IDR International Dental Research

Original Article

ProTaper Retreatment system versus balanced force technique for apical extrusion and gutta-percha removal

Esma Sarıçam[1], Bülent Altunkaynak[2], Güven Kayaoğlu[3]

[1] Ankara Yildirim Beyazit University, Faculty of Dentistry, Department of Endodontics, Ankara, Turkey.
[2] Gazi University, Faculty of Science, Department of Statistics, Ankara, Turkey.
[3] Gazi University, Faculty of Dentistry, Department of Endodontics, Ankara, Turkey.

Correspondence:

Dr. Esma SARIÇAM
Ankara Yildirim Beyazit University, Faculty of Dentistry, Department of Endodontics, Ankara, Turkey.

E-mail:dt.esmasaricam@gmail.com

Received: 19 January 2019
Accepted: 11 July 2019

Access Online

DOI:
10.5577/intdentres.2019.vol9.no2.5

Abstract

Aim: The aim was to compare root canal wall cleanliness, amounts of apically extruded debris and irrigant during retreatment using the ProTaper Universal Retreatment (PT) system or balanced force technique (BFT).

Methodology: Root canals of extracted mandibular premolar teeth (n=44) were endodontically prepared and obturated, then the teeth were divided into two groups: BFT and PT. Apically extruded material was collected into preweighed Eppendorf tubes using the Myers and Montgomery method. The root halves were photographed under a stereomicroscope. Area of the remnant filling material (coronal, middle, apical thirds and total canal surface) was measured by software. Data were analyzed by Mann-Whitney U test.

Results: The BFT and PT system provided similar degrees of canal wall cleanliness ($p>0.05$) and amounts of extruded irrigant ($p>0.05$). The PT system caused less debris extrusion ($p<0.05$).

Conclusions: Although the BFT was shown to cause less apical extrusion in primary root canal treatment compared to other manual instrumentation techniques, in the present study, BFT caused more debris extrusion than the PT group.

Keywords: Chloroform, endodontics, retreatment, root canal irrigant

How to cite this article: Sarıçam E, Altunkaynak B, Kayaoğlu G. ProTaper Retreatment system versus balanced force technique for apical extrusion and gutta-percha removal. Int Dent Res 2019;9(2):63-8.

Introduction

Steps in nonsurgical endodontic retreatment include complete removal of previous root filling, reshaping, disinfection, and refilling (1). Gutta-percha (GP) may be removed by stainless-steel hand files, nickel-titanium (NiTi) rotary instruments, heat-bearing instruments, or ultrasonic equipment (2).Canal filling material forms a mechanical barrier that hinders contact of the irrigant and intracanal dressing to the root canal walls, making its removal necessary (3). Remnant obturation material causes bacteria to

remain, which might be responsible for periapical inflammation and posttreatment disease persistence (4).

Filling materials, necrotic pulp tissue, bacteria, or irrigating solution may be introduced into the apical lesion during root canal treatment (5). Apically extruded material can cause postoperative pain and flare-ups in the short term and failure of apical healing in the long term (6,7). Amounts of apically extruded debris and irrigant are related, at least in part, to the instrumentation technique (8). Compared to other hand instrumentation techniques, the balanced force technique (BFT) is associated with less apical extrusion during primary root canal preparation (9).

Complete removal of previous obturation material while leaving minimal amounts of extruded debris and irrigant are essential components of a successful root canal retreatment procedure. However, to date, no study has evaluated the efficiency of the BFT in GP removal or debris and irrigant extrusion during retreatment. The aim of this study was to compare root canal wall cleanliness and the amounts of debris and irrigant extruded from the apex during retreatment by using the ProTaper Universal Retreatment (PT) system (Dentsply Maillefer, Ballaigues, Switzerland) or the BFT. The null hypothesis was that the BFT and the PT system would not lead to significant differences in the amounts of extruded debris and irrigant or the degree of root canal surface cleanliness.

Materials and Methods

Tooth selection

Sample size calculation was done prior to the study. Based on data from a previous study (10). 20 teeth were needed for each group to achieve 90% statistical power (α = 0.05) (Statistica, StatSoft, Oklahoma City, OK, USA). Considering a drop-out rate of 10%, 44 extracted mandibular permanent premolar teeth with straight roots and single canals were used.

Endodontic access was prepared by using a #10 K-file placed in the canal until it was just visible at the apical foramen. Working length (WL) was established 1 mm short of this length. Teeth with WL of 18-21 mm were included in the study.

Root canal preparation

Root canals were prepared with a standardized instrumentation technique (quarter clockwise turn and pull motion) until the #30 K-file (master apical file) reached WL. Root canals were prepared by using #35 to 45 K-files with the step-back technique (1-mm increments). The coronal third was flared by using #1 (2/3 of WL) and #2 (2 mm shorter than range of #1) Gates-Glidden (GG) drills. At each instrument change, 2 ml of 2.5% NaOCl were used for irrigation. To remove the smear layer, 2 ml of 17% EDTA (pH 7.6, 3 min) and 2 ml of 2.5% NaOCl (1 min) were applied. Apical patency was checked with a #10 K-file.

Root canal obturation

Root canals were dried with paper points and obturated by lateral condensation with a #30 master and #25 accessory GP cones (Pearl Endo; Pearl Dent, Bucheon, Gyeonggi-do, South Korea), with AH26 as sealer (Dentsply, DeTrey, Konstanz, Germany). The access cavity was temporarily sealed (CavitG; *3M ESPE*, *Seefeld*, Germany*). Teeth were stored at 37 °C at 100% humidity for 28 days*.

Root canal retreatment

Test apparatus

A previously described method was used to evaluate the volume of irrigant and weight of debris extruded apically (11). Teeth were inserted through the rubber lid of a glass vial and fixed with cyano-acrylate. An Eppendorf tube was placed into the glass vial. The root was placed within the Eppendorf tube to collect extruded irrigant and debris from the apical foramen. Two 21-gauge needles were inserted in the vial's lid to equalize the external and internal pressures. An empty 2ml Eppendorf tube (one tube per tooth) was preweighed three times on a precision digital balance (10-4 g; XB 220A; Precisa, Dietikon, Switzerland). The average measurement for each tube was registered as the initial weight.

Experimental groups

Group 1 (GP removal and reshaping with BFT; n = 22)

To remove GP, GG drills (#2 and #1) and K-files (#45 to #30) were used in a crown-down manner (Table 1). K-files were used with the BFT. The first step of the technique was a passive clockwise rotation of about 90° to engage dentin. In the second step, the instrument was held in the canal with adequate axial force and rotated counterclockwise to loosen the engaged dentin chips and obturation material from the canal wall. In the third step, the file was removed with a clockwise rotation to be cleaned (12). A #30 K-file was used to reach the apical foramen. At each instrument change, 1 ml of distilled water was used for irrigation, with a total of 6 ml being needed to reach WL. After the apical foramen was reached, a #15 K-file was inserted 1 mm beyond the apical foramen to maintain apical patency, which was checked after each irrigation step. The root canal was dried with paper points. A few drops of chloroform were used at each file change, with a total of 0.5 ml of chloroform being needed to reach the apical foramen.

For reshaping, apical preparation was done by using K-files up to #40 (master apical file). Then, #45 to #55 K-files were used with the step-back technique with 1-mm increments (Table 1). The coronal part was reflared with #2 GG at 2/3 of WL and #3 GG at 2 mm

shorter than the range of #2 GG. At each instrument change, 1 ml of distilled water was used for irrigation, for a total of 7 ml during reshaping.

Group 2 (GP removal and reshaping with PT files; n = 22)

Retreatment was performed with ProTaper Universal Retreatment instruments at 500 rpm and 2 N/cm torque according to the manufacturer's instructions (X-Smart; Dentsply Maillefer, Ballaigues, Switzerland). The D1 file (30/.09) was used for removal of the coronal third, followed by use of the D2 file (25/.08) at the middle third. The D3 file (20/.07) was used at WL (Table 1). Apical patency was checked as in Group 1. At each instrument change, 2 ml of distilled water was used for irrigation, with a total of 6 ml being needed to reach WL. Chloroform was used as described in Group 1.

Reshaping was performed with ProTaper Universal system instruments F2, F3, and F4 at 300 rpm and 2 N/cm torque, according to the manufacturer's instructions (X-Smart; Dentsply Maillefer). At each instrument change, 2.33 ml of distilled water was used for irrigation, for a total of 7 ml during reshaping (Table 1).

After the reshaping procedure, the PT and BFT groups had almost the same size at all canal levels. For irrigation, a 27-gauge needle was used with an in-out motion. The needle was placed without exceeding a maximum depth of 3 mm shorter than WL. All procedures were done by one operator (E.S.).

Table 1. Instruments, operational depths, and irrigating solution volumes for both techniques during retreatment (until reaching the apical foramen) and reshaping.

	Instruments and operational depths				Irrigating solution volume
	BFT		PT		
Retreatment	#2 GG	2 mm short of 2/3 of WL	D1	Coronal third	6 ml of distilled water + 0.5 ml of chloroform
	#1 GG	2/3 of WL			
	#45	3 mm short of WL	D2	Middle third	
	#40	2 mm short of WL			
	#35	1 mm short of WL	D3	Apical third/WL	
	#30	WL			
Reshaping	#35	WL	F2, F3, and F4 at WL		7 ml of distilled water
	#40	WL			
	#45	1 mm short of WL			
	#50	2 mm short of WL			
	#55	3 mm short of WL			
	#2 GG	2/3 of WL			
	#3 GG	2 mm short of 2/3 of WL			

BFT: balanced force technique, PT: ProTaper Universal Retreatment system; WL: working length

Evaluation of irrigant and debris extrusion

Immediately after instrumentation, the Eppendorf tube was removed from the vial. The volume of extruded irrigant was measured by placing the calibrated Eppendorf tube series next to the one used in the study (11). All tubes were incubated at 68 °C for 5 days to evaporate extruded irrigant. Tubes were weighed three times, and the average of these measurements was registered as the final weight. Weight of extruded debris was defined as the difference between the final and initial weights.

Analysis of remnant filling material

Roots were grooved longitudinally in a buccolingual direction. The half having a greater amount of residual filling material was photographed under a stereomicroscope (Leica EZ4D; *Leica Microsystems*, Wetzlar, Germany) at 8x magnification for the total root surface image and 20x magnification for close-up of the coronal, middle, and apical thirds. Each image was assigned a 3-digit randomly generated numeric code by the senior investigator (G.K.). Areas of the canal surface and remaining material were measured by ImageJ 1.48v (National Institute of Health, Bethesda, MD, USA). Coded specimens were analyzed in a blinded manner by the principal investigator (E.S.). The ratio of the filling debris area to canal area was recorded for each tooth specimen (Fig. 1).

Statistical Analysis

The Kolmogorov-Smirnov normality test and Mann-Whitney U test (for nonnormally distributed data) were used for statistical analysis. The level of statistical significance was set at $p<0.05$.

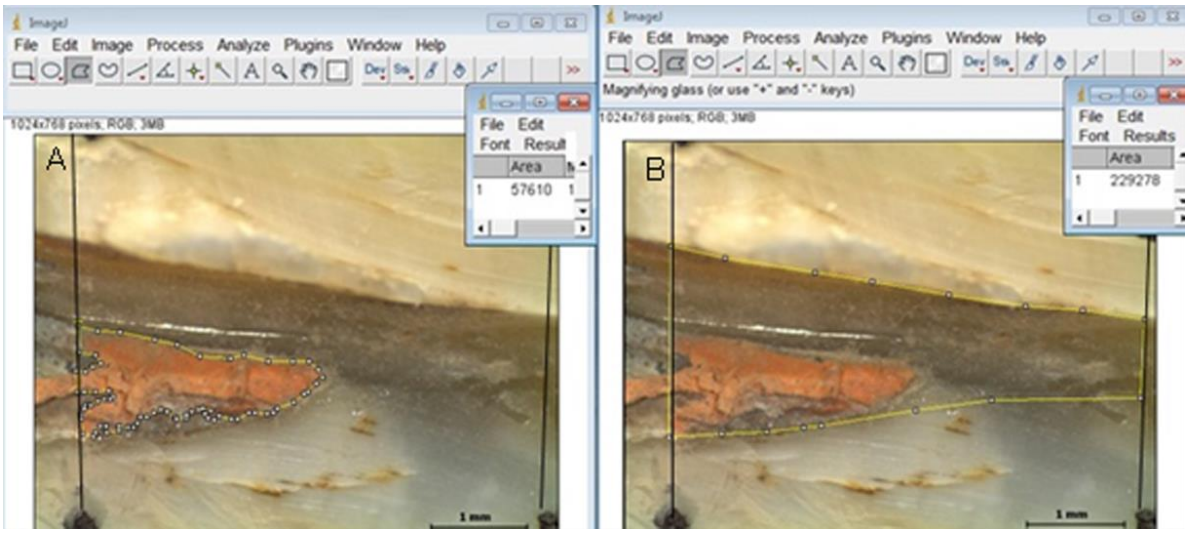

Figure 1. Representative images of **(A)** residual material area measurement and **(B)** total canal surface area measurement. Measurements were made by using an image analysis software. Bar = 1 mm.

Results

The experimental procedure was completed successfully in 22 samples of Group 1 and 21 samples of Group 2 (file separated in 1 sample). Statistical power of the study was estimated to be 92.6%. The BFT group had a greater volume of extruded debris than the PT group ($p<0.05$). No differences in the amounts of extruded irrigant, the percentage of remaining filling material on the coronal, middle, and apical thirds, or the area of the total canal surface were found between the groups ($p>0.05$; Table 2).

Table 2. Extruded volumes of debris and irrigant, and area of remnant filling material for the two groups.

Parameter	Group	n	Mean ± SD	Median	Test	p
Debris (g)	BFT	22	0.00030 ± 0.00052	0.0001	-2.48 †	0.01*
	PT	21	0.00018 ± 0.00055	0.0000		
Irrigant (µL)	BFT	22	1147.73 ± 1581.78	350.00	-1.53 †	0.13
	PT	21	828.57 ± 1465.06	0.00		
Remnant in coronal third (%)	BFT	22	23.80 ± 25.41	15.95	-1.40 †	0.16
	PT	21	30.32 ± 19.87	33.20		
Remnant in middle third (%)	BFT	22	8.68 ± 15.97	0.78	-0.79 †	0.43
	PT	21	9.94 ± 17.24	6.27		
Remnant in apical third (%)	BFT	22	6.95 ± 8.58	2.33	-0.05 †	0.96
	PT	21	13.03 ± 19.02	1.10		
Remnant in total surface (%)	BFT	22	16.73 ± 18.01	9.02	-1.84 †	0.07
	PT	21	22.27 ± 12.98	20.73		

†Z value for Mann-Whitney U test(nonnormally distributed data).
*$p<0.05$.BFT: balanced force technique, PT: ProTaper Universal Retreatment system.

Discussion

Further enlargement of the filled canal from its original size significantly reduces the amount of residual filling material (13, 14). The PT and BFT groups had almost the same size at each canal level after the reshaping procedure. No significant differences were observed between the groups for the remaining filling material, indicating that the techniques provided similar degrees of canal wall cleanliness. The results of this study are similar to those of previous studies that compared the residual filling material after retreatment by using hand instrumentation or PT with a solvent (15-19). The master apical file sizes of hand instrumentation and the PT system were similar in those studies. Whereas all previous studies employed manual instrumentation techniques with rotational movements, the present study is the only one to use BFT during retreatment.

No previous study has evaluated the BFT in retreatment for the amounts of apically extruded debris and irrigant. In this study, the BFT group had a significantly larger volume of extruded debris compared to the PT group. Topcuoglu et al. compared amounts of extruded debris for H-files and some NiTi rotary instruments, including ProTaper Universal Retreatment system, during retreatment (10).The hand instrumentation group extruded a greater amount of debris than the PT system, which they attributed to the crown-down pressure less motion of rotary NiTi retreatment instruments. Another study showed that the PT system caused less debris extrusion than manual instrumentation using K-files in retreatment (20). The BFT was shown to cause less apical extrusion in primary root canal treatment compared to other manual instrumentation techniques (9). However, in the present study, BFT caused more debris extrusion than the PT group. This result supports the hypothesis that engine-driven rotary NiTi instruments produce less debris than hand instrumentation techniques (21).

The irrigation protocol was standardized for the two groups, and apical patency was checked after irrigation at each file change. The groups had almost the same size at each canal level; hence, the instrumented canals had similar geometries in both groups. Parallel to the similarity of the canal shapes, the volumes of extruded irrigant were similar in both groups.

Conclusions

Under the conditions of this study, the BFT and PT system provided similar degrees of canal wall cleanliness and amounts of extruded irrigant. However, the BFT caused greater debris extrusion. Thus, the null hypothesis were accepted for canal surface cleanliness and irrigant extrusion but was rejected for debris extrusion.

Ethical Approval: Ethics committee approval was received for this study from Faculty of Dentistry of Ankara University (Protocol #36290600/116).

Peer-review: Externally peer-reviewed.

Author Contributions: Conception - E.S.; Design - E.S; Supervision - G.K.; Materials - E.S.,G.K.; Data Collection and/or Processing- B.A.; Analysis and/or Interpretation - B.A., Literature Review - E.S.; Writer - E.S.; Critical Review - G.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: This study was financially supported by Scientific Research Projects, Gazi University (BAP #03/2015-02).

Acknowledgments: This study was done at Dentistry Faculty of Gazi University. This study constitutes part of the dissertation thesis by Esma Saricam, entitled "Comparison of the effectiveness of mechanical and manual techniques for debris extrusion and guttapercha removal during retreatment" (Gazi University, Ankara, 2015). This study was presented as oral presentation at the 24th Turkish Dental Association Congress. The authors thank Olga Yucel for her assistance during the experiments.

References

1. Stabholz A, Friedman S. Endodontic retreatment--case selection and technique. Part 2: Treatment planning for retreatment. J Endod 1988;14(12):607-14. (Crossref)
2. Gordon MP. The removal of gutta-percha and root canal sealers from root canals. N Z Dent J 2005;101(2):44-52.
3. Barletta FB, Rahde Nde M, Limongi O, Moura AA, Zanesco C, Mazocatto G. In vitro comparative analysis of 2 mechanical techniques for removing gutta-percha during retreatment. J Can Dent Assoc 2007;73(1):65.
4. Hammad M, Qualtrough A, Silikas N. Three-dimensional evaluation of effectiveness of hand and rotary instrumentation for retreatment of canals filled with different materials. J Endod 2008;34(11):1370-3. (Crossref)
5. 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(9):1102-05. (Crossref)
6. Somma F, Cammarota G, Plotino G, Grande NM, Pameijer CH. The effectiveness of manual and mechanical instrumentation for the retreatment of three different root canal filling materials. J Endod 2008;34(4):466-9. (Crossref)
7. Tinaz AC, Alacam T, Uzun O, Maden M, Kayaoglu G. The effect of disruption of apical constriction on periapical extrusion. J Endod 2005;31(7):533-5. (Crossref)
8. 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(5):354-8. (Crossref)
9. Al-Omari MA, Dummer PM. Canal blockage and debris extrusion with eight preparation techniques. J Endod 1995;21(3):154-8. (Crossref)
10. Topcuoglu HS, Akti A, Tuncay O, Dincer AN, Duzgun S, Topcuoglu G. Evaluation of debris extruded apically during the removal of root canal filling material using ProTaper, D-RaCe, and R-Endo rotary nickel-titanium retreatment instruments and hand files. J Endod 2014;40(12):2066-9. (Crossref)

11. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. J Endod 1991;17(6):275-9. (Crossref)
12. Roane JB, Sabala CL, Duncanson MG, Jr. The "balanced force" concept for instrumentation of curved canals. J Endod 1985;11(5):203-11. (Crossref)
13. Roggendorf MJ, Legner M, Ebert J, Fillery E, Frankenberger R, Friedman S. Micro-CT evaluation of residual material in canals filled with Activ GP or GuttaFlow following removal with NiTi instruments. Int Endod J 2010;43(3):200-9. (Crossref)
14. Hassanloo A, Watson P, Finer Y, Friedman S. Retreatment efficacy of the Epiphany soft resin obturation system. Int Endod J 2007;40(8):633-43. (Crossref)
15. Schirrmeister JF, Wrbas KT, Meyer KM, Altenburger MJ, Hellwig E. Efficacy of different rotary instruments for gutta-percha removal in root canal retreatment. J Endod 2006;32(5):469-72. (Crossref)
16. Gergi R, Sabbagh C. Effectiveness of two nickel-titanium rotary instruments and a hand file for removing gutta-percha in severely curved root canals during retreatment: an ex vivo study. Int Endod J 2007;40(7):532-7. (Crossref)
17. Dall'Agnol C, Hartmann MS, Barletta FB. Computed tomography assessment of the efficiency of different techniques for removal of root canal filling material. Braz Dent J 2008;19(4):306-12. (Crossref)
18. Rodig T, Hausdorfer T, Konietschke F, Dullin C, Hahn W, Hulsmann M. Efficacy of D-RaCe and ProTaper Universal Retreatment NiTi instruments and hand files in removing gutta-percha from curved root canals - a micro-computed tomography study. Int Endod J 2012;45(6):580-9. (Crossref)
19. Madani ZS, Simdar N, Moudi E, Bijani A. CBCT Evaluation of the Root Canal Filling Removal Using D-RaCe, ProTaper Retreatment Kit and Hand Files in curved canals. Iran Endod J 2015;10(1):69-74.
20. Deonizio MD, Sydney GB, Batista A, Pontarolo R, Guimaraes PR, Gavini G. Influence of apical patency and cleaning of the apical foramen on periapical extrusion in retreatment. Braz Dent J 2013;24(5):482-6. (Crossref)
21. Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod 1998;24(3):180-3. (Crossref)