Apically Extruded Debris with Reciprocating Single-File and Full-sequence Rotary Instrumentation Systems

Sebastian Bürklein, Dr med dent, and Edgar Schäfer, Prof Dr med dent

Abstract

Introduction: The purpose of this *in vitro* study was to assess the amount of apically extruded debris using rotary and reciprocating nickel-titanium instrumentation systems. **Methods:** Eighty human mandibular central incisors were randomly assigned to 4 groups (n = 20 teeth per group). The root canals were instrumented according to the manufacturers' instructions using the 2 reciprocating single-file systems Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) and the 2 full-sequence rotary Mtwo (VDW, Munich, Germany) and ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) instruments. Bidistilled water was used as irrigant. The apically extruded debris was collected in preweighted glass vials using the Myers and Montgomery method. After drying, the mean weight of debris was assessed with a microbalance and statistically analyzed using analysis of variance and the post hoc Student-Newman-Keuls test. The time required to prepare the canals with the different instruments was also recorded. **Results:** The reciprocating files produced significantly more debris compared with both rotary systems ($P < .05$). Although no statistically significant difference was obtained between the 2 rotary instruments ($P > .05$), the reciprocating single-file system Reciproc produced significantly more debris compared with all other instruments ($P < .05$). Instrumentation was significantly faster using Reciproc than with all other instrument ($P < .05$). **Conclusions:** Under the condition of this study, all systems caused apical debris extrusion. Full-sequence rotary instrumentation was associated with less debris extrusion compared with the use of reciprocating single-file systems. *(J Endod 2012;38:850–852)*

Key Words

Debris extrusion, M-wire, nickel-titanium, reciprocating, single-file systems

From the Central Interdisciplinary Ambulance in the School of Dentistry, University of Münster, Münster, Germany.

Address requests for reprints to Dr Edgar Schäfer, Central Interdisciplinary Ambulance in the School of Dentistry, Waldeyerstr 30, D-48149 Münster, Germany. E-mail address: eschaef@uni-muenster.de

0099-2399/$ - see front matter

doi:10.1016/j.joen.2012.02.017

During root canal preparation procedures, dentin chips, pulp tissue, microorganisms, and/or irrigants may be extruded into the periradicular tissues. A thorough control of the working length may decrease this risk, but nevertheless any extrusion of debris may potentially cause postoperative complications such as flare-ups (1). Flare-up is described as the occurrence of pain, swelling, or the combination of both during root canal treatment causing unscheduled visits of the patients (2). This phenomenon is also called interappointment emergency (3, 4). Irritants left within the root canal system, iatrogenic factors, and (local) host factors are related to postoperative pain (5). The incidence of flare-ups during root can treatment is reported to range between 1.4% and 16% (6).

Currently, all preparation techniques and instruments are associated with extrusion of debris, even when the preparation is maintained short of the apical terminus and manual instrumentation seems to produce greater extrusion compared with engine-driven rotary preparation (7–9).

The recently introduced single-file nickel-titanium systems Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) are claimed to be able to completely prepare root canals with only 1 instrument. These files are made of a special nickel-titanium (NiTi) alloy called M-Wire that is created by an innovative thermal treatment process (10). The benefits of this M-Wire alloy are increased flexibility and improved resistance to cyclic fatigue of the instruments (11, 12). The Reciproc and WaveOne files are used in a reciprocal motion that requires special automated devices. Reciproc files are available in different sizes (ie, 25.08, 40.06, and 50.05), whereas WaveOne consists of the sizes 21.06, 25.08, and 40.08. The reciprocating movement relieves stress on the instrument by special counterclockwise (cutting action) and clockwise (release of the instrument) movements and, therefore, reduces the risk of cyclic fatigue caused by tension and compression (13, 14). The angles of reciprocating are specific to the design of the particular instruments. The aim of this investigation was to compare the preparation time and the amount of apically extruded debris after preparation of straight root canals in extracted human teeth using the 2 new reciprocating single-file systems Reciproc and WaveOne compared with the rotary full-sequence Mtwo (VDW, Munich, Germany) and ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) systems.

Materials and Methods

A total of 80 extracted human maxillary incisors with mature apices and straight root canals (<5°) according to the Schneider method were selected for this investigation (15). 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. Coronal access was achieved using diamond burs, and the canals were controlled for apical patency with a size 15 K-file (VDW). Additionally, the root canal width near the apex was approximately compatible with size 15. This was checked with silver points sizes 15 and 20 (VDW). For all teeth, the distance between the cementoenamel junction to the apex was measured using a digital caliper (Mitutoyo IP67; Mitutoyo, Neuss, Germany). The teeth were allocated into 4 identical groups based on the measured distances from the cementoenamel junction to the apex. The homogeneity of the 4 groups with respect to this parameter was assessed using analysis of variance and the post hoc Student-Newman-Keuls test (P = 1.0). The working length (WL) was obtained by measuring the length of the initial instrument (size 15) at the apical foramen minus 1 mm.

After each instrument or after 3 pecks using the reciprocating files (as recommended by the manufacturers), 2 mL of bidistilled water was used as irrigant. The irrigation needle (NaviTip 31ga; Ultradent, South Jordan, UT) was placed as deep as possible into the canal without resistance but not deeper as the predetermined WL minus 1 mm.

All types of instruments were set into permanent rotation with a 6:1 reduction handpiece (Sirona, Bensheim, Germany) powered by a torque-limited electric motor (VDW Silver Reciproc Motor, VDW). For each file, the individual torque limit and rotational speed programmed in the file library of the motor were used, whereas Reciproc and WaveOne were used in a reciprocating working motion generated by the motor. The preparation sequences were as follows:

1. Group 1: All Mtwo instruments were used to the full length of the canals according to the manufacturer's instructions using a gentle in-and-out motion. The instrumentation sequence was 10.04, 15.05, 20.06, 25.06, 30.05, 35.04, and 40.04.
2. Group 2: ProTaper instruments were used according to the manufacturer's instructions using a gentle in-and-out motion. The instrumentation sequence was SX at two thirds of the WL; S1 and S2 at WL − 1 mm; and then F1 (20.07), F2 (25.08), F3 (30.09), and F4 (40.06) at the WL. Once the instrument had negotiated to the end of the canal and had rotated freely, it was removed.
3. Group 3: A R40 Reciproc file having a size 40 at the tip and a taper of 0.06 over the first 3 mm was used in a reciprocating, slow in-and-out pecking motion according to the manufacturer's instructions. The flutes of the instrument were cleaned after 3 in-and-out-movements (pecks). No glide path was created before instrumentation as the initial size of all canals was equal to size 20.
4. Group 4: A large reciprocating WaveOne file having a size 40 and a taper of 0.06 was used in a reciprocating, slow in-and-out pecking motion according to the manufacturer's instructions. The flutes of the instrument were cleaned after 3 pecks. No glide path was created before instrumentation because the initial size of all canals was equal to size 20.

In each of these 4 test groups, 20 canals were enlarged. Instruments were used to prepare 4 canals only. All root canal preparations were completed by 1 operator, whereas the assessment of extruded debris was performed by a second examiner who was blind with respect to all experimental groups.

The extruded debris and the irrigant (bidistilled water) were collected in a preweighed receptor tube attached to the lower edge of an individual rubber plug made for each tooth as previously described (16) (Fig 1). The root apex hung within the receptor tube. A second bottle was used to hold the device during instrumentation so that no contact to the collecting vial was possible. The bottle was vented with a 25-G needle alongside the rubber plug to equalize the pressure. The bottle was obscured that the operator could not see the root apex during instrumentation. Once instrumentation had been completed, each tooth was separated from the receptor tube, and the debris adhering to the root surface was collected from the root surface by washing the root with 1 mL of bidistilled water into the receptor tube. The receptor tubes were then stored in an incubator at 70°C for 5 days in order to evaporate the moisture before weighing the dry debris. An electronic balance (Sartorius Cubis, Göttingen, Germany) with an accuracy of ±0.00001 g was used to weigh the tubes containing the debris. Three consecutive weights with a difference of < 0.00002 g were obtained for each tube, and the mean value was calculated. The dry weight of extruded debris was calculated by subtracting the weight of the empty tube from the weight of the tube containing debris.

The time for canal preparation was recorded and included total active instrumentation, instrument changes within the sequence, cleaning of the flutes of the instruments, and irrigation. The amount of extruded debris and preparation times were analyzed statistically using the analysis of variance and post hoc Student-Newman-Keuls test at a significance level of $P < .05$.

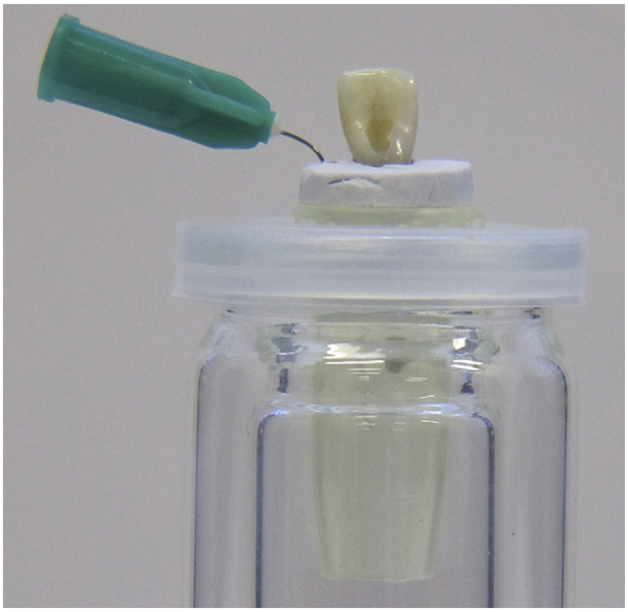

Figure 1. Experimental setup according to Myers and Montgomery (16). Further details are given in the text.

Results

Instrumentation with Reciproc files was significantly faster than with all other instruments ($P < .05$) (Table 1). WaveOne was significantly faster than Mtwo and ProTaper ($P < .05$). There was no statistically significant difference between Mtwo and ProTaper ($P > .05$).

The reciprocating single-file WaveOne and Reciproc systems produced significantly more debris compared with both full-sequence rotary systems ($P < .05$) (Table 2). Although no statistically significant difference was obtained between Mtwo and ProTaper ($P > .05$), the reciprocating single-file system Reciproc produced significantly more debris compared with all other instruments ($P < .05$).

Discussion

According to the results of this study, apical debris extrusion occurred independent of the type of instrument used. The reciprocating single-file systems extruded significantly more debris compared with the full-sequence rotary NiTi instruments ($P < .05$). Reciproc extruded significantly more debris than all other files ($P < .05$). Previous studies showed that the amount of apical debris extrusion can be related to the root canal anatomy and/or the instrumentation technique, and currently no method completely avoids debris extrusion (13, 17–23).

The obtained differences may be caused by the preparation technique and the cross-sectional design of the instruments. Mtwo and Reciproc have an identical S-shaped cross-sectional design with sharp

TABLE 1. Preparation Time with the Different Instruments

Preparation Time (s)	ProTaper	Mtwo	WaveOne	Reciproc
Mean	207.45[a]	202.05[a]	88.4[b]	73.3[c]
SD	16.61	22.76	14.68	13.17
Min	175	168	63	54
Max	230	242	112	93

Values with the same letters were not statistically different at $P = .05$.

TABLE 2. Amount of Apically Extruded Debris after the Use of the Different Instruments

Debris extrusion (g)	ProTaper	Mtwo	WaveOne	Reciproc
Mean	.00023[a]	.00020[a]	.00031[b]	.00039[c]
SD	.00011	.00009	.00013	.00009
Min	.00010	.00005	.00015	.00027
Max	.00046	.00041	.00064	.00058

cutting edges, whereas ProTaper and WaveOne are characterized by a triangular or modified triangular cross-section resulting in a lower cutting efficiency and smaller chip space (24). An increased cutting ability is usually associated with an increased cleaning efficacy (25, 26) but may enhance debris transportation toward the apex when used in combination with a reciprocal motion. Contrarily, continuous rotation may improve coronal transportation of dentin chips and debris by acting like a screw conveyor.

A certain degree of caution should be taken when transferring the present results to the clinical situation. Because of the absence of a physical back pressure provided by periapical tissues apical extrusion was not limited (26). Because of the zero back pressure used in this study design, gravity may have carried the irrigant out of the canal. This is an imminent shortcoming of *in vitro* designs with no periapical resistance as already discussed by Myers and Montgomery (16). It has been suggested to simulate resistance of periapical tissues by using floral foam (27, 28). However, foam may absorb some irrigant and debris when used as a barrier, and, therefore, no attempt has been made in the present study to simulate periapical resistance. Moreover, bidistilled water was used in the present investigation as irrigating solutions. It remains open to question whether the use of sodium hypochlorite and/or EDTA instead of water might have a positive impact on the amount of extruded debris.

Both the extrusion of irrigation solutions and debris can irritate the periapical tissues and may cause interappointment emergencies (29). This leads to the controversial discussion regarding the impact of the creation of an apical (dentin) plug or of the patency approach on the incidence of flare-ups and the treatment outcome. Myers and Montgomery (16) suggested a reassessment of the apical dentinal plug because of the potential benefits of reducing the amount of apically extruded debris and irrigants and the prevention of overinstrumentation in combination with extrusion of filling materials (16). Although establishing apical patency in mesiobuccal roots of maxillary molars resulted in apical extrusion of sodium hypochlorite in 100% of the specimens (30), in another study maintaining apical patency was associated with less apically extruded debris compared with teeth in which the constriction remained intact (31). More detailed descriptions of the impact of the patency approach on the amount of apical debris extrusion have recently been published (32, 33).

In conclusion, under the condition of this study, full-sequence rotary instrumentation was associated with less debris extrusion compared with the use of reciprocating single-file systems. The clinical relevance of this phenomenon and whether it outweighs the reported good shaping ability and cleaning efficiency of the reciprocation single-file systems (24) need to be evaluated in further studies.

Acknowledgments

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

References

1. Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. J Endod 1985; 11:472–8.
2. Harrington GW, Natkin E. Midtreatment flare-ups. Dent Clin North Am 1992;36: 409–23.
3. Mor C, Rotstein I, Friedman S. Incidence of interappointment emergency associated with endodontic therapy. J Endod 1992;18:509–11.
4. Sequiria JF, Rocas IN, Favieria A. Incidence of post operative pain after intracanal procedures based on an antimicrobial strategy. J Endod 2004;28:457–60.
5. Torabinejad M, Walton RE. Managing endodontic emergencies. J Am Dent Assoc 1999;122:99–103.
6. Siqueira JF, Rocas IN, Favieri A, Machado AG, Gahyva SM, Oliveira JCM. Incidence of post operative pain after intracanal procedures based on an antimicrobial strategy. J Endod 2002;28:457–60.
7. 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.
8. Azar NG, Ebrahimi G. Apically-extruded debris using the ProTaper system. Aust Endod J 2005;31:21–3.
9. 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.
10. Gutmann JL, Gao Y. Alteration in the inherent metallic and surface properties of nickel-titanium root canal instruments to enhance performance, durability and safety: a focused review. Int Endod J 2012;45:113–28.
11. Al-Hadlaq SM, Aljarbou FA, AlThumairy RI. Evaluation of cyclic flexural fatigue of M-wire nickel-titanium rotary instruments. J Endod 2010;36:305–7.
12. Alapati SB, Brantley WA, Iijima M, et al. Metallurgical characterization of a new nickel-titanium wire for rotary endodontic instruments. J Endod 2009;35:1589–93.
13. De-Deus G, Brandão MC, Barino B, Di Giorgi K, Fidel RA, Luna AS. Assessment of apically extruded debris produced by the single-file ProTaper F2 technique under reciprocating movement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;110:390–4.
14. Varela-Patiño P, Ibañez-Párraga A, Rivas-Mundiña B, Cantatore G, Otero XL, Martin-Biedma B. Alternating versus continuous rotation: a comparative study of the effect on instrument life. J Endod 2010;36:157–9.
15. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271–5.
16. 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.
17. Reddy S, Hicks L. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod 1998;24:180–3.
18. Mangalam S, Rao CV, Lakshminarayanan L. Evaluation of apically extruded debris and irrigant using three instrumentation techniques. Endodontology 2002;14:19–23.
19. Tanlap J, Kaptan F, Sert S, Kayahan B, Bayirl G. Quantitative evaluation of the amount of apically extruded debris using three different rotary instrumentation systems. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:250–7.
20. Kustarci A, Akpinar KE, Sumer Z. Apical extrusion of intracanal bacteria following use of various instrumentation techniques. Int Endod J 2008;41:1066–71.
21. Logani A, Shah N. Apically extruded debris using three contemporary Ni-Ti instrumentation systems: an ex-vivo comparative study. J Dent Res 2008;19:182–5.
22. Elmsallati EA, Wadachi R, Suda H. Extrusion of debris after use of rotary nickel-titanium files with different pitch: A pilot study. Aust Endod J 2009;35:65–9.
23. Bidar M, Rastegar AF, Ghaziani P, Namazikhah MS. Evaluation of apically extruded debris in conventional and rotary instrumentation techniques. J Calif Dent Assoc 2004;32:665–71.
24. Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J (in press).
25. Schäfer E, Vlassis M. Comparative investigation of two rotary nickel-titanium instruments: ProTaper versus RaCe. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endod J 2004;37:239–48.
26. Bonaccorso A, Cantatore G, Condorelli GG, Schäfer E, Tripi TR. Shaping ability of four nickel-titanium rotary instruments in simulated S-shaped canals. J Endod 2009;35:883–6.
27. Hachmeister DR, Schindler WG, Walker WA, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. J Endod 2002;28:386–90.
28. Altundasar E, Nagas E, Uyanik O, Serper A. Debris and irrigant extrusion potential of 2 rotary systems and irrigation needles. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e31–5.
29. Hülsmann M, Rödig T, Nordmeyer S. Complications during root canal irrigation. Endod Topics 2009;16:27–63.
30. Camoes IC, Salles MR, Fernando MV, Freitas LF, Gomes CC. Relationship between the size of patency file and apical extrusion of sodium hypochlorite. Indian J Dent Res 2009;20:426–30.
31. Lambrianidis T, Tosounidou E, Tzoanopoulou M. The effect of maintaining apical patency on periapical extrusion. J Endod 2001;27:696–8.
32. Hülsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endod Topics 2005;10:30–76.
33. Hülsmann M, Schäfer E. Apical patency: fact and fiction—a myth or a must? A contribution to the discussion. ENDO (Lond Engl) 2009;3:285–307.