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RECIPROC VERSUS TWISTED FILE FOR ROOT CANAL FILLING REMOVAL: ASSESSMENT OF APICALLY EXTRUDED DEBRIS*

Kök Kanal Dolgusunun Uzaklaştırılmasında Reciproc ile Twisted File'ın Karşılaştırılması: Apikalden Taşan Debrisin Değerlendirilmesi

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ABSTRACT

Purpose: The aim of this study was to evaluate the amount of apically extruded debris during endodontic retreatment with different file systems. **Materials and Methods:** Sixty extracted human mandibular premolar teeth were used in this study. Root canals of the teeth were instrumented and filled before being randomly assigned to three groups. Gutta-percha was removed using the Reciproc system, the Twisted File system (TF), and Hedström-files (H-file). Apically extruded debris was collected and dried in pre-weighed Eppendorf tubes. The amount of extruded debris was assessed with an electronic balance. Data were statistically analyzed using one-way ANOVA, Kruskal-Wallis, and Mann-Whitney U tests. **Results:** The Reciproc and TF systems extruded significantly less debris than the H-file ($p<0.05$). However, no significant difference was found between the Reciproc and TF systems. **Conclusion:** All tested file systems caused apical extrusion of debris. Both the rotary file (TF) and the reciprocating single-file (Reciproc) systems were associated with less apical extrusion compared with the H-file.

Keywords: Endodontics; Retreatment; Root canal preparation; Apical debris; Endodontic file

ÖZ

Amaç: Bu çalışmanın amacı, farklı eğe sistemleriyle tekrarlayan endodontik tedaviler sırasında apikalden taşan debris miktarını değerlendirmektir. **Gereç ve Yöntem:** Bu çalışmada, altmış adet çekilmiş mandibular premolar insan dişi kullanıldı. Dişlerin kök kanalları rastgele üç gruba ayrılmadan önce şekillendirildi ve dolduruldu. Guta-perka Reciproc sistem, Twisted File sistem (TF) ve Hedström eğelerle (H-tipi) uzaklaştırıldı. Apikalden taşan debris önceden tartılmış Eppendorf tüplerinde toplandı ve kurutuldu. Taşan debris miktarı elektronik tartı ile belirlendi. Veriler one-way ANOVA, Kruskal-Wallis ve Mann-Whitney U testleri kullanılarak istatistiksel olarak analiz edildi. **Bulgular:** Reciproc ve TF sistemleri H-tipi eğelerden anlamlı derecede az debris taşırdı ($p<0.05$). Bununla birlikte, Reciproc ve TF arasında anlamlı farklılık bulunmadı. **Sonuç:** Tüm test edilen eğe sistemleri debrisin apikalden taşmasına neden oldu. Rotary eğe (TF) ve reciprokal tek eğe (Reciproc) sistemlerinin her ikisi de H-tipi eğelerle karşılaştırıldığında daha az apikal taşma ile ilişkili bulundu.

Anahtar kelimeler: Endodonti; Tekrarlayan tedavi; Kök kanal preparasyonu; Debris; Kanal eğesi

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Introduction

Nonsurgical endodontic retreatment is needed when microbial infection persists or recurs after initial root canal treatment because of insufficient cleaning and shaping, missed canals, inadequate root filling, or coronal leakage (1). Thus, the main objective of retreatment is to completely remove all fillings from the root canal system to provide effective cleaning, shaping, and refilling (2). During the retreatment procedures, dentin chips, filling materials, microorganisms, and/or irrigants may be extruded from the root canal space into the periradicular tissues. Extrusion of these materials may be clinically responsible for inducing of inflammation and postoperative pain and delaying of periapical healing, even in teeth prepared short of the foramen (3, 4). Numerous studies (1, 5-10) have evaluated the extrusion of intracanal debris, microorganisms, and irrigants through the periradicular region. Debris extrusion is a problem with virtually all preparation techniques and files: the amount of debris extrusion may differ according to which technique/file is used. Several techniques have been used to remove fillings from canals, including hand and rotary files, which can be used by softening the filling with or without solvents and heat and/or ultrasonics (11-14). Rotary files are generally preferred for removing fillings from canal walls because retreatment with hand files can be a tedious, time-consuming process. Thus, some studies (15-17) have researched rotary file efficacy, cleaning ability, and safety during the removal of the canal fillings. The Twisted File (TF; SybronEndo, Orange, CA, USA) is a rotary NiTi file and the manufacturer claims that its technology and twisted file design (triangular cross-section, variable pitch and safe-ended tip) allows use of this system in retreatment of root canals (18). Marfisi *et al*. (18) found no significant differences amongst ProTaper Retreatment files, Mtwo Retreatment files and TF in terms of the removal of root canal filling material. To our knowledge, no report has evaluated apical debris extrusion during root canal retreatment with the TF system. The Reciproc system (VDW, Munich, Germany) was designed to prepare canals with only one file and consists of three single-use files. Files of this system are made of an M-wire technology and are used in a reciprocating movement. This movement provides improved resistance to cyclic fatigue compared to full-sequence rotary NiTi systems (19). Also, Zuolo *et al.* (20) stated that a reciprocating instrument was significantly more effective than rotary files in removing root canal fillings. However, some studies reported no significant differences in the efficacy of rotary and reciprocating file systems for removing filling material during endodontic retreatment (21-23). Because of its different design and kinematics, the effect of the Reciproc system in terms of apical debris extrusion in root canal retreatment has also been evaluated in previous studies (24-26). The aim of this study was to compare the *in vitro* amount of apically extruded debris during endodontic retreatment using the Reciproc and TF systems and H-file. The null hypothesis tested was that there are no significant differences in the amount of debris extruded between the tested NiTi rotary and reciprocating systems.

Materials and Methods

Specimen Preparation

Sixty extracted human mandibular premolars with mature apices, straight root canals, and no calcification were selected for this study. Only single-rooted teeth with a single canal and a single apical foramen were included. This was verified by viewing their buccal and proximal radiographs. The selected teeth were stored in a 0.1% thymol solution until use. Roots were standardized to 17 mm in length using a diamond disc operated at low speed. The working length (WL) was established by subtracting 1 mm from the length of a size 10 K-file (Dentsply Maillefer) that was visible at the major apical foramen. Additionally, the foramen diameter of all teeth was standardized to a size 15 K-file (Dentsply Maillefer).

Root Canal Treatment

The coronal third of each canal was prepared using the ProTaper SX NiTi rotary file (Dentsply Maillefer) and sizes 4-2 Gates-Glidden drills (Dentsply Maillefer) in decreasing order. Then, the middle and apical thirds were prepared with S1 and S2 files until encountering slight resistance, and the canal was then finished using files F1-F3 until the WL was reached. After each file was used and before proceeding to the next size, canals were irrigated with 2 mL of 2.5% NaOCl. When preparation of the root canal was complete, 2 mL 17% EDTA was applied for 1 min to remove the smear layer and the canal was flushed again with 2 mL 2.5% NaOCl. The root canal

was then dried with absorbent paper points. All canals were filled with gutta-percha and AH Plus (Dentsply De Trey, Konstanz, Germany) sealer by using the cold lateral condensation technique. Roots were then radiographed in buccolingual and mesiodistal directions to confirm the quality of the filling. Samples showing any voids within the filling were discarded. The access cavities were sealed with Cavit-G (3M ESPE, Seefeld, Germany). All specimens were stored at 37 °C and 100% humidity for 1 week to allow complete setting of the sealer.

Extrusion Test Design

An experimental method similar to that described in a previous study (27) was used to evaluate apically extruded debris. Empty Eppendorf tubes without covers were weighed with an electronic balance (Precisa; Precisa Inst., Dietikon, Switzerland) with a precision of 10^{-4} g. Three consecutive measurements were taken for each tube, and the mean weight was calculated. A hole was created on the cover of each Eppendorf tube and each tooth was inserted under pressure through the cover, which was fixed by an adhesive (Pattex Super Glue; Turk Henkel, Istanbul, Turkey). The apical part of the root was suspended within the tube, which acted as a collecting container for apical material evacuated through the foramen of the root. A bent 27-G needle was placed alongside the cover to use as a drainage cannula and to balance the internal and external pressures. Then, each cover, including the tooth and needle, was fitted into the Eppendorf tube. The tube was fitted into a vial to hold the device during instrumentation (Figure 1a). All vials were covered with aluminum leaf to prevent the operator from viewing debris extrusion during the retreatment phase (Figure 1b). In no case was the inner Eppendorf tube touched with fingers.

Retreatment Procedures

After the temporary fillings were removed, the teeth were randomly divided for retreatment into three groups of 20 specimens each.

Reciproc Group (n = 20): A Reciproc R40 file with a size 40 at the tip was used with an endomotor (VDW Silver; VDW) in a reciprocating, slow, in-and-out pecking motion at the RECIPROC ALL mode until the WL was reached. The flutes of the file were cleaned after 3 in-and-out movements (pecks).

TF Group (n = 20): Files were used with an endomotor (VDW Silver; VDW) according to the manufacturer's instructions, and root canal preparation commenced with coronal flaring using a size .08/25 file. A size .06/25 file was then inserted and was used to 2 mm short of the WL. Apical preparation to the WL was achieved using sizes .04/25, .06/25, .06/30, and .06/35 files, respectively. Canal preparation was completed with a size .04/40 file to the WL.

Hand File Group (n = 20): The canals were re-instrumented to the original WL with H-files (Dentsply Maillefer) up to size 40 in a circumferential, quarter-turn, push-pull filing motion to remove filling material until the WL was achieved. A step-back procedure with H-files was then completed coronally in 1 mm increments to file size 55. During retreatment, root canals were irrigated with 2 mL bidistilled water at each file change or after three pecks with the reciprocating file. Each NiTi or hand file was discarded after being used in 3 canals. The retreatment procedure was considered complete when the working length was reached and no more gutta-percha or sealer was detected on the file surfaces.

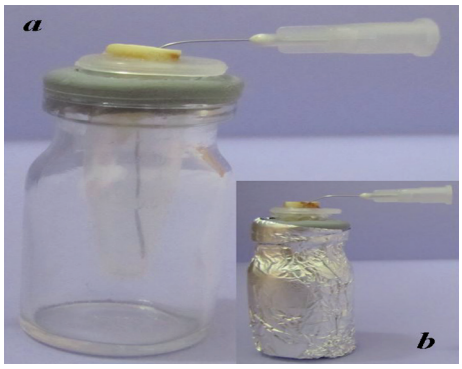

Figure 1. *The experimental model used to evaluate debris extrusion during root canal retreatment.* ***(a)*** *Vial holding the device during instrumentation.* ***(b)*** *Vial covered with aluminum leaf to prevent the operator from viewing debris extrusion during the retreatment phase.*

Evaluation

After the instrumentation was performed, the cover, needle, and tooth were separated from the Eppendorf tube, and the debris adhered to the root surface was collected by washing the root with 1 mL bidistilled water in the tube. The tubes were then stored in an incubator at 50 °C for 7 days to evaporate the distilled water before weighing the dry debris. The net weight of the extruded debris was determined by subtracting the initial weight from the final weight.

Statistical Analysis

All statistical analyses were performed with SPSS 15.0 (SPSS for Windows; SPSS Inc., Chicago, IL, USA). Data were statistically analyzed with the one-way ANOVA, Kruskal-Wallis, and Mann-Whitney U tests. Statistical significance was defined as $p<0.05$.

Results

The amount of apically extruded debris for each group is presented in Table 1. Although all the retreatment techniques resulted in apical extrusion; the Reciproc and TF systems produced significantly less apical extrusion than the H-file ($p<0.05$). However, no statistical difference was observed between the Reciproc and TF systems.

Table 1. *Amount of apically extruded debris after the use of the different file systems.*

Debris extrusion (g)	Reciproc	Twisted File	H-file
Mean	0.00135[a]	0.00142[a]	0.00219[b]
Standard deviation	0.00088	0.00074	0.00094
Number of samples	20	20	20
Minimum	0.0004	0.0003	0.0010
Maximum	0.0035	0.0027	0.0037

The values with the same letters were not significantly different.

Discussion

Removing as much filling material and infected dentin as possible from an inadequately prepared and filled root canal system is crucial to uncover remnants of necrotic tissue or bacteria that may be responsible for periapical inflammation and failure (12). Variations in canal morphology greatly influence the changes that occur after canal preparation and as a logical extension, after retreatment procedures (28). In this study, in order to minimize these variables, teeth were flattened coronally, and the WL of each canal was standardized so that varying lengths could not influence the results (19, 22). Teeth were carefully selected according to tooth type, canal size, WL, and canal curvature. Also, they were digitally radiographed from buccal and proximal views to ensure that they had single canals and orifices.

To date, many studies (13, 14, 18, 20, 22) have investigated the retreatment performance of different NiTi systems. Although these systems were not originally designed for retreatment, the special design of the files as well as the reciprocating or rotary motion can be potentially beneficial for the effective removal of filling. Favorable results were observed in those previous reported studies. When endodontic treatment or retreatment is performed, irritants in the form of filling materials, necrotic pulp tissues, bacteria, or irrigants might be introduced into the periradicular region. Apically extruded materials are held clinically responsible for postoperative inflammation and flare-ups or even failure of apical healing (3, 4). Apical extrusion of debris and irrigants during root canal treatment or retreatment has been studied extensively because of its clinical relevance. Reddy and Hicks (29) were the first to compare apical debris extrusion among hand files and two rotary NiTi (Lightspeed and Profile Series 29) files, comparing the weights of extruded debris and showing that a step-back technique produces significantly more debris than the rotary NiTi files. Following to this study, numerous studies have reported that rotary NiTi files are associated with less debris extrusion than hand files in endodontic treatment or retreatment (8, 10, 17, 27, 30, 31). To our knowledge, only one study (32) has evaluated the apically extruded debris during root canal treatment with TF. That study (32) showed that there was no significant difference between the TF group and the ProTaper Next and WaveOne groups.

Results presented herein are consistent with other apical extrusion studies in endodontic retreatment (17, 31) and reinforce the fact that it is impossible to prepare root canals without any extrusion of debris. This result might be due to the fact that early flaring of the coronal part of the preparation with the rotary NiTi files improves instrument control during preparation of the apical thirds of the canal, and because of the rotational motion, which tends to direct debris toward the orifice, keeping it from becoming compacted in the root canal. Hülsmann and Bluhm (33) stated that the design of the rotary files could have an effect on their cleaning ability. Thus, another factor for the

better performance of TF can probably be attributed to its design. The features of the TF system such as its twisted design, not ground, surface deoxidation treatment, triangular cross-section, variable pitch, and safe-ended tip allow its effective use in root canal retreatment. Large amounts of fillings from the canals can be removed in spirals around the files, whereas H-files only remove gutta-percha in small increments (10). Furthermore, in the hand instrumentation technique, H-files are used in a push-pull filling motion, which has been reported to lead a greater amount of apically extruded debris (34). To date, few studies (5, 25, 35-38) have investigated apical debris extrusion during root canal treatment or retreatment with the Reciproc system. Some studies (5, 25, 35) have revealed the superiority of rotary NiTi instrumentation over Reciproc instrumentation in terms of the amount of apically extruded debris. In contrast, two studies (37, 38) observed similar amounts of extruded debris after rotary NiTi and Reciproc instrumentation, while some studies (24, 26, 36) have reported the superiority of Reciproc instrumentation over rotary NiTi instrumentation. The present study found no significant differences between the Reciproc, TF, and H-file. However, in the current study, apical debris extrusion was studied during root canal retreatment. Therefore, we compared our results only with the results of Lu *et al.* (25), Silva *et al.* (26), and Dincer *et al.* (24) because the retreatment procedure might affect the amount of apically extruded debris compared with the standard root canal treatment procedure. Lu *et al.* (25) reported that reciprocal instrumentation produced significantly more apically extruded debris and irrigant than rotary instrumentation. However, Silva *et al*. (26) stated that less apically extruded debris was produced with reciprocating systems (Reciproc R40 and WaveOne Large) than with a conventional rotary retreatment system (ProTaper Universal Retreatment). Also, Dincer *et al.* (24) reported that the Reciproc system was associated with less debris extrusion when compared with full-sequence rotary NiTi instruments (ProTaper Universal Retreatment and Mtwo Retreatment systems) and hand files. The contrast between the outcomes of those previous studies and the present study might be explained by root canal anatomy, amount of irrigant, instrumentation technique, file design, number of files, and especially, the experimental set up. Also, it must be stated that comparisons of different studies might show different results due to the variety of experimental set ups used in studies. In Lu *et al.*'s study (25), the weight of the apically extruded debris and irrigant were calculated together when the removal of gutta-percha was completed. However, only the apically extruded debris was calculated in the current retreatment study. Thus, the difference between the studies may be due to the apically extruded irrigant. According to the current results, apical debris extrusion occurred in all of the tested file systems. As expected, manual instrumentation produced significantly more debris compared with the continuous rotation (TF) and reciprocating motion (Reciproc) systems. However, no statistical difference was observed between the Reciproc and TF systems. Therefore, the null hypothesis was accepted. It must be stated that the current *in vitro* results cannot be directly extrapolated to clinical situations, mainly because of the absence of back pressure provided by periradicular tissues. A clinical study may give different results, as periradicular tissues may serve as a natural barrier, inhibiting apical extrusion. Results may also differ because of the persistence of residual pulp tissue, the pulp condition, canal curvature, and normal/pathological periapical tissues (39-41). Furthermore, the current study was limited to teeth with mature root morphology. The observed results should not be generalized to teeth with immature root development and open apices, as suggested by Kustarci *et al.* (8).

Conclusion

All file systems tested in this study caused apical debris extrusion. However, the rotary file (TF) and reciprocating single-file (Reciproc) systems were associated with less apical extrusion than hand files. Caution should be exercised when applying these results to clinical conditions. Further research will be necessary to determine the clinical performance of the tested instrumentation systems during retreatment.

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Conflict of interest
None declared

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