Evaluation of remaining dentin thickness following use of three different rotary nickel–titanium retreatment files: A cone-beam computed tomography study

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Abstract

Aim: The aim of the study is to measure the amount of remaining dentin thickness (RDT) following retreatment using three different rotary nickel–titanium (NiTi) systems.

Methodology: Mesiobuccal roots of 45 extracted maxillary first molars were prepared up to F2 ProTaper File and obturated. After cone-beam computed tomography (CBCT) imaging, to evaluate the obturation, the samples were randomly assigned to three retreatment groups (n = 15). Group I was retreated with ProTaper Universal retreatment kit, Group II and III with MTWO and D-Race retreatment files, respectively. Postoperatively, all samples were subjected to CBCT imaging and evaluated with AutoCAD software (AutoDesk, Inc.) Mill Valley, California, U.S. to calculate the RDT. Data were statistically analyzed using one-way ANOVA and Tukey’s post hoc tests, and the level of significance was set at \( P = 0.05 \).

Results: The amount of RDT was significantly more in D-Race and MTWO groups when compared to ProTaper group.

Conclusion: D-Race and MTWO instruments were associated with significantly more RDT than ProTaper.

Keywords: Cone-beam computed tomography; maxillary first molar; remaining dentin thickness; retreatment

INTRODUCTION

Root canal therapy, despite having a high success rate, may not lead to the desired outcome, and failure may occur.\[1\] Endodontic failures occur even when the highest standards and most meticulous treatment procedures are adhered to.\[2\] The main causes of endodontic failures are the persistence of bacteria within the intricacies of the root canal system due to improper cleaning and filling of root canal system, procedural errors or the lack of sufficient fluid-tight seal, which enables the survival of microorganisms inside dentinal tubules, apical ramifications, accessory, and secondary canals.\[3\] In the quest to preserve such teeth, conventional or nonsurgical endodontic retreatment is the first option. The main goal of retreatment is to remove contents and establish clean root canal system free of infection.

The contemporary techniques used to remove root filling material include the use of hand or rotary nickel–titanium (NiTi) instruments with or without heat, solvent and/or ultrasonic instruments. Various specialized...
rotary instruments are now designed for retreatment procedures such as R Endo, M_{two}, Pro Taper R, and D-RaCe. The use of NiTi rotary instrumentation in removing obturation material from the root canal system has been shown to be more effective than hand files. It has the advantage of removing Gutta-percha and simultaneously shaping the root canals.\[1\] Cleaning and shaping remove all the tissue debris and inner layers of root canal dentin regardless of the instrumentation technique. Fracture susceptibility of endodontically re-treated teeth increases proportionally with an increase in the amount of root dentin removal.\[4\]
The remaining dentin thickness (RDT) is an important factor as it gives resistance to fracture of root canal treated teeth. As retreatment requires more mechanical manipulations and further preparations of the root canal, a concern in some recent studies was expressed about the damage caused to the root canal wall after these procedures. Thus, in order to minimize damage to root dentin and improve working safety, nowadays instruments with newer designs have been introduced.

In the past, various methods were employed to assess RDT following retreatment, however more recently cone-beam computed tomography (CBCT), a nondestructive technique has been advocated which provides highly accurate, high resolution, fully quantifiable three-dimensional images.⁵,⁶ Thus, acknowledging the importance of preserving the remaining dentinal wall through proper usage of various instrument systems, the purpose of this study was to evaluate the amount of RDT using three retreatment instruments through CBCT.

**METHODOLOGY**

Mesiobuccal roots of 45 extracted maxillary first molars were selected for the study. In the selected samples, soft tissue and calculus were mechanically removed from the root surfaces, and the teeth were disinfected with 5% Glutaraldehyde solution — Korsolex Rapid (Raman & Well, Hamburg, Germany) for 15–20 min.

After preparation of access cavity in each tooth using a high-speed handpiece and No. 2 round bur (Mani) with air-water spray, a #10 stainless steel K-file (Dentsply Mailiefer, Ballaigues, Switzerland) was placed in the root canal so that the file tip was visible at the apical foramen. Digital radiographic images were recorded by RVG (Carestream 5100) and processed by Kodak Dental Imaging Software 6.6., Onex Corporation, Rochester, New York, U.S.A.

In order to standardize all the teeth, the teeth were decoronated to reach a root length of 18 mm, and a WL of 17 mm was chosen for all the teeth. All the samples were prepared by the same operator using ProTaper instruments up to F₂ file installed in an electric motor (Endo- Mate AT NE305, NSK, Nakanishi Inc., Tokyo, Japan) with a speed of 300 rpm and 3 N/m torque. The canals were irrigated with 5 ml 3% NaOCl (Prime Dental Products, Thane) between files.

After completion of preparation, the smear layer was removed with 5 mL of 17% ethylenediaminetetraacetic acid - AvuePrep (Dental Avenue, Thane) and 5 mL of 3% sodium hypochlorite was used as the final rinse and dried with absorbent paper points (Dentsply, DeTrey, Konstanz, Germany) up to 1 mm short of the apex. The root canals were obturated with No. 25 Gutta-percha cones (Dentsply, DeTrey, Konstanz, Germany) and AH-Plus sealer (Dentsply, DeTrey, Konstanz, Germany) using the cold lateral compaction technique; until the last lateral cone could not penetrate the canals more than 5 mm. A hot plugger was used to remove extra Gutta-percha up to the orifice level. The quality and the apical extension of the obturation was evaluated by digital radiography in the buccolingual and mesiodistal directions. The postobturation images were processed on a computer, and the quality of obturation was observed.

At this stage, all the primary CBCT images were taken [Figures 1-4]. The access cavities were temporarily sealed. The samples were stored at 37°C and 100% relative humidity for the complete setting of the sealer. The samples were then randomly allocated into three groups (n = 15) according to the retreatment technique.

**Retreatment procedure**

The temporary restorations were removed, and one drop of GP SolventRC Solve (Prime Dental Products, Thane) was used for 2 min for softening the Obturating Material.

**Group 1 (ProTaper universal retreatment kit)**

ProTaper Retreatment files were used at a speed of 300 rpm with a 3 N/m torque. The coronal third of the canal was cleaned with ProTaper D1 file (30/0.09). The Obturating Material (OM) in the middle and apical thirds were removed with D₂ (25/0.08) and D₃ (20/0.07) files, respectively. Preparation of the apical area was carried out with F₂ (25/0.08) and F₃ (30/0.09) instruments.

**Group 2 (M₂retreatment files)**

R₂ (size 25, 0.05 taper) was used to the working length. Progression of the rotary file was performed by applying slight apical pressure. Finally, conventional M₂ rotary instrument (size 30, 0.05 taper) was used till the working length.

**Group 3 (D-RaCe retreatment files)**

D-RaCe files were used with a speed/torque of 600 rpm and 1 N/m, respectively. The coronal third of the OM was removed with DR₁ file (30/0.10). Then the DR₂ file (25/0.4)
was used in an apical direction to the working length. The apical preparation was done with IR3 (25/0.06) and then IR4 (35/0.04) instrument (IRaCe, FKG Dentaire, La Chaux-de-Fonds, Switzerland).

All rotary files were used according to the manufacturer’s instructions. The removal of obturating material was ensured on post-retreatment CBCT images [Figures 5-7].

**Cone-beam computed tomography procedures and evaluation**

Then the postretreatment CBCT images were taken and evaluated in axial, coronal, and sagittal planes. CBCT cross-sections were 90 µm thick, and interslice distance was 1 mm for axial and coronal planes and 90 µm for sagittal plane. The total number of slices varied according to the root length and width of mesiobuccal root of maxillary first molar and according to the type of sections.

In this way, the entire root was viewed in the apical one-third, middle one-third, and coronal one-third and the RDT of the walls was calculated using the measurement mode of CBCT.

**Statistical analysis**

- Descriptive statistics were employed to study mean, standard deviation and frequency of various study variables
- One-way ANOVA and Kruskal–Wallis tests were employed to compare the difference in the amount of obturation material postretreatment in three groups
- Statistical significance was fixed at 0.05
- All the statistical analysis was performed using Statistical Package for the Social Sciences, Version 17, IBM, Armonk, New York U.S.A.

**RESULTS**

The present in vitro study was conducted to evaluate the amount of RDT following retreatment using CBCT. The intergroup comparison of RDT in cervical, middle, and apical regions is presented in Tables 1-3.

The amount of RDT was more in D-Race and Mtwo groups when compared to ProTaper group.

**DISCUSSION**

Persistent apical periodontitis is mainly caused by intracanal microorganisms that survive primary root canal treatment. Residual necrotic tissue or bacteria beneath Gutta-percha or sealer can also be responsible for periapical inflammation or pain. However, the option of retreatment the tooth through the root canal system is possible in almost all cases.

**Table 1: Comparison of remaining dentin thickness in cervical region in three groups**

| Groups | Mean  | SD    | F     | P    |
|--------|-------|-------|-------|------|
| Pre    |       |       |       |      |
| ProTaper | 1.660 | 0.6246| 0.510 | 0.602|
| M2     | 1.585 | 0.3752|       |      |
| D-Race | 1.560 | 0.3264|       |      |
| Post   |       |       |       |      |
| ProTaper | 1.300000 | 0.3714146| 2.277 | 0.107|
| M2     | 1.462500 | 0.3279208|       |      |
| D-Race | 1.382500 | 0.3201662|       |      |

One-way ANOVA test. SD: Standard deviation

**Table 2: Comparison of remaining dentin thickness in middle region in three groups**

| Groups | Mean  | SD    | F     | P    |
|--------|-------|-------|-------|------|
| Pre    |       |       |       |      |
| ProTaper | 1.275 | 0.4343| 1.644 | 0.198|
| M2     | 1.155 | 0.3289|       |      |
| D-Race | 1.150 | 0.2621|       |      |
| Post   |       |       |       |      |
| ProTaper | 0.938 | 0.2871| 1.339 | 0.266|
| M2     | 1.053 | 0.3442|       |      |
| D-Race | 1.137 | 0.8378|       |      |

One-way ANOVA test. SD: Standard deviation

**Table 3: Comparison of remaining dentin thickness in apical region in three groups**

| Groups | Mean  | SD    | F     | P    |
|--------|-------|-------|-------|------|
| Pre    |       |       |       |      |
| ProTaper | 0.905 | 0.3755| 0.317 | 0.729|
| M2     | 0.928 | 0.3382|       |      |
| D-Race | 0.867 | 0.3041|       |      |
| Post   |       |       |       |      |
| ProTaper | 0.592 | 0.3116| 1.035 | 0.358|
| M2     | 0.675 | 0.3295|       |      |
| D-Race | 0.590 | 0.2560|       |      |

One-way ANOVA test. SD: Standard deviation

A major goal of root canal retreatment is the removal of the filling material. Numerous materials and techniques have been used for this purpose to allow effective action of irrigating solutions and instruments on remaining debris and microorganisms surviving primary root canal therapy. The basic and latest methods to evaluate the amount of residual root filling material are radiographs, longitudinally splitting the roots to evaluate microscopically the canal walls or stereomicroscopic analysis of transparent teeth scanning electron microscopy, micro-computed tomography or CBCT.

Literature has revealed that, although techniques employed in retreatment were successful a major cause of concern was the effect of these on RDT in the root canals.

As the RDT after retreatment is crucial in the success of retreatment cases, root curvature also plays an important role in the efficacy of root canal instrumentation. Nevertheless, our literature search has revealed that studies related to the use of rotary NiTi systems in curved canals...
is sparse. Thus, the present in vitro study was conducted to assess the amount of RDT after retreatment using ProTaper Universal Retreatment System, $M_{\text{two}}$ Retreatment files, and D-RaCe Retreatment System in curved root canals by CBCT.

PTUR system comprises of three retreatment files ($D_1$, $D_2$, $D_3$). $D_1$ (30/0.09) is worked in the coronal third, $D_2$ (25/0.08) in the middle third, and $D_3$ (20/0.07) throughout the entire length of the root canal. The retreatment instruments are used at a constant speed of 500 rpm for $D_1$ and 400 rpm for $D_2$ and $D_3$, with a torque of 3 Nm. These instruments have a convex triangular cross-section similar to the ProTaper shaping and finishing files.

The $M_{\text{two}}$ rotary system also has two specifically designed files with cutting tips for retreatment. 280 rpm speed is recommended for this system. The highest torque is 30 nm. The $M_{\text{two}}$ file has an H file-like motion (up and down). It comes as a #25 file with 0.05 taper to be used in the coronal and a #15 file with 0.05 taper in the middle and apical section.

The D-RaCe rotary system consists of two files - DR1 and DR2 (DR1#30 with 10% flaring for coronal section) (DR2#25 with 0.04 flaring for middle and apical sections). DR1 set at 1000 rpm is a 10% tapered size 30 file, 15.8 mm in length capable of cleaning the coronal one-third. DR2 set at 600 rpm is a 4% tapered size 25 file, 25.16 mm in length for apical two-third cleaning.

The results of the study revealed that the amount of RDT was more for D-RaCe instruments. This could be attributed to their alternating cutting edges which eliminate the “screwing – in” effect and blocking of the instrument in continuous rotation along with its superior flexibility.[7]$M_{\text{two}}$ instruments exhibited intermittent RDT values owing to their low cross-sectional area, relatively less number of spirals and high flexibility.[7,8] The least amount of remaining dentin thickness associated with ProTaper group may be due multiple tapers within the shaft and large internal mass.[5,9]

In another study, Deka et al. observed that the mean percentage of area increase in different thirds of the canal was highest for ProTaper followed by I-Race and Revo-s.[5] Similarly, Sartaj et al. also found that all rotary NiTi retreatment files caused dental defects, but the incidence was more for ProTaper R and $M_{\text{two}}$ retreatment files as compared to Edge Endo files.[1]

**CONCLUSION**

Within the limitations of this study, D-RaCe file system exhibited significantly greater amount of RDT as compared to $M_{\text{two}}$ and ProTaper Universal Retreatment files. However, further studies are still required in the future to prove the efficiency of ProTaper, $M_{\text{two}}$, and D-race retreatment files in biomechanical preparation of root canals after the removal of Gutta-percha.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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