Quantitative Evaluation of Debris Extruded Apically by Using ProTaper Universal Tulsa Rotary System in Endodontic Retreatment

Xiangya Huang, MS, Junqi Ling, PhD, Xi Wei, MS, MDS, and Lisha Gu, MS

Abstract

This study evaluated the amount of apical debris during endodontic retreatment by using the ProTaper Universal Tulsa rotary files. Forty-five extracted human anterior teeth were root filled before randomly assigned to 3 groups. In group A, gutta-percha was removed by using the ProTaper Universal Tulsa retreatment system, and canals were re-prepared with ProTaper rotary files. In group B, gutta-percha was removed by using Hedström files with chloroform, and canals were reshaped with ProTaper rotary files. In group C, the same method as that in group B was used for gutta-percha removal, and canals were reshaped with K-flex files. Apical debris was collected and compared among 3 groups. Although all retreatment techniques resulted in apical extrusion, the ProTaper Universal Tulsa rotary technique in group A produced significantly less amount of apical extrusion than other 2 methods ($P < .001$). The ProTaper Universal Tulsa rotary technique proves to be a viable alternative method in endodontic retreatment. *(J Endod 2007;33:1102–1105)*

Key Words

Apical debris, endodontic retreatment, nickel-titanium, ProTaper Universal Tulsa rotary instruments

From the Department of Operative Dentistry and Endodontics, Guanghua College of Stomatology, Sun Yat-sen University, Guangzhou, China.

Address requests for reprints to Jun-qi Ling, PhD, Department of Operative Dentistry and Endodontics, Guanghua College of Stomatology, Sun Yat-sen University, Guangzhou, P. R. China. E-mail address: lingjq@mail.sysu.edu.cn.

0099-2399/$0 - see front matter

doi:10.1016/j.joen.2007.05.019

A growing interest in endodontic retreatment has been seen as a result of an increasing demand to preserve teeth. Whenever feasible, nonsurgical retreatment should be performed over surgery (1). The main goal of nonsurgical endodontic retreatment is to reestablish healthy periapical tissues after ineffective root canal treatment.

When endodontic retreatment is performed, irritants in the form of filling materials, necrotic pulp tissues, bacteria, or irrigants might be introduced into the apical lesion. The apically extruded materials have been held clinically responsible for postoperative inflammation and flare-up or even failure of apical healing (2–5). A large body of evidence indicates that almost all instrumentation techniques promote apical extrusion of debris to some degree (6–8). However, the amount of debris extruded apically might vary according to the technique used. A common finding is that techniques involving a push-pull filing motion usually create a greater mass of debris than those involving some sort of rotational action (9–13). Therefore, appropriate retreatment technique should be selected to remove the preexisting filling material as completely as possible while minimizing the amount of apical extrusion.

Recently a new generation of nickel-titanium rotary instruments, ProTaper Universal Tulsa (Dentsply Tulsa, Tulsa, OK), became available. Apart from shaping and finishing files, it contains a retreatment system, which is designed for root filling removal in case of retreatment. This system comprises 3 flexible instruments (D1, D2, and D3), of which the tapers and tip diameters are equivalent to size 0.09/0.30 mm, 0.08/0.25 mm, and 0.07/0.20 mm, respectively. The lengths are 16 mm for D1, 18 mm for D2, and 22 mm for D3. These instruments are specially designed for root filling removal from the coronal, middle, and apical portions of root canals. The retreatment files have a convex triangular cross section, which is similar to the ProTaper shaping and finishing files. In addition, D1 has a working tip that facilitates its initial penetration into the filling materials.

According to our knowledge, there have been few studies investigating the use of ProTaper Universal Tulsa rotary system in endodontic retreatment to date. The purpose of this study was to quantitatively evaluate the amount of debris extruded beyond the apical foramen during endodontic retreatment when comparing the ProTaper Universal Tulsa system with traditional hand-filing/solvent techniques.

Materials and Methods

Specimen Preparation

Forty-five extracted human maxillary anterior teeth of single canal and similar root length were collected. The soft tissue remnants and calculus on the external root surface were mechanically removed. Teeth were examined under an operating microscope (Carl Zeiss, Jena, Germany) to verify the presence of a single apical foramen (7). After access cavity, the canal patency was established with a size 10 K-type file (Dentsply Maillefer, Ballaigues, Switzerland). Canals that were patent to greater than International Standards Organization (ISO) size 15 and/or with curvature >10 degrees were discarded (14).

Root Canal Preparation and Obturation

The working length (WL) of each canal was visually determined with the use of size 10 K-type files to 1 mm short of the major apical foramen. A circumferential "staging

platform'' was created near the canal orifice so that a uniform WL of 15 mm was achieved.

Root canal preparation was performed with a modified step-back flare technique. The coronal portion was initially flared with sizes 1–3 Gates Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland). Canals were then prepared with K-type files to a master apical file size 30 and step back in 1-mm increment to a file size 50. On withdrawal of each instrument, canals were irrigated alternatively with 2 mL of 5.25% NaOCl and 17% ethylenediaminetetraacetic acid. Canal patency was maintained by inserting a size 15 K-type file slightly beyond the apical foramen during recapitulation.

All canals were then obturated with gutta-percha and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) by using cold lateral condensation technique. The coronal extension of root fillings was uniformly limited to the level of staging platform as an attempt to control the amount of root fillings in each tooth. The access cavities were sealed with Cavit (Dentsply DeTrey). Teeth were radiographed in buccolingual and mesial-distal directions to confirm the quality of obturation. All teeth were stored at 37°C in a humidor for 30 days to allow complete setting of the sealer.

Retreatment and Debris Collection

Debris was collected as previously reported (15). The schematic representation of the collection assembly prepared for assaying the apical extrusion is shown in Fig. 1. All ampules were covered with adhesive tape to prevent the operator from viewing debris extrusion during the retreatment phase. The entire apparatus was handled only by the outer vial. In no case was the inner Eppendorf tube touched with fingers.

Before retreatment, the Eppendorf tubes were weighed to 10^{-5} precision by using a microbalance (Sartorius AG, Göttingen, Germany). Three consecutive measurements were taken for each tube, and the mean value was recorded. All teeth were coded and then randomly assigned to 3 groups of 15 specimens each.

Group A: Gutta-percha Removal With ProTaper Universal Tulsa Retreatment Files and Re-preparation With ProTaper Universal Tulsa Treatment Files

Gutta-purcha was removed with ProTaper Universal Tulsa retreatment system following the manufacturer's instructions. D1, D2, and D3 were sequentially used at 500 rpm until the pre-established WL was reached. No solvent was used. In case the rotary files could not go deeper, stainless steel K-type files were used to achieve the canal patency before reintroducing the rotary instruments. Root canal refining was accomplished with ProTaper Universal Tulsa rotary shaping (S1, S2) and finishing (F1, F2, and F3) files (Dentsply Tulsa) following the manufacturer's instructions. The tapers and tip diameters of F1, F2, and F3 are equivalent to size 0.07/0.20 mm, 0.08/0.25 mm, and 0.09/0.30 mm, respectively. After re-preparation with F3, the canal was 0.39 mm in diameter at the level of 1 mm short of the WL.

Group B: Gutta-percha Removal With Hedström files and Chloroform and Re-preparation With ProTaper Universal Tulsa Treatment Files

Gutta-percha in the coronal portion was removed by using size 1–3 Gates Glidden drills. The root fillings in the apical portion were then removed by sequential use of sizes 20–30 Hedström files (Dentsply Maillefer) with chloroform. Once the bulk of root filling had been removed, chloroform in conjunction with paper points was used to remove the filling material that remained in the irregularities of canal

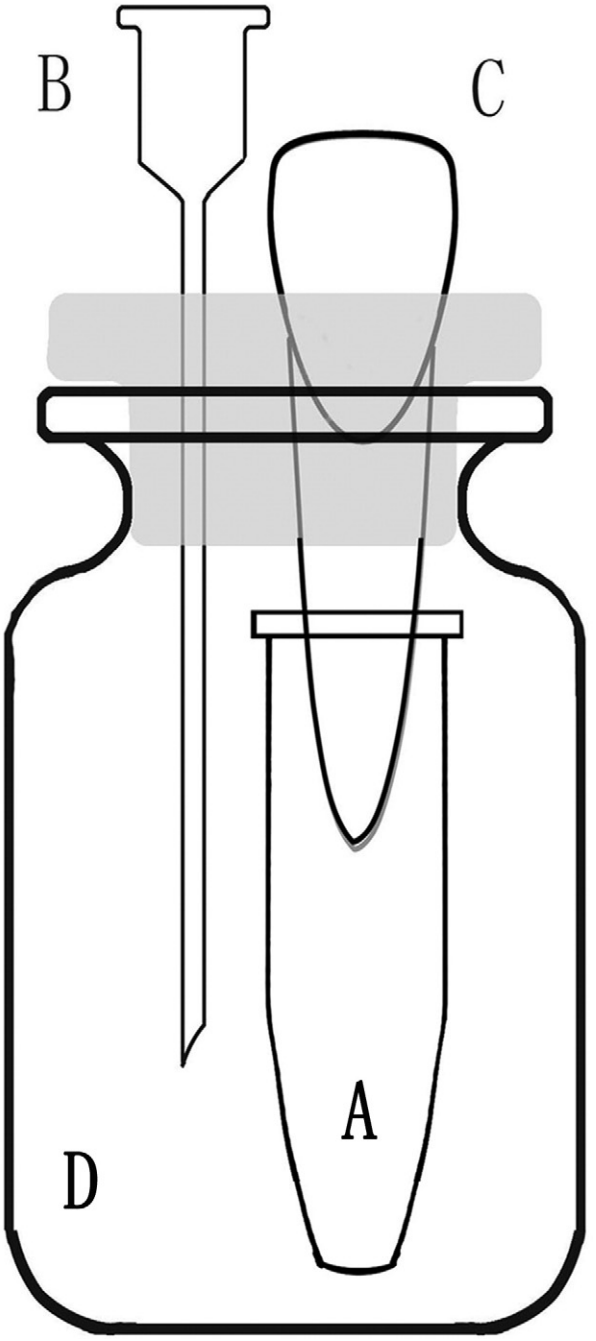

Figure 1. Schematic representation of the collection assembly prepared for the evaluation of apically extruded debris. (*A*) Eppendorf tube in which the apically extruded debris is collected. (*B*) Needle inserted in the rubber stopper of ampule to equalize the internal and external pressures. (*C*) Tooth secured on the ampule's removable rubber stopper. (*D*) Ampule acting as a carrier.

system. ProTaper Universal Tulsa rotary shaping and finishing files were then used for root canal re-preparation.

Group C: Gutta-percha Removal With Hedström Files With Chloroform and Re-preparation With K-flex Files

The method for gutta-percha removal was the same as that in group B. Root canal reshaping was accomplished with stainless steel K-flex files (Dentsply Maillefer), with apical enlargement up to size 35 and step-back in 1-mm increments to size 50. Consequently, the canal

diameter at the level of 1 mm short of the WL was 0.40 mm, which was comparable to the samples in groups A and B.

On withdrawal, adherent material was removed from the file, and canals were irrigated with 2 mL distilled water to avoid any possible weight increase caused by NaOCl crystal formation (16). The total volume of irrigant was 20 mL per tooth. One set of instruments was used for 5 canals. Retreatment was deemed complete when no debris of gutta-percha/sealer was visible on the instrument surfaces, and canal walls were smooth.

Evaluation

Retreatment procedures were carried out by a single operator (X.Y.H.), and evaluation was done by a second examiner (L.S.G.) who was blinded to group assignment.

On completion of the retreatment procedure, the Eppendorf tubes were removed from the ampules. The debris adherent to the external surface of the apex was scraped and collected into its tube. The extruded debris was evaporated to dry and weighed with the Eppendorf tubes by using the microbalance. The net weight of the dry debris was determined by subtracting the original weight of the empty Eppendorf tube from the gross weight.

Statistical Analysis

Statistical analysis of the amount of extruded debris was performed with one-way analysis of variance and Bonferroni multiple comparison test. Statistical significance level was established at .05.

Results

The amount of apical debris for each group was presented in Table 1. It was found that all techniques resulted in a measurable amount of debris. Retreatment techniques in groups B and C produced significantly greater amount of debris extrusion than that in group A ($P < .001$). No statistical difference was observed between groups B and C in which chloroform was used as solvent ($P > .05$).

Discussion

Apical extrusion of debris produced in endodontic treatment and retreatment might lead to postoperative pain and discomfort (2). The apical extrusion of various instrumentation techniques in initial endodontic treatment has been studied extensively (4, 6, 8). According to our knowledge, there has been no study investigating the use of ProTaper Universal Tulsa rotary system in endodontic retreatment. In the present study, quantitative evaluation of debris extruded apically during endodontic retreatment with ProTaper Universal Tulsa rotary system was performed.

Results presented herein are consistent with other apical extrusion studies (7, 17, 18) and reinforce the fact that it is impossible to prepare a root canal system chemomechanically without any extrusion of debris. Some investigations (17, 18) demonstrated that the amount of debris extrusion was independent of the technique used. However, most of these studies evaluated the amount of apical debris in a semiquantitative form with the use of the scoring system. It would not be sensitive enough to detect the tiny differences among various techniques and thus tends to provide an overoptimistic evaluation of apical extrusion (19). In contrast, studies measuring the amount of debris with the aid of microbalance accurate to ten thousandths' digit did find out the difference (7, 10). Our results demonstrated that, with only few exceptions, the amount of apically extruded materials for each sample was below 0.01 g, and significant differences were found among groups. It is thus speculated that the discrepancy among studies might be the result of differences in the way of evaluation.

In this study, ProTaper Universal Tulsa technique in group A resulted in the least amount of debris. This might be due to the fact that this technique combines rotational motion with a crown-down pressureless action, whereas techniques used in the other 2 groups incorporated a push-pull filing action (16, 20, 21). The push-pull filing actions of the Hedström files and K-flex files act as a piston, posing a risk of pumping the debris and irrigant through the patent apical foramen (22). Furthermore, we observed that ProTaper Universal Tulsa retreatment files could remove gutta-percha from the canals in large pieces around the spirals of instruments, whereas Hedström files only removed gutta-percha in small increments. The better performance is probably attributed to the unique instrument design. D1, D2, and D3 have 3 progressive tapers and lengths, which fit the coronal, middle, and apical portions of the canal, respectively. Moreover, the files have a convex triangular cross section that reduces the area of contact between the instrument and the dentin walls. During instrumentation, the debris is positioned between the apical blades and augered up the flutes of the rotating instrument, which helps to decrease the amount of the debris extruded (23).

Caution should be exercised when applying the current result to clinical situations. The in vitro setup had the apex suspended in air, whereas in vivo the apex would be surrounded by granulomatous or periradicular tissues, which could help to restrict apical extrusion to some extent (24). Thus, further research will be necessary to evaluate the clinical performance of the ProTaper Universal Tulsa rotary system during retreatment.

In conclusion, the ProTaper Universal Tulsa rotary system caused a significantly less amount of debris extrusion during endodontic retreatment compared with other traditional techniques. It proved to be a viable alternative method in endodontic retreatment.

TABLE 1. Weight of Apically Extruded Debris ($\times 10^{-3}$ g) during Retreatment by 3 Techniques

Group	n	Mean Weight	SD	Range
A	15	0.39*	0.21	0.12–0.76
B	15	0.87	0.65	0.14–1.41
C	15	1.01	0.25	0.51–1.64

SD, standard deviation.

*There was a significant difference among 3 groups. Group A had significantly less debris extrusion than groups B and C ($P < .001$).

Acknowledgments

This study was supported by Key Clinical Program of the Ministry of Health, China.

References

1. Paik S, Sechrist C, Torabinejad M. Levels of evidence for the outcome of endodontic retreatment. J Endod 2004;30:745–50.
2. Seltzer S, Naidorf IJ. Flare-ups in endodontics. I. Etiological factors. J Endod 1985;11:472–8.
3. Tinaz AC, Alacam T, Uzun O, Maden M, Kayaoglu G. The effect of disruption of apical constriction on periapical extrusion. J Endod 2005;31:533–5.
4. Siqueira JF. Microbial causes of endodontic flare-ups. Int Endod J 2003;36:453–63.
5. Nair PN. On the causes of persistent apical periodontitis: a review. Int Endod J 2006;39:249–81.
6. Al-Omari MA, Dummer PM. Canal blockage and debris extrusion with eight preparation techniques. J Endod 1995;21:154–8.
7. Tanalp J, Kaptan F, Sert S, Kayahan B, Bayirl G. Quantitative evaluation of the amount of apically extruded debris using 3 different rotary instrumentation systems. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:252–9.
8. Hinrichs RE, Walker WA, Schindler WG. A comparison of amounts of apically extruded debris using handpiece-driven nickel-titanium instrument systems. J Endod 1998;24:102–6.

9. Khademi A, Yazdizadeh M, Feizianfard M. Determination of the minimum instrumentation size for penetration of irrigants to the apical third of root canal systems. J Endod 2006;32:417–20.
10. Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod 1998;24:180–3.
11. McKendry DJ. Comparison of balanced forces, endosonic and step-back filing instrumentation techniques: quantification of extruded apical debris. J Endod 1990; 16:24–7.
12. Ferraz CC, Gomes NV, Gomes BP, Zaia AA, Teixeira FB, Souza-Filho FJ. Apical extrusion of debris and irrigants using two hand and three engine-driven instrumentation techniques. Int Endod J 2001;34:354–8.
13. Albrecht LJ, Baumgartner JC, Marshall JG. Evaluation of apical debris removal using various sizes and tapers of ProFile GT files. J Endod 2004;30:425–8.
14. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1971;32:271–5.
15. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and canal master techniques. J Endod 1991;17:275–9.
16. Fairbourn DR, McWalter GM, Montgomery S. The effect of four preparation techniques on the amount of apically extruded debris. J Endod 1987;13:102–8.
17. Betti LV, Bramante CM, Quantec SC. Rotary instruments versus hand files for gutta-percha removal in root canal retreatment. Int Endod J 2001;34:514–9.
18. Schirrmeister JF, Wrbas KT, Schneider FH, Altenburger MJ, Hellwig E. Effectiveness of a hand file and three nickel-titanium rotary instruments for removing gutta-percha in curved root canals during retreatment. Oral surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:542–7.
19. Hulsmann M, Bluhm V. Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. Int Endod J 2004;37:468–76.
20. Martin H, Cunningham WT. The effect of endosonic and hand manipulation on the amount of root canal material extruded. Oral Surg Oral Med Oral Pathol 1982;53:611–3.
21. Ruiz-Hubbard EE, Gutmann JL, Wagner MJ. A quantitative assessment of canal debris forced periapically during root canal instrumentation using two different techniques. J Endod 1987;13:554–8.
22. Brown DC, Moore BK, Brown CE, Newton CW. An in vitro study of apical extrusion of sodium hypochlorite during endodontic canal preparation. J Endod 1995; 12:587–91.
23. Beeson TJ, Hartwell GR, Thornton JD, Gunsolley JC. Comparison of debris extruded apically in straight canals: conventional filing versus ProFile .04 Taper Series 29. J Endod 1998;24:18–22.
24. Salzgeber RM, Brilliant JD. An in vivo evaluation of the penetration of an irrigating solution in root canals. J Endod 1977;3:394–8.