioceramic sealer was assessed as a secondary objective in this study.

Reciproc files are commercially available in sizes R25, R40, and R50, whereas Mtwo-R files selected for the study are available only in two sizes 15/0.05 and 25/0.05. Despite the initial canal preparation being ISO #40 size, Reciproc R25 was used for the removal of gutta-percha to standardize the size of the files between the groups.

CBCT was used to assess the efficacy of gutta-percha removed as it is a noninvasive, three-dimensional technique to assess the removal of gutta-percha when compared to
other techniques used previously for assessing gutta-percha removal such as digital radiography and stereomicroscopy. It has been proven that the different voxel sizes of CBCT images (0.1 mm, 0.15 mm, and 0.2 mm) for assessing the volume in root canals correlate highly when compared to the micro-CT voxel (21 μm).[18] Thus, a CBCT of 0.1 mm voxel was used in our study to assess the residual volume of gutta-percha. As an adjunct to volume measurement with CBCT, the surface area of the residues was assessed using digital photographs taken using a dental operating microscope.[19,20]

In our study, the removal of gutta-percha and bioceramic sealer was significantly higher with Reciproc-CCW motion kinematic and thus rejecting the null hypothesis. Previous literature has proven that the gutta-percha removal efficacy of Reciproc and Reciproc blue ranges between 74% and 92%.[6,21] The increased efficacy of Reciproc over Mtwo-R in our study could be attributed to the increased taper of the file and kinematics of its use.[6] Reciproc file being a single file of larger taper (0.07) and size 25 would be able to remove more gutta-percha when compared to Mtwo-R files (15/0.05 and 25/0.05).

An interesting finding in our study is that the full continuous counterclockwise motion kinematics performed better than Mtwo-R files and Reciproc in reciprocation motion. The S shaped cross section, sharp cutting edges, large chip space and the continuous taper in the apical 3 mm of the file aids in better debris removal. In the Mtwo-R group, multiple instruments were used in sequence to remove the debris; thus, the initial smaller instrument size could have compacted the material in the apical region and thereby reducing the action of the subsequent larger instrument.[15] It was observed that the residues of gutta-percha and sealer were observed in the apical third, which was similar to the findings in previous studies.[22,23]

Silva et al.[5] concluded that Reciproc files showed the least amount of remaining gutta-percha (3.62%) when compared to Mtwo-R. The amount of gutta-percha retained in our study with regard to Reciproc was in the range of 10%–14%. This could be attributed to the difference in size of the Reciproc file (R40) used for the removal of gutta-percha between the studies. In contrary, Alves et al.[21] showed that Mtwo R (96%) instruments retrieved significantly higher filling material when compared to Reciproc (89%) from curved canals of molars.

The least amount of time was taken for the Reciproc-R group when compared to the other groups. Although Reciproc-R group was the fastest, the efficiency of full counterclockwise was 1.1 times more effective in the removal of gutta-percha and sealer when compared to Reciproc-R. Mtwo-R was 1.7 times slower than Reciproc-R mode, which could be attributed to the sequential files of Mtwo-R file system. The method of using Mtwo R involves repeated brushing motions of the files, which facilitates the removal of gutta percha and sealer when compared to Reciproc, a single large file which is used in a pecking motion. Silva et al.[5] concluded that the time taken by Mtwo-R and Reciproc to complete retreatment procedure was 10 min, which was similar to this study. Whereas, few studies found that the time taken for completion of retreatment by Reciproc was lesser than Mtwo-R.[6,24,25]

The potential limitation of the study could be the use of Reciproc size 25 for gutta-percha removal. It has been shown that larger size single files remove gutta-percha and sealer more efficiently than smaller size files.[24] It can be concluded that the new suggested full counterclockwise motion with Reciproc was found to be effective in the removal of gutta-percha and bioceramic sealer. Future studies with curved canals and comparison with single larger Reciproc files can shed more knowledge.

**CONCLUSION**

Within the limitations of the study, no technique completely facilitated the removal of gutta-percha and bioceramic sealer. Full counterclockwise rotation motion of a reciprocating file was found to be an effective method for the removal of gutta-percha and bioceramic sealer during retreatment. As clinicians, complete elimination of infection from the root canal during root canal retreatment should be the goal and further studies are needed to find a method that can completely eliminate root canal filling material and sealer to improve endodontic success.

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**Conflicts of interest**

There are no conflicts of interest.

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