APICAL DEBRIS EXTRUSION DURING INSTRUMENTATION WITH CONTINUOUS AND RECIPROCATING SYSTEMS

Manoela Teixeira de Sant'Anna **Dadalti**[1], Beatriz de Melo Cabral **Mosquéra**[1], Renata Jorge de **Oliveira**[1], Isadora Minervini de Aquino **Leite**[1], Natalia Felizardo **Oliveira**[1], Patrícia de Andrade **Risso**[1*]

[1]Department of Dental Clinic, School of Dentistry, Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro, Rio de Janeiro, Brazil.

Palavras-chave: Extrusão Apical de Debris. Endodontia. Reciprocante. Canal Radicular. Rotatório.

RESUMO

Objetivo: avaliar a quantidade de debris extruidos apicalmente durante o preparo do canal radicular usando sistemas de rotação contínua e reciprocante. **Materiais e Métodos**: Quarenta incisivos inferiores foram selecionados e randomicamente divididos em quatro grupos (n=10) para o preparo do canal radicular. Dois sistemas de limas múltiplas de rotação contínua (iRace® e Mtwo®) e dois sistemas de limas únicas reciprocantes (Reciproc® e WaveOne®) foram usados. No grupo iRace®, foram utilizados os instrumentos R1 (15/.06), R2 (25/.04) e R3 (30/.04). No grupo Mtwo®, foram utilizados os instrumentos 10/.04, 15/.05, 20/.06, 25/.06. Nos grupos Reciproc® e WaveOne®, foram utilizados os instrumentos R25 e 25.04, respectivamente. A extrusão apical de debris foi calculada pela diferença entre os pesos dos tubos Eppendorf antes e após a instrumentação. A análise estatística foi feita usando o teste de análise de variância (ANOVA) seguida do teste de Bonferroni (p<0,05). **Resultados**: O grupo iRace® demonstrou significativamente mais extrusão quando comparado ao Reciproc (p<0,05). Não houve diferença estatisticamente significativa entre os grupos Mtwo®, Reciproc®, e WaveOne® (p>0,05). **Conclusão**: Todos os sistemas avaliados produziram extrusão apical de debris. O Sistema iRace® produziu mais extrusão apical de debris do que o Sistema Reciproc® e não foi observada diferença entre os sistemas Mtwo®, Reciproc® e WaveOne®.

Keywords: Apical Extrusion of Debris. Endodontic. Reciprocating. Root canal. Rotary.

ABSTRACT

Objective: to evaluate the amount of apical debris extrusion during root canal preparation using continuous and reciprocating systems. **Material and Methods**: Forty lower incisors were selected and randomly divided into four groups (n=10) for root canal preparation. Two multifile systems with continuous rotation (iRace® and Mtwo®) and two reciprocating single-file systems (Reciproc® and WaveOne®) were used. In the iRace® group, the R1 (15/.06), R2 (25/.04) and R3 (30/.04) instruments were used. In the Mtwo® group, the 10/.04, 15/.05, 20/.06, and 25/.06 instruments were used. In the Reciproc® and WaveOne® groups, the R25 and 25/.04 instruments were used, respectively. Apical debris extrusion was determined by calculating the difference between the pre- and post-instrumentation weight of the Eppendorf tubes. Statistical analysis was performed using the analysis of variance (ANOVA) test with the Bonferroni correction (p<0.05). **Results**: The iRace® group demonstrated significantly more apical extrusion than the Reciproc® group (p<0.05). There was no statistically significant difference between the Mtwo®, Reciproc®, and WaveOne® groups (p>0.05). **Conclusion**: All of the evaluated systems produced apical debris extrusion. The iRace® system produced more apical debris extrusion than the Reciproc® system, and there was no difference observed in this regard between the Mtwo®, Reciproc®, and WaveOne® systems.

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***Correspondence to:**
Patrícia de Andrade Risso
Address: Prof. Rodolpho Paulo Rocco, 325, 2 andar. Cidade Universitária, Rio de Janeiro, RJ, Brazil. Zip code: 21941-913
Telephone number: +55 (21) 3938-2032
E-mail: patriciarisso@odonto.ufrj.br

INTRODUCTION

The success of endodontic therapy primarily depends on suitable chemical-mechanical preparation and three-dimensional filling of the root canal system.[1,2] However, during chemical-mechanical preparation, vital or necrotic pulp tissue, dentin residues, microorganisms, endotoxins, and irrigants may extrude into periradicular tissues.[3,4] Such apical debris extrusion may produce postoperative pain, provoke inflammation, and increase the difficulty of repairing the periapical tissues.[5,6]

Previous studies[3,7-11] have shown that all instrumentation techniques and systems cause apical debris extrusion at different levels. According to some authors, the amount of apical debris extrusion is influenced by factors such as instrument design[12,] type of movement[12], working length (WL)[13], and number of instruments used in the WL.[3]

A variety of rotary multifile systems with continuous rotation currently exists, including Mtwo® (VDW, Munich, Germany) and iRace® (FKG, La ChauxdeFonds, Switzerland), as well as reciprocating single-file systems such as Reciproc® (VDW, Munich, Germany) and WaveOne® (Dentsply Maillefer, Ballaigues, Switzerland). Previous research has compared the apical debris extrusion caused by rotary multifile multifile systems with continuous rotation and reciprocating single-file systems, but the results are inconsistent.[3,4,7,8,10,14]

Burklein *et al*.[3] investigated the apical debris extrusion caused by instrumentation with Mtwo®, ProTaper® (Dentsply Maillefer, Ballaigues, Switzerland), Reciproc®, and WaveOne® and concluded that the rotary multifile systems with continuous rotation extruded less debris compared to the reciprocating single-file ones. However, Uzun *et al*.[10] examined the same systems and found no difference among them. Furthermore, Silva *et al*.[14] found that ProTaper Universal® (Dentsply Maillefer, Ballaigues, Switzerland) extruded more debris than ProTaper Next®, WaveOne®, and Reciproc®. To our knowledge, no studies have investigated apical debris extrusion using the iRace® system.

Due to this gap in the literature and the lack of consensus among previous studies on apical debris extrusion resulting from rotary multifile systems with continuous rotation versus reciprocating single-file systems, the current study seeks to evaluate *in vitro* the amount of apical debris extrusion present during root canal preparation with two multifile systems with continuous rotation (iRace® and Mtwo®) and two reciprocating single-file systems (Reciproc® and WaveOne®).

MATERIALS AND METHODS

This study was approved by the local ethics committee (3.442.251). The sample was determined based on the samples used in previous studies.[15,16] Forty human lower incisors that exhibited a single canal, fully formed apex, and curve up to 25° were selected. The teeth were extracted for periodontal reasons in the Oral Surgery Clinic of a public university. Following collection, they were stored in 0.1% thymol solution at 4^{0}C until used. Teeth with incomplete root formation, resorption, calcification, or previous endodontic treatment were excluded. X-rays in the buccolingual and mesiodistal directions were subsequently performed on each incisor.

To ensure standardization of the specimens, dental crowns were removed from the sample and the roots were standardized to a total length of 13 mm. A size 10 K-file (VDW, Munich, Germany) was passively introduced into the canal until the tip of the file was visible at the apical foramen. The working length (WL) was determined to be 1 mm shorter than that length, using an optical microscope. A size 15 K-file was then introduced up to the WL for standardization of the apical diameter. The teeth were then randomly distributed into four groups (n=10), corresponding to the four systems under examination. A single precalibrated operator prepared all samples. In each group, distilled water was used as the irrigant solution, in a syringe with a 30-gauge needle, employing passive penetration at 5 mm below the foramen. After the use of each instrument or three penetrations with the same instrument, the canal was irrigated with 2 mL of distilled water. At the end of the instrumentation, all canals were again irrigated with 2 mL of distilled water to remove any residue adhered to the external wall of the root.

The instruments were used with an X-SmartPlus® (Dentsply Maillefer, Ballaigues, Switzerland) endodontic motor. The iRace® and Mtwo® systems were employed with individual torque and speed according to the manufacturer's recommendations, while the Reciproc® and WaveOne® systems were applied in a reciprocating motion. The preparation sequences were as follows:

iRace® group (G1) (n=10): Instrument R1 (15/.06) was used with sligth movements in a back-and-forth manner progressing toward the WL. Subsequently, instruments R2 (25/.04) and R3 (30/.04) were used in the same way.

Mtwo® group (G2) (n=10): Instrument 25/.06 was used in the middle and cervical thirds with a brushing motion on the canal walls. The WL preparation was then completed with an inandout motion with the instruments 10/.04, 15/.05, 20/.06 and 25/.06, in sequence.

Reciproc® group (G3) (n=10): Instrument R25 (25/.08) was introduced into the canal using 3 in-and-out pecking motion about 3 mm in amplitude with light apical pressure up to the WL.

WaveOne® group (G4) (n=10): The primary instrument (25/.04) was used in the middle and cervical thirds. The same instrument was used with a gentle in-and-out pecking motion up to the WL.

***Table 1**: Amount of apical debris extrusion (g).*

	iRace®	Mtwo®	Reciproc®	WaveOne®
Mean	0.001079	0.000880	0.000370	0.000740
Standard deviation	0.000648	0.000784	0.000275	0.000327

When retention during instrumentation in all groups prevented the instrument's rotation, the instrument was removed from the canal, cleaned, and reinserted. Patency was performed at each instrument change with a size 10 K-file. The instrumentation of the teeth was carried out in stages. Two samples from each group were instrumented per day, totaling eight samples per day.

The Myers and Montgomery experimental model[13] was used to analyze the amount of apical debris extrusion. Separate Eppendorf tubes were used for each sample. The extruded debris was first collected in a preweighed Eppendorf tube attached to the lower edge of an individual silicone plug prepared for each tooth, and a second tube was used to hold the device during instrumentation. A disposable 27-gauge needle was inserted into the silicone plug, simulating a cannula, to balance the internal and external pressure. The Eppendorf tubes were sealed so the operator could not observe their contents. In each group, following instrumentation, the root was removed from the Eppendorf tube and the debris adhered to its external surface was collected by washing the root with 1 mL of distilled water inside the tube. The tubes were then placed in an oven at 37°C for seven days to evaporate the distilled water.

A high-precision analytical balance (model FA-2104N; Bioprecisa, Curitiba, Brazil) with an accuracy of 10^{-4} g, was used to weigh the Eppendorf tubes. The tubes were weighed prior to instrumentation (before the roots were inserted and attached) and after instrumentation (after root removal, irrigation of the roots' outside, and drying). Three consecutive measurements were obtained for each tube both prior to and following instrumentation, and the average final dry weight and initial weight for each sample was calculated from these measurements. The apical extrusion of debris was determined by the difference between the mean final dry weight and the mean initial weight of each sample. A single independent operator measured the weights of each sample.

Data analysis was performed by a blind and independent evaluator using Statistical Package for the Social Sciences (SPSS) version 2.0 (IBM Corp., Armonk, NY, USA). The mean apical debris extrusion in grams was calculated for each group, and the difference between the groups was analyzed statistically using the analysis of variance (ANOVA) test with Bonferroni correction (p<0.05).

RESULTS

Apical debris extrusion occurred in all groups (Table 1). The iRace® group showed significantly more debris extrusion than the Reciproc® group (p<0.05). There was no significant difference in debris extrusion between the Mtwo®, Reciproc®, and WaveOne® groups (p>0.05). No instrument was fractured during the study.

DISCUSSION

During root canal preparation, flare-up may occur as a consequence of apical debris extrusion.[5,6] However, this occurrence can be minimized with preparation techniques,[16] working lengths, and instrument design[17] that are known to cause less apical debris extrusion. In the present study, we compared different nickel-titanium instruments used in root canal preparation. It was verified that all four systems under study caused apical debris extrusion, corroborating with previous findings.[3,10,14,17-22]

The iRace® group, a rotary multifile system with continuous rotation, produced significantly more apical debris extrusion than the Reciproc® group. No statistical difference was found when comparing the results of the other multifile system with continuous rotation, Mtwo®, with the Reciproc® and WaveOne® reciprocating single-file groups. Therefore, the results indicated that rotary multifile systems multifile systems with continuous rotation did not cause more apical debris extrusion than reciprocating single-file ones.[3,12] Notably, our results are consistent with those of Uzun *et al.*[10], who did not find a statistical difference between Mtwo®, Reciproc®, and WaveOne®.

Burklein *et al.*[3] evaluated the apical debris extrusion that occurred during the root canal preparation of maxillary incisors with Mtwo®, ProTaper Universal®, Reciproc®, and WaveOne® instruments. Conversely to the results of the current study, Burklein *et al.*[3] found that the reciprocating instruments extruded more debris than those employing continuous rotation motion. According to Lu *et al.*[21], the reciprocating motion allows the instrument to advance continuously forward and, therefore, may push debris toward the apex. This difference in results may be due to the teeth used and/or the diameter of the instruments used relative to the initial diameters of the canals.

Among previous studies examining apical debris extrusion with the reciprocating instruments used in the present study,[14,20,22] most researchers found no significant difference between Reciproc® and WaveOne®,[14,20,22] which is consistent with our findings.

The tip diameter of the last instrument used in the WL was 0.25 mm for the Mtwo®, Reciproc®, and WaveOne®. No significant difference between them was found. However, a diameter of 0.30 mm was chosen for the iRace® group to assess whether a relationship existed between the amount of apical debris extruded and the instruments' tip diameter. The amount of apical extrusion debris was significantly higher for the iRace® group compared to the Reciproc® group. Although not statistically significant, the amount of apical extrusion debris was higher in the iRace® group compared to the Mtwo® and WaveOne® groups. Therefore, it is thought that the wider instrument tip diameter may have influenced the amount of apical debris extruded.[14] However, the cross-section of the instrument could be the main criterion in determined the amount of apical debris extrusion.[12]

No study was found evaluating the iRace® system, although some previous studies have evaluated apical debris extrusion caused by the BT-Race®[24] and Race®[18] systems, which are similar to iRace® and made by the same manufacturer. These investigations showed that BT-Race® demonstrated no significant difference in comparison with Reciproc® and Mtwo®.[23] Additionally, while Race® showed no significant difference from GT®, it extruded less than the ProTaper Manual®.[18]

To standardize the sample, lower incisors with a single straight canal were selected, and the crowns of all samples were removed. Standardization of the initial apical preparation was also performed, using a file at the WL set at 1 mm below the total length. It has been shown that a 1 mm WL of the apical foramen significantly reduces apical debris extrusion.[13] Patency was performed following each instrument change in all groups. However, a previous study has shown that apical patency does not influence the amount of apical debris extruded in rotary instruments.[24]

As the clinical quantification of periapical debris extrusion was not feasible,[12] in the present study, the Myers and Montgomery[13] model was used. This method is widely used[3,10,14,18-20,25] and offers the advantage of separately quantifying the debris and irrigants. However, it does have disadvantages, such as a lack of reverse pressure, which simulates the periodontal ligament, as well as its dependence on an operator's ability.[3,12,14] Like many previous studies,[3,10,14,20] distilled water was used as the irrigating substance, as sodium hypochlorite forms sodium crystals which can add to the weight of the apically extruded debris.[3,10,25]

In conclusion, all systems under evaluation caused apical debris extrusion. The iRace® group showed a significantly greater amount of apical debris extrusion than the Reciproc® group. There was no significant difference between the Mtwo®, Reciproc®, and WaveOne® groups.

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REFERENCES

1.Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974 Apr;18(2):269-96.
2.Schilder H. Filling root canals in three dimensions. 1967. J Endod. 2006 Apr;32(4):281-90. doi: 10.1016/j.joen.2006.02.007.
3.Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod. 2012 Jun;38(6):850-2. doi: 10.1016/j.joen.2012.02.017.
4.Burklein S, Benten S, Schafer E. Quantitative evaluation of apically extruded debris with different single-file systems: Reciproc, F360 and OneShape versus Mtwo. Int Endod J. 2014 May;47(5):405-9. doi: 10.1111/iej.12161.
5.Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. 1985. J Endod. 2004 Jul;30(7):476-81. doi: 10.1097/00004770-200407000-00005.
6.Siqueira JF Jr. Microbial causes of endodontic flare-ups. Int Endod J. 2003 Jul;36(7):453-63. doi: 10.1046/j.1365-2591.2003.00671.x.
7.Surakanti JR, Venkata RC, Vemisetty HK, Dandolu RK, Jaya NK, Thota S. Comparative evaluation of apically extruded debris during root canal preparation using ProTaper™, Hyflex™ and Waveone™ rotary systems. J Conserv Dent. 2014 Mar;17(2):129-32. doi: 10.4103/0972-0707.128045.
8.Koçak MM, Çiçek E, Koçak S, Saðlam BC, Yýlmaz N. Apical extrusion of debris using ProTaper Universal and ProTaper Next rotary systems. Int Endod J 2015 Mar;48(3):283-6. doi: 10.1111/iej.12313.
9.Ehsani M, Farhang R, Harandi A, Tavanafar S, Raoof M, Galledar S. Comparison of Apical Extrusion of Debris by Using Single-File, Full-Sequence Rotary and Reciprocating Systems. J Dent (Tehran). 2016 Nov;13(6):394-399.
10.Uzun I, Güler B, Özyürek T, Tunc T. Apical extrusion of debris using reciprocating files and rotary instrumentation systems. Niger J Clin Pract. 2016 Jan-Feb;19(1):71-5. doi: 10.4103/1119-3077.173715.
11.Delvarani A, Mohammadzadeh Akhlaghi N, Aminirad R, Tour Savadkouhi S, Vahdati SA. *In vitro* Comparison of Apical Debris Extrusion Using Rotary and Reciprocating Systems in Severely Curved Root Canals. Iran Endod J 2017 Winter;12(1):34-37. doi: 10.22037/iej.2017.07.
12.Caviedes-Bucheli J, Castellanos F, Vasquez N, Ulate E, Munoz HR. The influence of two reciprocating single-file and two rotary-file systems on the apical extrusion of debris and its biological relationship with symptomatic apical periodontitis. A systematic review and meta-analysis. Int Endod J 2016 Mar;49(3):255-70. doi: 10.1111/iej.12452.
13.Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and canal master techniques. J Endod. 1991 Jun;17(6):275-9. doi: 10.1016/S0099-2399(06)81866-2.
14.Silva EJ, Carapiá MF, Lopes RM, Belladonna FG, Senna PM, Souza EM, et al. Comparison of apically extruded debris after large apical preparations by full-sequence rotary and single-file reciprocating systems. Int Endod J 2016 Jul;49(7):700-5. doi: 10.1111/iej.12503.

15.Gunes B, Yesildal Yeter K. Effects of Different Glide Path Files on Apical Debris Extrusion in Curved Root Canals. J Endod. 2018 Jul;44(7):1191-1194. doi: 10.1016/j.joen.2018.04.012.
16.Garlapati R, Venigalla BS, Patil JD, Raju R, Rammohan C. Quantitative evaluation of apical extrusion of intracanal bacteria using K3, Mtwo, RaCe and protaper rotary systems: An in vitro study. J Conserv Dent. 2013 Jul;16(4):300-3. doi: 10.4103/0972-0707.114353.
17.Mittal R, Singla MG, Garg A, Dhawan A. A Comparison of Apical Bacterial Extrusion in Manual, ProTaper Rotary, and One Shape Rotary Instrumentation Techniques. J Endod. 2015 Dec;41(12):2040-4. doi: 10.1016/j.joen.2015.09.002.
18.Nagaveni SA, Balakoti KR, Smita K, Ratnakar P, Satish SV, Aravind T. Quantitative evaluation of apical extrusion of debris and irrigants using four rotary instrumentation systems: an in vitro study. J Contemp Dent Pract. 2013 Nov 1;14(6):1065-9. doi: 10.5005/jp-journals-10024-1452.
19. Soi S, Yadav S, Sharma S, Sharma M. In Vitro Comparison of Apically Extruded Debris during Root Canal Preparation of Mandibular Premolars with Manual and Rotary Instruments. J Dent Res Dent Clin Dent Prospects. 2015 Summer;9(3):131-7. doi: 10.15171/joddd.2015.026.
20. Verma M, Meena N, Kumari RA, Mallandur S, Vikram R, Gowda V. Comparison of apical debris extrusion during root canal preparation using instrumentation techniques with two operating principles: An *in vitro* study. J Conserv Dent 2017 Mar-Apr;20(2):96-99. doi: 10.4103/0972-0707.212239.
21. Lu Y, Wang R, Zhang L, Li HL, Zheng QH, Zhou XD, et al. Apically extruded debris and irrigant with two NiTi systems and hand files when removing root fillings: A laboratory study. Int Endod J 2013;46:1125-30. doi: 10.1111/iej.12104.
22. Lu Y, Chen M, Qiao F, Wu L. Comparison of apical and coronal extrusions using reciprocating and rotary instrumentation systems. BMC Oral Health. 2015 Aug 7;15:92. doi: 10.1186/s12903-015-0081-z.
23. Cabreira LJ, Gominho LF, Rôças IN, Dessaune-Neto N, Siqueira JF Jr., Alves FR. Quantitative analysis of apically extruded bacteria following preparation of curved canals with three systems. Aust Endod J 2019 Apr;45(1):79-85. doi: 10.1111/aej.12287.
24. Deonizio MDA, Sydney GB, Antonio Batista A, Roberto Pontarolo R, Guimarães PRB, 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. doi: 10.1590/0103-6440201302016.
25. Dincer AN, Er O, Canakci BC. Evaluation of apically extruded debris during root canal retreatment with several NiTi systems. Int Endod J 2015 Dec;48(12):1194-8. doi: 10.1111/iej.12425.