Apically Extruded Debris after Retreatment Procedure with Reciproc, ProTaper Next, and Twisted File Adaptive Instruments

Koray Yılmaz, DDS, and Taha Özyürek, DDS, PhD

Abstract

Introduction: The aim of this study was to compare the amount of debris extruded from the apex during retreatment procedures with ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland), Reciproc (RCP; VDW, Munich, Germany), and Twisted File Adaptive (TFA; SybronEndo, Orange, CA) files and the duration of these retreatment procedures. **Methods:** Ninety upper central incisor teeth were prepared and filled with gutta-percha and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) using the vertical compaction technique. The teeth were randomly divided into 3 groups of 30 for removal of the root filling material with PTN, RCP, and TFA files. The apically extruded debris was collected in preweighed Eppendorf tubes. The time for gutta-percha removal was recorded. Data were statistically analyzed using Kruskal-Wallis and 1-way analysis of variance tests. **Results:** The amount of debris extruded was RPC > TFA > PTN, respectively. Compared with the PTN group, the amount of debris extruded in the RPC group was statistically significantly higher ($P < .001$). There was no statistically significant difference among the RCP, TFA, and PTN groups regarding the time for retreatment ($P > .05$). **Conclusions:** Within the limitations of this *in vitro* study, all groups were associated with debris extrusion from the apex. The RCP file system led to higher levels of apical extrusion in proportion to the PTN file system. In addition, there was no significant difference among groups in the duration of the retreatment procedures. *(J Endod 2017;43:648–651)*

Key Words

Apical extrusion, ProTaper Next, Reciproc, retreatment, Twisted File Adaptive

In cases in which root canal treatment is unsuccessful, nonsurgical retreatment is the first treatment option (1). During retreatment, root canal filling materials, necrotic pulpal tissues, irrigation solutions, and microorganisms can extrude into the periradicular tissues, and these extruded materials can lead to postoperative pain and inflammation (2).

Significance

Avoiding or decreasing the apically extruded debris from the apex might be an important factor for successful endodontic treatment. Thus, knowing the performance of NiTi files on apical extrusion is important for both dentists and endodontics.

To remove the filling material in the root canal, various methods, such as nickel-titanium (NiTi) files (3), ultrasonic systems (4), laser systems (5), and chemical solvents (6), are used. Previous studies showed that these methods caused various levels of debris extrusion from the apex (7, 8). Compared with manual files, studies showed that rotary NiTi files resulted in much less apical extrusion (9, 10) and that apical extrusion was much lower with systems using full rotation motion compared with those using reciprocal motion (8).

Retreatment is much more difficult and time-consuming than the initial root canal treatment. The use of NiTi files makes the retreatment procedure easier (11). Many studies have examined the effectiveness of the Reciproc (RPC; VDW, Munich, Germany) file during retreatment procedures (12–14). However, according to a review of the literature, very few studies have investigated debris extrusion from the apex using the RPC system in root canal retreatment procedures (15–17).

The ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) file system, which was released in recent years, has a square cross section that moves continuously asymmetrically during rotation and is made of M-Wire alloy. There have only been a few studies on the application of this system in retreatment procedures (18, 19). Another file system, the Twisted File Adaptive (TFA; SybronEndo, Orange, CA), has its own endodontic motor (Elements Motor, SybronEndo) and combines the advantages of rotation and reciprocation motions. Unless there is stress on the file, the file rotates 600° clockwise, stops, and then continues the rotation motion. In the case of an increase in stress on the file, the Elements Motor modifies the motion of the file up to 370° clockwise and 50° counterclockwise (20).

According to a comprehensive literature review, no studies have compared the amounts of debris extruded from the apex using PTN, RPC, and TFA files in retreatment procedures. Thus, the aim of the present study was to compare the amount of debris extruded from the apex during retreatment procedures with PTN, RPC, and TFA files and the duration of these retreatment procedures. The null hypothesis was that there

From the Department of Endodontics, Faculty of Dentistry, Ondokuz Mayis University, Samsun, Turkey.
Address requests for reprints to Dr Taha Özyürek, Department of Endodontics, Faculty of Dentistry, Ondokuz Mayis University, Atakum, Samsun, Turkey, 55137. E-mail address: tahaozyurek@hotmail.com
0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2016.12.003

would be no difference among the amounts of debris extruded from the apex using the PTN, RPC, and TFA files and the duration of the retreatment procedures.

Material and Methods

Sample Selection

After obtaining ethics committee approval, 90 upper central incisor teeth, which had been extracted because of periodontal reasons, were included in the present study. Radiographies of the teeth confirmed that the apexes of all the teeth were completely mature; there was no resorption, calcification, or previous root canal filling in the canal; and the root had a curvature of less than 5° (21). All the soft and hard tissue remnants on the teeth were mechanically removed.

Root Canal Preparation

The endodontic access cavities of all the teeth were prepared under water cooling. The working length was set to be 1 mm shorter than the length where a #10 K-file (Dentsply Maillefer) reached the level of the minor apical foramen. Root canal preparation was performed via the crown-down technique using a K-file manual file to produce an apical diameter of 40.02. After instrumentation with each of the canal files, the canals were irrigated with 2 mL 5.25% sodium hypochlorite (NaOCl). In the final irrigation, 2 mL 5.25% NaOCl, 2 mL 17% EDTA for 2 minutes, and 5 mL distilled water were used.

Root Canal Obturation

Root canal obturation was performed with a 40.02 master apical cone (Diadent Group International, Chongchong BukDo, Korea) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) using the Calamus 3D Obturation System (Dentsply International, Johnson City, TN) and the vertical compaction technique. Gutta-percha was removed by cutting 16 mm away from the apex. The teeth were kept at 37° and 100% humidity for 14 days for setting of the sealer by closing the canal openings with a temporary filling material (Cavit G; 3M ESPE, Seefeld, Germany).

Retreatment Procedure

The teeth were coated with a thin layer of silicone material to simulate the periodontal ligament. Then, the teeth were randomly divided into 3 groups ($n = 30$). A single operator performed all the retreatment procedures.

Group 1: PTN

The PTN X3 (30.07) and X2 (25.06) NiTi files were used with the crown-down technique. The PTN X3 file was used to remove the gutta-percha and root canal sealer from one third of the coronal part of the working length, and the PTN X2 file was used in the entire working length of the canal. The files were operated according to the instructions of the manufacturer at 300 rpm and 2 Nm torque with an endodontic motor (VDW Silver Reciproc, VDW). Finally, the PTN X5 (50.06) file was used in apical preparation. A total of 20 mL distilled water was used during the retreatment procedure.

Group 2: TFA

As in the PTN group, the TFA ML2 (35.06) and ML1 (25.08) files were used with the crown-down technique. The TFA ML2 (35.06) file was used to remove the gutta-percha and root canal sealer from the coronal one third of the canal, and the ML1 (25.08) file was used throughout the working length. According to the manufacturer's instructions, the files were operated using the "TF Adaptive" program of the Elements Motor. Finally, the TFA ML3 (50.04) file was used in apical preparation. A total of 20 mL distilled water was used during the retreatment procedure.

Group 3: RPC

The RPC R25 (25.08) file was used at the working length with the VDW Silver Reciproc endodontic motor in the "Reciproc ALL" program. In accordance with the manufacturer's instructions, mild apical pressure and a brushing movement were used with the file. Finally, the RPC R50 (50.05) file was used in apical enlargement.

In all the groups, the duration of the retreatment procedures was recorded using a digital chronometer. The time taken for file replacements and canal irrigations was not included in the duration for retreatment. Twenty milliliters of distilled water was used during the retreatment procedure.

Debris Collection

In all the groups, the method of Bürklein et al (22) was used to evaluate the amount of debris extruded from the apex. The teeth were placed on a rubber stopper and then in a 4-mL Eppendorf tube, the weight of which was determined by weighing the tube 3 times on an electronic scale (AUW-220D; Shimadzu, Tokyo, Japan) with 10^{-5} g sensitivity. The tube containing the teeth was placed in a dark-colored bottle. To equalize the air pressure inside and outside the bottle, a 23-G syringe was inserted into the rubber stopper and placed in the bottle. Via this method, the extruded debris from the apex during root canal shaping was collected in the Eppendorf tubes. In each of the samples, 20 mL distilled water was used during the retreatment procedure. After the retreatment procedure, the debris remaining on the root surface was washed with 1 mL distilled water and added to the debris collected in the Eppendorf tubes.

A single operator performed all the procedures to eliminate inconsistencies between the amount of debris extruded during the final apical enlargement and irrigation procedures and the removal of gutta-percha and sealer in the root canals. To vaporize the distilled water in the Eppendorf tubes and measure the weight of the extruded debris, the tubes were kept in a drying oven at 70° for 7 days. In all the experiment groups, the measurements were performed in triplicate for each sample in the Eppendorf tube, and the mean values of these measurements were calculated. The amount of debris extruded from the apex was calculated by subtracting the weight of the empty tubes from the weight of the tubes containing the debris.

Statistical Analysis

After preparing the obtained debris data for analyses, the Shapiro-Wilk test showed that the data were not distributed normally. The Levene variance homogeneity test showed that the variances were not distributed homogenously. Therefore, the Kruskal-Wallis test was used for intergroup comparisons of the amount of debris.

After preparing the obtained time data for analyses, the Shapiro-Wilk test revealed that the data were distributed normally. The Levene variance homogeneity test showed that the variances were distributed homogenously. Therefore, the intergroup comparisons of the duration of the retreatment procedures were executed using the 1-way analysis of variance test. In all the statistical analyses, SPSS 21 (IBM SPSS Inc, Chicago, IL) software was used. The statistical significance level was set at 5%.

Results

The median, minimum, and maximum values of the amount of debris extruded from the apex, in addition to the mean and standard

TABLE 1. Medians (Minimum–Maximum) of Apically Extruded Debris (g) and Total Time (seconds) Required for Retreatment

Group	*n*	Median	Minimum	Maximum	Time
ProTaper Next	30	0.00019[a]	0.00011	0.00048	36.35 ± 13.90[a]
Reciproc	30	0.00032[bc]	0.00017	0.00064	30.50 ± 12.03[a]
Twisted File Adaptive	30	0.00030[ac]	0.00017	0.00050	38.44 ± 16.93[a]
P value		<.05			>.05

Different superscript letters in the same column indicate a significant difference among groups.

deviation values of the retreatment procedure durations, for each of the groups are presented in Table 1. According to the data, in increasing order, the amount of debris extruded from the apex was RPC > TFA > PTN, respectively. Compared with the PTN group, the amount of debris extruded in the RPC group was statistically significantly higher ($P < .05$). A comparison of the duration of the retreatment procedures revealed no statistically significant difference among the RCP, TFA, and PTN groups ($P > .05$).

Discussion

The leading reason for failure after retreatment is debris extruded from the apex during the retreatment procedure (23, 24). Bacteria, irrigation solution, gutta-percha, and the remains of dentin in debris may be extruded from the apex (17). Research has shown that even a very low amount of debris, if it contains a high level of bacteria, can cause inflammation in the periapical region (25). Previous studies reported that all preparation techniques led to debris extrusion from the apex (9, 26).

A review of the literature revealed that only a few studies evaluated the amount of debris extruded from the apex during retreatment (15–17, 27–29). Thus, the present study compared the amount of debris extruded from the apex during retreatment procedures using PTN, RCP, and TFA file systems, which have different designs and working principles. According to the results of the present study, the RCP group extruded significantly more debris than the PTN group. Thus, the null hypothesis of the present study was rejected.

In the present study, the method developed by Bürklein et al (22) to measure the amount of debris extruded from the apex during the retreatment procedures was used. The teeth were coated with a thin layer of silicone material to simulate the periodontal ligament. Considering that NaOCl may become crystallized and affect these measurements, only distilled water was used during the retreatment procedures.

In the literature review, no study could be found that compares the apical extrusion levels of the PTN and TFA file systems during retreatment procedures. Previous studies reported that during root canal preparation single-file reciprocation systems caused more apical extrusion than single-file or multiple-file rotary systems (8, 22). The results of the present study showed that, when the movement kinematic changes to reciprocation from continuous rotation, the apically extruded debris decreases. Lu et al (15) reported that the RCP system caused more apical extrusion during retreatment than the Mtwo R (VDW) file system. Dincer et al (17) compared the ProTaper Universal Retreatment (PTR, Dentsply Maillefer), RCP, and Mtwo R file systems and reported that the RCP system showed the lowest apical extrusion. Silva et al (16) compared the apical extrusion of PTR, RCP, and WaveOne (Dentsply Maillefer) files during retreatment and determined that the level of apical extrusion was higher when using the PTR system compared with the RCP and WaveOne systems. Topçuoğlu et al (28) compared the apical extrusion levels of PTN, Vortex Blue (Dentsply Maillefer), K3XF (SybronEndo), and RCP files during root canal preparation. The authors reported that the PTN and Vortex Blue systems led to lower levels of apical extrusion than the other file systems. In a comparison of the amounts of apical extrusion produced during root canal preparation when using the ProTaper Universal (Dentsply Maillefer), SAF (ReDent Nova, Ra'anana, Israel), Revo-S (Micro Mega, Besancon, France), and RCP systems, the authors reported that the RCP system resulted in the lowest level of apical extrusion, but there was no statistically significant difference among the groups (30).

In another study, the ProTaper Universal system led to a statistically significantly higher level of apical extrusion during root canal preparation (31). However, in accordance with the results of the present study, there was no statistically significant difference between the PTN and TFA groups. In a study that compares the apical extrusion levels of the PTN, TFA, and WaveOne systems, the PTN system resulted in the highest level of extrusion, but there was no statistically significant difference between the PTN and TFA groups (32). In the present study, the lower level of apical extrusion in the PTN group compared with the other groups might be because of the offset design of the file. In the offset design, there is more space in the canal for conveying the debris through the canal compared with that of the TFA and RCP systems. Also, in the present study in the PTN and TFA groups, 2 files were used to remove the root canal filling materials, but in the RCP group only 1 file was used. The low amount of apically extruded debris in the PTN group might be caused by the file number used to remove the root canal filling materials because removing the root canal filling material in the coronal third with an X3 file might relieve the movement of the second X2 file. As a result of the relieving of the NiTi file, the apical force that occurs during retreatment might be decreased; thus, the apically extruded debris might be decreased too.

According to the results of the present study, there was no statistically significant among group differences in the duration of the retreatment procedures. Dincer et al (17) reported a statistically significant difference in the duration of retreatment procedures between the PTR and RCP groups; the duration of the retreatment procedure in the Mtwo R group was shorter than that of the other groups. These contrary findings may be explained by operator-related variables and methods for calculating the total retreatment time.

Conclusion

Within the limitations of the present study, all the file systems led to apical extrusion during the retreatment procedures. The RCP file system led to higher levels of apical extrusion in proportion to the PTN file system, but there was no statistically significant difference between the RCP and TFA file systems. In addition, there was no significantly difference among groups in the duration of the retreatment procedures.

Acknowledgments

The authors deny any conflicts of interest related to this study.

References

1. Sjögren U, Hägglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod 1990;16:498–504.
2. Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. J Endod 1985; 11:472–8.

3. Pirani C, Pelliccioni GA, Marchionni S, et al. Effectiveness of three different retreatment techniques in canals filled with compacted gutta-percha or Thermafil: a scanning electron microscope study. J Endod 2009;35:1433–40.
4. Ladley RW, Campbell AD, Hicks ML, Li SH. Effectiveness of halothane used with ultrasonic or hand instrumentation to remove gutta-percha from the root canal. J Endod 1991;17:221–4.
5. Vidučić D, Jukić S, Karlović Z, et al. Removal of gutta-percha from root canals using an Nd:YAG laser. Int Endod J 2003;36:670–3.
6. Mushtaq M, Farooq R, Ibrahim M, Khan FY. Dissolving efficacy of different organic solvents on gutta-percha and Resilon root canal obturating materials at different immersion time intervals. J Conserv Dent 2012;15:141.
7. Betti L, Bramante C, Quantec SC. rotary instruments versus hand files for gutta-percha removal in root canal retreatment. Int Endod J 2001;34:514–9.
8. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod 2012;38:850–2.
9. Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod 1998;24:180–3.
10. Kuştarcı A, Akpınar KE, Er K. Apical extrusion of intracanal debris and irrigant following use of various instrumentation techniques. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:257–62.
11. Duncan HF, Chong BS. Removal of root filling materials. Endod Topics 2008;19:33–57.
12. Zuolo A, Mello J, Cunha R, et al. Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. Int Endod J 2013;46:947–53.
13. Rödig T, Reicherts P, Konietschke F, et al. Efficacy of reciprocating and rotary NiTi instruments for retreatment of curved root canals assessed by micro-CT. Int Endod J 2014;47:942–8.
14. Plotino G, Grande N, Porciani P. Deformation and fracture incidence of Reciproc instruments: a clinical evaluation. Int Endod J 2015;48:199–205.
15. Lu Y, Wang R, Zhang L, et al. Apically extruded debris and irrigant with two Ni-Ti systems and hand files when removing root fillings: a laboratory study. Int Endod J 2013;46:1125–30.
16. Silva EJ, Sá L, Belladonna FG, et al. Reciprocating versus rotary systems for root filling removal: assessment of the apically extruded material. J Endod 2014;40:2077–80.
17. Dincer A, Er O, Canakci B. Evaluation of apically extruded debris during root canal retreatment with several NiTi systems. Int Endod J 2015;48:1194–8.
18. Nevares G, Diana S, Freire LG, et al. Efficacy of ProTaper NEXT compared with Reciproc in removing obturation material from severely curved root canals: a micro–computed tomography study. J Endod 2016;42:803–8.
19. Özyürek T, Demiryürek EÖ. Efficacy of different nickel-titanium instruments in removing gutta-percha during root canal retreatment. J Endod 2016;42:646–9.
20. Gambarini G, Testarelli L, De Luca M, et al. The influence of three different instrumentation techniques on the incidence of postoperative pain after endodontic treatment. Ann Stomatol (Roma) 2013;4:152.
21. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271–5.
22. Bürklein S, Benten S, Schäfer E. Quantitative evaluation of apically extruded debris with different single-file systems: Reciproc, F360 and OneShape versus Mtwo. Int Endod J 2014;47:405–9.
23. Siqueira J. Microbial causes of endodontic flare-ups. Int Endod J 2003;36:453–63.
24. Al-Haddad A, Ab Aziz ZC. Apically extruded debris during removal of Real-seal™ using two re-treatment rotary systems. Aust J Basic Appl Sci 2011;5:114–9.
25. Tanalp J, Güngör T. Apical extrusion of debris: a literature review of an inherent occurrence during root canal treatment. Int Endod J 2014;47:211–21.
26. Azar NG, Ebrahimi G. Apical extruded debris using the ProTaper system. Aust Endod J 2005;31:21–3.
27. Huang X, Ling J, Wei X, Gu L. Quantitative evaluation of debris extruded apically by using ProTaper Universal Tulsa rotary system in endodontic retreatment. J Endod 2007;33:1102–5.
28. Topçuoğlu HS, Zan R, Akpek F, et al. Apically extruded debris during root canal preparation using Vortex Blue, K3XF, ProTaper Next and Reciproc instruments. Int Endod J 2016;49:1183–7.
29. Çanakçi BC, Ustun Y, Er O, Sen OG. Evaluation of apically extruded debris from curved root canal filling removal using 5 nickel-titanium systems. J Endod 2016;42:1101–4.
30. Koçak S, Koçak MM, Sağlam BC, et al. Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems. J Endod 2013;39:1278–80.
31. Capar ID, Arslan H, Akcay M, Ertas H. An *in vitro* comparison of apically extruded debris and instrumentation times with ProTaper Universal, ProTaper Next, Twisted File Adaptive, and HyFlex instruments. J Endod 2014;40:1638–41.
32. Üstün Y, Çanakçi B, Dinçer A, et al. Evaluation of apically extruded debris associated with several Ni–Ti systems. Int Endod J 2015;48:701–4.