Evaluation of 3 Different Retreatment Techniques in Maxillary Molar Teeth by Using Micro–computed Tomography

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Abstract

Introduction: Nonsurgical retreatment procedure involves the complete removal of the previous filling material to allow thorough instrumentation, disinfection, and refilling of root canal system. We aimed to determine the residuals of the root-filling material by using 3 different retreatment techniques with the aid of micro–computed tomography. **Methods:** Thirty extracted human maxillary molar teeth were included. All root canals were also obturated with F2 ProTaper single cones and AH Plus sealer. The following retreatment techniques were performed: group 1, ProTaper retreatment files; group 2, Mtwo retreatment files; and group 3, ProFile files. For the assessment of residual filling material, preoperative and postoperative micro–computed tomography scans were compared with each other, and the working time was recorded. One-way analysis of variance was used to analyze the differences between the groups. The significance level was set at $P < .05$. **Results:** None of the retreatment techniques were capable of removing the whole filling material. The percentages of the residual filling materials for groups 1, 2, and 3 were 34.45, 45.43, and 23.63, respectively. There was a statistically significant difference between groups 2 and 3 ($P < .05$). ProTaper and ProFile instruments required less time for the removal of filling materials when compared with Mtwo instrument. **Conclusions:** ProFile files revealed the best results for endodontic retreatment in terms of both removing capacity and time requirement. *(J Endod 2017;■:1–5)*

Key Words

Endodontics, micro-CT, retreatment

Significance

The removal of previous filling materials is the first important step of root canal retreatment to clean and refill the root canal system. Usually this can be accomplished by using rotary nickel-titanium instruments. ProFile system was found to be more effective than Mtwo retreatment files and ProTaper retreatment files, despite the fact that it was originally developed for root canal preparation but not for retreatment.

Nonsurgical root canal retreatment is usually considered to be the first treatment option for endodontic failure. The retreatment procedure involves the complete removal of the previous filling material to allow thorough reinstrumentation, disinfection, and refilling of the root canal system. Specifically, curved canal retreatment is quite difficult because of the occurrence of possible complications. Therefore, several techniques have been developed for removing root-filling materials. Hand files, nickel-titanium rotary files, solvents, heat, ultrasonics, and lasers have been suggested for retreatment procedures (1–5). However, none of those techniques were found to be capable of completely removing whole filling material in the root canal. Therefore, the ProTaper retreatment system was suggested for this purpose. This system comprises D1, D2, and D3 files that have convex, triangular cross section in a continuous rotation motion (3). D1 file has an active working tip that first penetrates into the root canal filling material. On the other hand, ProFile system has U-type cross section and removes the root filling in small pieces. Previous studies suggested conflicting results when ProTaper retreatment system and ProFile System were compared with each other in terms of their efficacy (6, 7). Mtwo retreatment instruments comprise R1 and R2 files that have cutting tips and constant helical angles. Both destructive and radiographic methods were used for the evaluation of residual filling materials. The destructive method includes splitting teeth and microscopically assessing the structures, whereas two-dimensional radiographic methods are used by taking periapical radiography. However, both methods are unable to provide quantitative volumetric information before and after conducting retreatment procedures (8–11). Although cone-beam computed tomography may provide three-dimensional (3D) information regarding retreatment outcomes, their low resolution and high radiation dose remain a barrier for its routine use in endodontic follow-up of retreatment procedures. High-resolution micro–computed tomography (micro-CT) is an innovative, nondestructive, and reproducible device that produces very thin sections and a true 3D reconstruction of the object with cubic voxels and isotropic resolution. Technically it is

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possible to produce ultra-high resolutions of 1 μm *ex vivo* by using microfocal spot x-ray sources and high-resolution detectors, and it can be considered a radiological gold standard with a high radiation dose that is incompatible with human organism. Older models could only be used in *ex vivo* studies, but newer models are able to image small live animals (12, 13). Therefore, we aimed to assess the efficacy of 3 different retreatment techniques in maxillary molar teeth by using micro-CT.

Materials and Methods

Specimen Preparation

The study protocol was reviewed and approved by the Ethics Committee of Ankara University, Faculty of Dentistry (Review No: 36290600/68). Thirty human extracted maxillary molars with a radiographically confirmed formed apex and without internal calcifications and previous endodontic treatment were selected for the present study. To eliminate effects of canal curve variation, only teeth with 15°–20° curved canals were included for standardization. Debris and soft tissue remnants were cleaned, and teeth were kept in 0.1% thymol solution. After preparation of the access cavity, a size #10 K-file was inserted into the canal until the tip of the instrument was just visible at the apical foramen, and the working length was established 1 mm shorter than that point. All root canals were then instrumented by using ProTaper rotary instruments (Dentsply Maillefer, Tulsa, OK) in a crown-down manner. According to the manufacturer's instructions, the following sequence was used: SX file was used at one half of the working length, and S1, S2, F1, and F2 files were used to the full working length. Between each instrument, apical patency was checked with #15 K-file, and irrigation was performed with 2 mL 2.5% sodium hypochlorite (NaOCl) solution. After completion of instrumentation, final irrigation was performed with 2 mL 17% EDTA, 2 mL 2.5% NaOCl, and 5 mL distilled water. Thereafter, the root canals were dried with paper points and obturated with size F2 ProTaper single cone and AH Plus Sealer (Dentsply DeTrey, Konstanz, Germany). The sealer was placed in the cone tip and then inserted into the canal in a single movement. Any excess gutta-percha was removed with a hot excavator at the level of the canal orifice. Specimens were radiographed in both buccolingual and mesiodistal directions to confirm the adequacy of the root canal filling. Access cavities were temporarily sealed with Cavit (ESPE, Seefeld, Germany), and then specimens were stored for 2 weeks at 37°C and 100% humidity to ensure the complete setting of the sealer.

Root Canal Retreatment

After full setting of the sealer, the coronal third of the root filling was removed with Gates-Glidden drills, and the teeth were divided randomly into 3 groups of 10 teeth each. In group 1, teeth were retreated with ProTaper retreatment files (D1, D2, D3). The coronal third of the root filling was removed by using a D1 30/.09 rotary file. Then the D2 25/.08 instrument was used in the middle third, and finally, the D3 20/.07 instrument was inserted until the working length was reached. ProTaper Universal Retreatment files were used with 500 rpm and a torque of 2 N cm with minimal apical pressure as recommended by the manufacturer. In group 2, Mtwo R (VDW, Munich, Germany) file sizes 25/0.05 and 15/0.05 were used in a crown-down manner. Instrument size 15/0.05 was carried to the working length. The removal of filling material was performed according to the manufacturer's instructions at a speed of 300 rpm and a torque of 1.2 N cm. In group 3, the filling material was removed by using ProFile instruments sizes 40, 0.06 taper, 35, 0.06, 30, 0.06, 25, 0.06, and 20, 0.06 in a crown-down sequence at a speed of 600 rpm and a torque of 2.4 N cm. Pecking and brushing motions were applied to remove the gutta-percha down to the working length. The canals in all groups were rinsed with 2 mL 5.25% NaOCl between each instrument change. Each instrument was used to prepare 4 root canals. When the retreatment was considered to be finished, root canals were irrigated with 3 mL 17% EDTA solution. Irrigation during preparation was always performed with 30-gauge NaviTip (Ultradent Products Inc, South Jordan, UT) needles taken up to 3 mm short of the working length. No additional instruments and solvents were applied. Retreatment was considered as complete when no gutta-percha or sealer was detected on the instrument surfaces or inside the root canal or dentinal walls under a dental operating microscope (Leica Microsystems, Wetzlar, Germany). In addition, the required time for the complete retreatment procedures beginning with the initial filling removal was recorded by using a stopwatch. An endodontist with 10 years of experience conducted all treatment and retreatment procedures.

Micro-CT Scanning Procedures and Evaluation

Teeth were scanned preoperatively and postoperatively by using Skyscan 1174 micro-CT (Bruker MicroCT, Kontich, Belgium) with the following parameters: 800 μA, 50 kVp, and 21 μm projections within 180° rotation and 4000 milliseconds scanning time for each specimen. Scan time was 60 minutes in duration. Three-dimensional reconstruction data were obtained with the aid of dedicated software (NRecon version 1.6.9.4; Skyscan) by using post threshold based segmentation and viewed by using Dataviewer Program (version 1.5.2.4; Bruker MicroCT). Scanning was then transferred into CTan software (version 1.13.5.1) for image analysis. The inflection point of the micro-CT absorption histogram between dentin and filling material compartments was used as segmentation threshold. Preoperative and postoperative volumes of filling materials were calculated in mm^3, and the mean values for each specimen were determined. The mean percentage of residual filling material was color coded and calculated (Fig. 1).

Statistical Analysis

Differences among the residual filling materials for the different techniques were compared by using one-way analysis of variance. The significance level was set at $P < .05$. In addition, mean time required for each technique was recorded.

Results

Residual Filling Materials

The percentages of the residual filling materials for groups 1 (ProTaper), 2 (Mtwo), and 3 (ProFile) were 34.45, 45.43, and 23.63, respectively. There was a statistically significant difference between groups 2 and 3 ($P < .05$). The lowest residual material was found with group 3 (ProFile). According to one-way analysis of variance, there was no statistically significant difference between groups 1 and 2 ($P > .05$, $P = .222$). However, there was a statistically significant difference between groups 2 and 3 ($P < .05$, $P = .019$). In addition, there was a slightly significant difference between groups 1 and 3 ($P = .064$). Percentages of residual filling materials in groups 1, 2, and 3 were 11, 13.98, and 4.93% for distobuccal root canals, 14.55, 14.26, and 12.20 for mesiobuccal root canals, and 8.90, 17.19, and 6.50 for palatal root canals, respectively (Table 1). None of the retreatment techniques were capable of removing whole filling materials from the root canals.