

Comparison of Apical Debris and Irrigants Extrusion using Four Different Thermally Treated Endodontic File Systems: An *ex vivo* Study

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Abstract

Aim: This study evaluated the apical debris and irrigant extrusion of four different thermally treated rotary and reciprocating file systems. **Materials and Methods:** Sixty extracted human mandibular molars were sectioned into two halves, and the distal half was discarded. The mesial portion of the root, along with the crown, was mounted in glass vials with a rubber stop and randomly divided into four groups ($n = 15$) depending on the rotary/reciprocating and blue/gold files used – Group A: Reciproc Blue files, Group B: Wave One Gold files, Group C: Vortex Blue files and Group D: Protaper Gold. The apically extruded debris and irrigants were collected in pre-weighed glass vials. The vials were dried and then weighed in an electronic weighing machine. **Statistical Analysis Used:** The data obtained were statistically analyzed using paired *t*-test. **Results:** The reciprocating file systems extruded significantly less debris than the rotary file systems ($P < 0.05$). Reciproc Blue extruded the least debris, followed by Wave One Gold, Vortex Blue, and Protaper Gold. **Conclusion:** All systems extruded debris during the instrumentation. The reciprocating file system extruded significantly less debris than the rotary file system.

Keywords: Apical extrusion, Debris, Reciprocating, Rotary.

INTRODUCTION

Dentinal debris that is extruded apically during instrumentation results in inflammation, pain, delayed healing, and flare-ups post-operatively.^[1,2] Furthermore, depending on the instrumentation technique, material property, cross-section, taper and symmetry, and design of the root canal instrument used, the amount of debris extruded may vary.^[3-5]

The introduction of nickel-titanium (NiTi) files and their recent advances in the thermal treatment of alloys and kinematics have restructured the root canal treatment.^[6] Although, NiTi endodontic instruments have been reported to be more flexible with an increased torsional fracture resistance when compared to stainless steel instruments, the fracture of rotary NiTi instruments remains an inadvertent incident during clinical use.^[7,8] Hence, many alterations are being introduced in manufacturing procedures like thermal, mechanical, and surface treatment to improve the properties of NiTi alloys, enhance resistance to fracture, and increase flexibility.^[9]

There are Gold and Blue heat-treated NiTi systems available. Two of them are used in a rotary (ProFile Vortex Blue;

ProTaper Gold), and two in a reciprocating motion (Reciproc Blue; Wave One Gold). These instruments also exhibit a controlled memory effect and can be deformed.^[10] These files are ground before they go through post machining heat treatment.^[11] The blue color on the files is because of the deposition of the titanium oxide layer after the post-machining heat treatment.^[12]

The study aimed to compare the amount of extruded debris and irrigants using four thermally treated file systems. They are Reciproc Blue (RC Blue; VDW GmbH, Munich, Germany), WaveOne Gold (Dentsply Sirona, Ballaigues, Switzerland), Vortex Blue files (Dentsply Sirona, USA), and Protaper Gold (Dentsply Sirona, USA).

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The null hypothesis states that there is no significant difference in the amount of extruded debris in the four systems mentioned above.

MATERIALS AND METHODS

Sample size calculation

The sample size was calculated by G power v.3.1.9.4 for windows based on the proportional difference formula with an alpha type error of 0.05 and a power beta of 0.85. The estimated sample size was 15 teeth per group with four groups.

Inclusion and exclusion criteria

Sixty extracted human mandibular molars with mature apices without the previous endodontic treatment, intact non-carious teeth, teeth that are free of any cracks and defects, teeth that are not having any root canal aberrations, teeth with the mesial root of an average length of 19–21 mm, with no apical resorption and curvature of 25–30° measured using Schneider's method were selected. Soft-tissue remnants and calculus on the external root surface were removed mechanically and stored in saline until use.

Debris collection apparatus

The method used for collecting apically extruded debris was adopted from Myers and Montgomery.^[13] A glass vial with a rubber stopper was used. A heated instrument was used to create a hole through the center of each rubber stopper. A bent 25 gauge needle was introduced alongside teeth on the rubber stopper to balance the air pressure in and outside of the vials.^[14] Teeth were sectioned into two halves; distal halves were discarded, and mesial halves were mounted on pre-weighed glass vials. Coronal access was achieved using diamond burs, and working length was measured 1 mm short of the apex.

Root canal preparation

The sectioned teeth were randomly divided into four experimental groups ($n = 15$), Group 1 – Reciproc blue files, Group 2 – Wave one gold files, Group 3 – Vortex blue files, Group 4 – Protaper gold files, and each empty glass vial were weighed before the root canal procedure for three consecutive times on electronic weighing machine which is taken as (m_1).

Group 1 Reciproc Blue: R25 prepares the root canal to a diameter of 25 sizes with a taper of 0.08 over the first apical millimeter. The Reciproc Blue instruments were operated at 300 rpm with the “Reciproc ALL” program using the X-smart plus endo motor with gentle pecking movements 3 times with an amplitude of 3 mm.

Group 2 Wave One Gold: All canals were prepared with crown-down pressure less technique to the working length, with the file (#25/7%) Wave One Gold in a reciprocating motion (clockwise-140°, counterclockwise-45°). The Wave One Gold instruments were operated at 350 rpm with the “Wave One ALL” program using the X-smart plus endo motor. The device was introduced into the canal with light and slow

in-and-out pecking motion with amplitude of 3 mm for three pecking motions.

Group 3 Vortex Blue: Each canal was instrumented in a crown down manner, starting with 30/0.04 followed by 25/0.04, at a rotational speed of 500 rpm and 3N/cm torque until the file reached the WL. After that, the canal was enlarged in ascending order to size 25/0.04 using an electric motor (X-Smart plus; Dentsply Maillefer) with a 16:1 reduction handpiece for three pecking motions.

Group 4 ProTaper Gold: It is instrumented with ProTaper Gold in the sequence S1, SX, S1, S2, F1, and F2(25/0.08) as it can be considered as standard control preparation in continuous rotation with a speed of 300 rpm and a torque of 3 N/cm according to the manufacturer's recommendations. The NiTi rotary files were operated using an electric motor (X-Smart plus; Dentsply Maillefer) with a 16:1 reduction handpiece. Apical preparation was completed to a size 25 file. The first three shaping files were used with a brushing action, and the last finishing files were used with a non-brushing action until the working length was reached.

During root canal preparation, using ISO #10K file recapitulation was done with 2 mL of 17% Ethylenediamine tetraacetic acid (EDTA) (Prevest DenPro™) and frequent irrigation with 2 mL of 5% sodium hypochlorite (NaOCl) (Parcan, Septodont Healthcare India PVT Limited, Raigad, Maharashtra, India) using a #25 gauge side vented needle (Navi Tip, Ultradent, UT, USA) after every use of the instrument was done. Canal preparation was completed when the last file used reached working length freely without hindrance and then removed. Apical preparation was achieved till #25 in each group to gain constant master apical size. The root canals were then irrigated with 5 mL of 17% EDTA, 5 mL of 5% NaOCl, and 5 mL of saline (Sodium Chloride Irrigation Solution IP, Infutec Healthcare Limited, M.P., India) as a final rinse. Each file was used to prepare only four root canals, and all the root canals were prepared by a single operator. The debris and irrigants were collected in the glass vials. Then, the glass vials were placed in a hot air oven for 6 h at a temperature of 65°C for complete drying. The dried vials were weighed on the electric weighing machine 3 consecutive times, and the mean was calculated (m_2). The weight of dried debris was obtained by subtracting the weight of the vial after instrumentation from the weight of the vial before instrumentation ($m_2 - m_1$). The data obtained were statistically analyzed using paired *t*-tests. The level of significance was set at $P < 0.05$ using the Statistical Package for the Social Sciences version 20 for windows.

RESULTS AND FINDINGS

Extrusion of debris and irrigants were observed in all samples, and there were significant differences between all the groups ($P < 0.05$). Reciproc Blue File system produced significantly less extrusion of debris followed by Wave One Gold, Vortex Blue, and Protaper Gold. The mean values and standard deviations for all the groups are listed in Table 1.

Table 1: Summary of statistics of apically extruded debris and irrigants for each group before and after the instrumentation

	Reciproc blue		Wave one gold		Vortex blue		Protaper gold	
	Empty	Dried	Empty	Dried	Empty	Dried	Empty	Dried
Mean	37.98	38.09	37.95	38.10	37.74	38.05	36.56	37.64
SD	0.53	0.54	0.75	0.78	0.75	0.85	0.95	0.83
Mean diff	0.12		0.14		0.31		1.08	
t-value, d.f	-5.25, 14		-4.05, 14		-7.42, 14		-15.55, 14	
P-value	0.000122		0.001191		0.0000033		0.0000000032	

DISCUSSION

The extrusion of debris, irritants, and pulpal tissue remnants beyond the apical foramen has been associated with postoperative complications, which is an unpleasing situation for both patients and clinicians.^[15] To the best of our knowledge, there was no data on the amount of apically extruded debris and irrigants produced by reciproc blue, vortex blue, wave one gold, and pro taper gold file systems to date. The commonly accepted method of Myers and Montgomery was used to collect apically extruded debris. Although the vital periapical tissues cannot be mimicked, the technique allows the comparison of file systems.^[16] NaOCl and EDTA were used to simulate the clinical condition. However, the weight of the debris extruded using this method tended to exceed that obtained with a methodology using bidistilled water because NaOCl crystallizes after extrusion, and also the amount of irrigating solution was standardized to avoid the possible bias.^[17] The results of the present study showed that all tested groups showed apical debris and irrigant extrusion. Reciproc Blue File system produced significantly less extrusion of debris followed by Wave one Gold, Vortex Blue, and Protaper Gold. Hence, the null hypothesis was rejected.

According to the results of this study, apical debris and irrigant extrusion were less with the Reciproc Blue system. This result is per the previous studies, which also displayed less debris extrusion with reciprocating file systems compared to continuous rotary file systems.^[16,18] This may be because of the kinematics of reciprocating instruments, which is a balanced force pressure less technique that prevents the debris extrusion, and also, the rotary system has a screwing action into the root canal dentin which may cause aggressive cutting of dentin leading to more debris production which subsequently causes more extrusion.

Predin Djuric *et al.*^[19] Nair *et al.*,^[20] and Küçükyılmaz *et al.*^[21] showed did studies that all instrument techniques and files are associated with apical extrusion of debris with no significant difference between them even when the preparation is maintained at the apical terminus. A study done by Mollashahi *et al.*^[22] reported no significant difference in post-operative pain intensity between rotary and reciprocating single file system groups. Conflicting results were shown^[23,24] when comparing the rotary groups with reciprocating single-file groups. The reciprocating file system exhibited significantly

lower postoperative pain, which is again dependent on the amount of apically extruded debris.^[19]

In the present study, a higher amount of debris and irrigant extrusion was associated with the Protaper Gold file system. This result is from a study done by Üstün *et al.*^[18] in which it was observed that more extrusion was found with multiple file systems compared with the single file system. This may be because of numerous times of file placements in the canal.

While some studies done by Keskin *et al.*,^[15] Gummedi *et al.*,^[25] Elashiry *et al.*^[26] showed results contrary to the present study, the reasons could be variability in file design, the number of files used, tip type, file cross-section, flexibility, kinematics, and the canal anatomy difference between the studies, and the difference in the experimental conditions.^[19]

Limitations of the study were that the periapical tissues could not be mimicked, and the true clinical situation could not be represented. Gravity may have played a crucial role in carrying the irrigants out of the canal due to the lack of backpressure in this study. Therefore, the results of this study are to be assessed with caution as the clinical scenario cannot be replicated.^[20]

CONCLUSION

All the file systems showed apical debris and irrigant extrusion, with more significant extrusion seen with the Protaper Gold file system and least with the Reciproc Blue file system. Furthermore, there was no relevance between the debris and irrigant extrusion with the surface thermal treatment of the files.

REFERENCES

1. Seltzer S, Naidorf JJ. Flare-ups in endodontics: I. Etiological factors. *J Endod.* 1985a;11:472-8. doi: 10.1016/S0099-2399(85)80220-X.
2. Harrington GW, Natkin E. Mid treatment flare-ups. *Dent Clin North Am.* 1992;36:409-423.
3. Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. *J Endod.* 1998;24:180-183. doi:10.1016/S0099-2399(98)80179-9.
4. Azar NG, Ebrahimi G. Apically-Extruded Debris Using The ProTaper System. *Aust Endod J.* 2005;31:21-3. doi: 10.1111/j.1747-4477.2005.tb00202.x.
5. Vivekanandhan P, Subbiya A, Mitthra S, Karthick A. Comparison of apical debris extrusion of two rotary systems and one reciprocating system. *J Conserv Dent.* 2016;19:245. doi: 10.4103/0972-0707.181941.
6. Shen Y, Zhou HM, Zheng YF, Peng B, Haapasalo M. Current challenges and concepts of the thermomechanical treatment of nickel-titanium instruments. *J Endod.* 2013;39:163-72. doi: 10.1016/j.joen.2012.11.005.

7. Pruett JP, Clement DJ, Carnes DL Jr. Cyclic fatigue testing of nickel-titanium endodontic instruments. *J Endod*. 1997;23:77–85. doi: 10.1016/S0099-2399(97)80250-6.
8. 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. doi: 10.1111/j.1365-2591.2011.01957.x.
9. Zupanc J, Vahdat-Pajouh N, Schäfer E. New thermomechanically treated NiTi alloys - a review. *Int Endod J*. 2018;51:1088-1103. doi: 10.1111/iej.12924.
10. Plotino G, Grande NM, Cotti E, Testarelli L, Gambarini G. Blue treatment enhances cyclic fatigue resistance of vortex nickel-titanium rotary files. *J Endod*. 2014b;40:1451–3. doi: 10.1016/j.joen.2014.02.020.
11. Pereira ES, Viana AC, Buono VT, Peters OA, Bahia MG. Behavior of nickel-titanium instruments manufactured with different thermal treatments. *J Endod*. 2015;41:67–71. doi: 10.1016/j.joen.2014.06.005.
12. Hu W, Whitten B, Sedgley C, Svec T. Effect of three NiTi files on transportation of the apical foramen. *Int Endod J* 2014;47:1064–71. doi: 10.1111/iej.12249.
13. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filling and Canal Master techniques. *J Endod* 1991;17:275–9. doi: 10.1016/S0099-2399(06)81866-2.
14. Madhusudhana K, Mathew VB, Reddy NM. Apical extrusion of debris and irrigants using hand and three rotary instrumentation systems—An in vitro study. *Contemporary clinical dentistry* 2010;1:234. doi: 10.4103/0976-237X.76390.
15. Keskin C, Sarıyılmaz E. Apically extruded debris and irrigants during root canal filling material removal using Reciproc Blue, WaveOne Gold, R-Endo, and ProTaper Next systems. *J. Dent. Res. Dent. Clin. Dent. Prospects* 2018;12:272. doi: 10.15171/joddd.2018.042.
16. Koçak S, Koçak MM, Sağlam BC, Türker SA, Sağsen B, Er Ö. Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems. *J Endod* 2013;39:1278-80. doi: 10.1016/j.joen.2013.06.013.
17. Nevares G, Xavier F, Gominho L, Cavalcanti F, Cassimiro M, Romeiro K *et al.* Apical Extrusion of Debris Produced during Continuous Rotating and Reciprocating Motion. *ScientificWorldJournal* 2015;2015:267264. doi: 10.1155/2015/267264.
18. Üstün Y, Çanakçı BC, Dinçer AN, Er O, Düzgün S. Evaluation of apically extruded debris associated with several Ni-Ti systems. *Int Endod J*. 2015;48:701-4. doi: 10.1111/iej.12369.
19. Predin Djuric N, van der Vyver PJ, Vorster M, Vally ZI. Factors influencing apical debris extrusion during endodontic treatment - A review of the literature. *S. Afr. dent. j*. 2021;76:28-36.
20. Nair PN, Henry S, Cano V, Vera J. Microbial status of apical root canal system of human mandibular first molars with primary apical periodontitis after “one-visit” endodontic treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;99:231-52. doi: 10.1016/j.tripleo.2004.10.005.
21. Küçükylmaz E, Savas S, Saygili G, Uysal B. Assessment of apically extruded debris and irrigant produced by different nickel-titanium instrument systems. *Braz Oral Res* 2015;29:1-6. doi: 10.1590/1807-3107bor-2015.
22. Mollashahi NF, Saberi EA, Havaei SR, Sabeti M. Comparison of postoperative pain after root canal preparation with two reciprocating and rotary single-file systems: A randomized clinical trial. *Ir Endod J* 2017;12:15-9. doi: 10.22037/iej.2017.03.
23. Neelakantan P, Sharma S. Pain after single-visit root canal treatment with two single-file systems based on different kinematics - a prospective randomized multicenter clinical study. *Clin Oral Investig* 2015;19:2211-7. doi: 10.1007/s00784-015-1448-x.
24. Tinoco JM, De-Deus G, Tinoco EM, Saavedra F, Fidel RA, Sassone LM. Apical extrusion of bacteria when using reciprocating single-file and rotary multifile instrumentation systems. *Int Endod J*. 2014;47:560-6. doi: 10.1111/iej.12187.
25. Gummadi A, Panchajanya S, Ashwathnarayana S, Santhosh L, Jaykumar T, Shetty A. Apical extrusion of debris following the use of single-file rotary/reciprocating systems, combined with syringe or ultrasonically-facilitated canal irrigation. *J Conserv Dent*. 2019;22:351-355. doi: 10.4103/JCD.JCD_14_19.
26. Elashiry MM, Saber SE, Elashry SH. Apical extrusion of debris after canal shaping with three single-file systems. *Niger J Clin Pract*. 2020;23:79-83. doi: 10.4103/njcp.njcp_319_19.