

Analysis of the influence of different kinematic instrumentation in extrusion of apical debris

Carlos Eduardo Fontana¹, Giovana Menegatti Ferraresso², Letícia Pinheiro Derigi³, Gávila da Rocha Bastida Pinheiro⁴, Victor Camelotti Trevensoli⁵, Carlos Eduardo da Silveira Bueno⁶, Daniel Guimarães Pedro Rocha⁷, Rina Andrea Pelegrine⁸, Alexandre Sigrist De Martin⁹, João Daniel Mendonça de Moura¹⁰, Sérgio Luiz Pinheiro¹¹

^{1,11}Pontifical Catholic University of Campinas (PUC-Campinas), Center for Health Sciences, Postgraduate Program in Health Sciences, Campinas, São Paulo, Brazil.

^{2,3,4,5}Undergraduate Dentistry and Scientific Initiation PUC-Campinas, Center for Health Sciences, Campinas, São Paulo, Brazil.

^{6,8,9}Department of Endodontics, Faculdade São Leopoldo Mandic, Instituto de Pesquisas São Leopoldo Mandic, Campinas, SP, Brazil.

⁷Department of Endodontics, PUC-Campinas, Center for Health Sciences, Campinas, São Paulo, Brazil.

¹⁰Department of Endodontics, Federal University of Pará, Belém, Pará, Brazil.

Abstract— Endodontic instrumentation systems can cause extrusion of debris. Apical extrusion has been reported as the main cause of pain after completion of endodontic treatment. The purpose of this study was to compare canal preparation time and apical extrusion of debris during instrumentation with the ProTaper Next (PTN), WaveOne Gold (WOG), and Reciproc Blue (RCB) systems. Forty-five roots of extracted mandibular first molars, with curved mesiobuccal canals (10–20°) and independent foramina, were distributed across 3 experimental groups (n=15 each) according to the instrumentation system used. Roots were secured in Eppendorf tubes, the canals were irrigated with double-distilled water, and the instrumentation time was recorded. After instrumentation, the roots were removed from the device and the amount of extruded debris was calculated by subtracting the initial weight from the final weight. Descriptive analyses were performed, followed by the Kruskal–Wallis test with a post-hoc Dunn's test. The PTN system was associated with significantly ($p < 0.05$) greater amounts of extruded debris and longer instrumentation time. There was no significant difference between the WOG and RCB groups ($p > 0.05$) between the amount of debris extruded and instrumentation time. Conclusion: The RCB and WOG were associated with less debris extrusion and shorter instrumentation time when compared to the PTN system.

Keywords— Endodontics, flare-up, reciprocation motion, rotary systems, debris extrusion.

I. INTRODUCTION

One of the main objectives of the instrumentation of the root canal system is the elimination of irritating etiological factors on the one hand, and the maintenance of healthy periapical tissues, on the other, some of these irritating agents, such as contaminated dentin debris, microorganisms and pulp tissue remains, can, during instrumentation, extrude through the apical foramen to the periapical space. This extruded material when in contact with the periapical tissues also works as an irritating factor, providing, among other occurrences, the painful symptoms to the patient known as flare-up [1, 2, 3, 4].

Some studies have been carried out in order to evaluate the amount of material extruded for the periapical tissues including a variety of factors: kinematics, apical diameter, working length, quantity and type of irrigating substance, irrigation systems, instrument design [5,6,7], but few studies have been carried out to better evaluate this extrusion when using reciprocating systems [8,9].

The extrusion of debris through the apical foramen occurs more frequently in cases of apical periodontitis, due to the presence of pathologies involving this region or apical resorption [6]. On the contrary, normal periapical tissues exert a natural barrier, thus contributing to the control of apical extrusion of debris, but not in all cases

preventing the passage of this substrate through the foramen [10].

New endodontic instruments have been idealized and manufactured in order to make endodontic treatment more effective, with quality and faster. Thus, using a root canal instrumentation technique that minimizes apical extrusion of debris would be advantageous, providing a better postoperative and, consequently, more effective repair of periapical tissues [11,12].

Regarding the instrumentation time, since reciprocating systems employ a “single file” philosophy for the preparation of the root canal system and, therefore, probably need a shorter clinical time, possibly resulting in a lesser amount of debris formed that could be extruded through the apical foramen. For this reason, it is opportune to analyze different endodontic instrumentation systems regarding the condition of apical extrusion.

The aim of the study was to evaluate the apical extrusion of debris after different kinematics of endodontic instrumentation: WaveOne Gold and Reciproc Blue reciprocating systems and Protaper Next rotary system in curved mesial root canals of mandibular molars.

II. MATERIALS AND METHODS

Specimen selection and preparation:

Once approval from the Human Research Ethics Committee of the Pontifical Catholic University of Campinas had been obtained (no. 2,379,268), 45 mandibular first molars that had been extracted for various reasons were included in the present study. Teeth with fully formed roots showing independent foramina, curvature angles of 10–20°, absence of calcifications, or resorption, and with an initial apical canal diameter corresponding to that of a #15 K-file (Maillefer Corp, Ballaigues, Switzerland) were selected and disinfected by soaking in 1% chloramine-T trihydrate solution for ten days.

All teeth were de-coronated perpendicular to the long axis of the tooth with a diamond disc (Horico Dental Hpf; Ringleb, Berlin, Germany) coupled to a slow-speed handpiece powered by a micromotor, under constant refrigeration, standardizing roots segments of 13 mm in length. An evaluation under microscopy to analyze possible existing cracks was performed.

The initial diameter of the mesiobuccal canal was established by advancement of a #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) until it fit snugly within the canal and its tip was just visible in the apical foramen under an operating microscope at 12.5x magnification

(Stemi 508; Carl Zeiss, Jena, Germany). The same procedure was used to determine the working lengths of the specimens. Canals that did not meet this criterion were excluded from the study and replaced with new specimens. Two #10 K-files were introduced into each mesial root canal, in a clockwise/ counterclockwise motion with slight apical pressure, to confirm the presence of independent foramina under 8x magnification (Stemi 508; Carl Zeiss, Jena, Germany).

Group allocation:

The samples were randomly allocated into three 3 groups using a computer algorithm (www.random.org). Each group represented an endodontic instrumentation system used for instrumentation of the mesiobuccal canals. The mesiolingual canals were not exposed to any type of instrumentation or irrigation at any point in the experiment.

Instrumentation of sample groups:

PTN group: X1 (17.04) PTN file (Dentsply Maillefer, Ballaigues, Switzerland) was used in rotary motion (300 rpm, 2 N·cm). Three in-and-out movements (pecks), with a stroke amplitude of 3 mm, were performed until the WL was reached (1 mm short of the apical foramen). The exact same sequence was then followed with an X2 (25.06) instrument.

RCB group: R25 (25.08) RCB file (VDW, Ballaigues, Switzerland) was used in reciprocating motion. Three in-and-out movements with amplitude of 3 mm were performed in each third of the canal until the WL was reached (1 mm short of the apical foramen).

WOG group: The primary file of the WOG system (25.07) was used in a manner similar to that described for the RCB group.

The same operator performed all instrumentation with the X-Smart Plus motor (Dentsply Maillefer, Ballaigues, Switzerland), adjusted for each system. Each file was used for the preparation of only one canal, and later discarded.

During the instrumentation, the specimens were irrigated with 3 mL of double-distilled water per root third, through a 30G NaviTip needle (Ultradent Products Inc, South Jordan, UT). In all groups, after each cycle of instrumentation and irrigation, foramen patency was controlled with a #10 K-file advanced 1 mm beyond the foramen. At the end of the instrumentation, a final irrigation with 1 mL of the same irrigant used throughout was performed, never exceeding the total amount of irrigant standardized for all specimens (10 mL). Canals were dry with the aid of capillary tips (Ultradent, South Jordan, UT) and the paper points provided with the respective systems.

The present study followed the methodological parameters proposed by Myers and Montgomery [5]. and modified by other authors [13,14]. (Fig. 1) to quantify the amount of debris extruded through the apical foramen.



Fig. 1: Device for weighing extruded debris

The initial weight of each Eppendorf tube (Eppendorf do Brasil, São Paulo, SP, Brazil) was determined by weighing three consecutive times on a precision balance (Ohaus Corporation, Parsippany, NJ, USA) with a precision of 10^{-5} g. The root was pushed through this hole and a rubber dam (Madeitex, São Paulo, SP, Brazil) was placed for isolation, simulating a clinical procedure. To equalize the air pressure levels, a 27G short disposable anesthetic needle (Unoject DFL Ltda, Rio de Janeiro, RJ, Brazil) was inserted through the rubber dam and stopper. Each Eppendorf/root assembly was then placed into an opaque vial to prevent the operator from having any visual or manual contact with the tubes. Instrumentation was then performed, and any apically extruded debris was thus collected inside the Eppendorf tube.

To collect any residual debris still adherent to the outer root surface, 1 mL of double-distilled water in a 10-mL hypodermic syringe (BD Plastipak, Curitiba, Brazil) was used to rinse the root; any debris thus removed was caught in the Eppendorf tube after specimens instrumentation. In order to allow complete evaporation of water from the Eppendorf tubes and subsequent weighing of the extruded debris, the tubes incubated for 6 consecutive days at a constant temperature of 68°C (Model EL-14, Odontobrás, São Paulo, Brazil). In all experimental groups, each Eppendorf tube was weighed using the same procedure described above. The mean of the three weights was recorded as the final value. The weight of the extruded debris in grams was obtained by subtracting the mean final weight from the mean initial weight of each Eppendorf tube.

The time spent on instrumentation was timed (Seiko, Japan). The timer was started only when the instrument was activated and introduced into the root canal and

stopped whenever the instrument was removed, thus yielding the actual instrumentation time.

Statistical analysis:

Data on debris weight and instrumentation time were entered into BioEstat 5.0 for analysis. The D'Agostino test rejected the assumption of normality for both variables analyzed (amount of extruded debris and instrumentation time).

Descriptive analyses were performed and the nonparametric Kruskal–Wallis test (with Dunn's post-hoc test) was used, at a significance level of 5%.

III. RESULTS

Regardless of the instrumentation system used, debris extrusion levels were observed (Fig. 2).



Fig. 2: Debris extruded and collected in the eppendorf after drying.

Table 1 represents the amount of debris extruded and Table 2 the actual instrumentation time (in seconds) for all groups. PTN system was associated with the greatest amount of extrusion ($p < 0.05$) than the WOG and RCB systems. There was no significant difference between the WOG and RCB groups ($p > 0.05$).

Regarding instrumentation time, PTN system was associated with significantly longer time ($p < 0.05$) than the RCB or WOG systems. Again, there was no significant difference between the WOG and RCB groups ($p > 0.05$).

There was no instrument fracture and no preparation iatrogenesis during instrumentation of the root canals.

Table.1: Amount of debris extruded during instrumentation with each system

Abbreviations: MD, Median; IQD, interquartile deviation; MA, Mean; SD, standard deviation.

	WOG	PTN	RCB
Minimum	0,001	0,0052	0,0001
Maximum	0,0031	0,0086	0,0116
MA(SD)	0,0021 (0,0008) ^A	0,0068 (0,0012) ^B	0,0025 (0,0035) ^A
MD (IQD)	0,0019 (0,0007) ^A	0,007 (0,0001) ^B	0,0012 (0,0025) ^A
(p-kw)	p = 0,0000		

Table.2: Instrumentation time of each system

	WOG	PTN	RCB
Minimum	16,74	80,25	17,87
Maximum	39,44	135,02	41,22
MA(SD)	24,54 (7,11) ^A	103,02 (16,39) ^B	27,19 (7,09) ^A
MD (IQD)	22,28 (5,36) ^A	100,86 (12,67) ^B	26,47 (5,76) ^A
(p - kw)	p = 0,0000		

Abbreviations: MD, Median; IQD, interquartile deviation; MA, Mean; SD, standard deviation.

IV. DISCUSSION

Biomechanical preparation is a very important phase in endodontic treatment and requires attention from the clinician and / or specialist, avoiding unpleasant consequences such as accumulation of dentin residues and the extrusion of dentin that is often contaminated to the periapical region. It is known that this extrusion of residues, in addition to often reassessing a periapical process, causes postoperative pain and can also hinder the repair of periapical tissues [9,15]. Therefore, due to this frequent occurrence of apical extrusion during endodontic treatment, this work was designed with the aim of possibly identifying the type of instrumentation technique most related to this complication.

As also found in the present study, the extrusion of debris by the apical foramen was present regardless of the technique, instrument and kinematics employed, which

confirms the findings of several researches [9,16,17]. Thus, with the advent of new instruments with different kinematics, in this case the reciprocating ones, it is important to compare preparation systems with the objective of proving some technique that promotes the minimum extrusion of debris beyond the foramen and, clinically provides less pain after endodontic treatment [11,18,19]. In addition, preparation systems that spend less clinical time to be performed minimize fatigue not only for the patient but also for the professional who performs it [20].

The method used to collect debris extruded by the foramen was very similar and with few modifications to that indicated by Myers & Montgomery (1991) [5], which are widely used and cited in the most recent studies [5,8,9,11,15,18,19,21,22,23,24].

In order to simulate irrigation during endodontic preparation and not to influence possible subsequent weighing results, double-distilled water was used in the study as is also recommended in other researches [21,22].

The reciprocating movement has been related by some recent studies as a kinematics that promotes greater extrusion of contaminated debris [8,11], however the reason for such a discrepancy in results with the current study, may be linked to the lack of segmented preparation in the crown-down direction by root thirds, since these works do not clearly discriminate the protocol for the use of reciprocating files.

The crown-down preparation sequence and, further, its execution by root thirds was used in the present study and is cited in the literature as an important factor in reducing debris extrusion, as mentioned by Yeter et al. (2013) [25] and Garlapati et al. (2013) [26].

Another factor that may have contributed to this favorable result for reciprocating instruments in the present analysis is that the performance of the glide path was used in each preparation cycle by a third, which was also not idealized in other studies by Burklein & Schäfer (2012, 2014) [8,11]. The glide path maneuver not only facilitates the maintenance of the spatial center of the root canal during its preparation, but also promotes a greater facility for the instrument to reach that working length [7], thus, the apical preparation file it should need less force to reach its objective, which probably results in less extrusion of debris and microorganisms through the apical foramen [20,22,27].

During the reciprocal movement there is a greater amplitude of rotation in the counterclockwise direction, responsible for cutting the instrument, followed by a movement with less amplitude in the clockwise direction,

which aims to unscrew the dentin and also a greater centralization of the preparation, in this way it is probably explained the lower pressure in the apical direction by these instruments when compared to the rotating systems [28], this can also explain the lesser extrusion of debris by these instruments in this study compared to the rotating group represented by the Protaper Next.

The results of the present study are in agreement with those found by De Deus et al. (2014) [22], who also performed analysis on mandibular molars, as by Xavier et al. (2014) [15], who used a very similar methodology. Both studies concluded that the tested reciprocating systems promoted less debris extrusion compared to rotary systems. All authors defend the principle that the instrument performing the reciprocating kinematics in a greater control of the debris extrusion, as it is a type of balanced force movement with less apical pressure compared to the rotational system [28], in addition to use a single file even with greater cutting power than probably the files of the tested rotary system.

Another important point that must be taken into account is the number of instruments used to prepare the root canals. As the reciprocating systems use a single file to prepare the root canal over its entire length, this instrument, even being used for a few cycles until reaching the working length, results in less time spent for the entire series of instruments needed to complete the preparation of the instrument same root canal when using rotary systems. This can result in a greater amount of debris formed during instrumentation by the rotating systems and therefore explain the result obtained in this study [9,21,29,30,31].

Capar et al. (2014) [21] reported in their study that the Protaper system, as it presents a greater number of instruments used until the end of the apical preparation, demanded a longer working time than the other tested systems and this factor may explain the greater amount of debris formed during instrumentation and, therefore, extruded through the apical foramen. This fact can be extrapolated to the results obtained in the present study, since reciprocating systems use the same file during the preparation of the entire length of the root canal and due to the shorter working time, possibly promoting a lesser amount of debris to be extracted by the apical foramen. . Other studies also agree with these findings [15,22].

Thus, the study evidenced by the results obtained, a consequent interrelation between the number of instruments and probably the kinematics of their movement in relation to the extrusion of debris, which is in agreement with the conclusions of other authors [15,20,22,32].

In addition to the kinematics, the design and cross-section of the instrument can influence the extrusion of debris through the foramen as mentioned by Elmsallati et al. (2009) [18]. This was not observed among the reciprocating systems evaluated in the present study, since no statistically significant difference was found between these systems of similar movement, even recognizing their differences regarding the respective designs.

The effective instrumentation time obtained as a result at work was proportionally shorter in the groups that obtained coincidentally shorter debris extrusion results. This correlation makes sense, since if an instrument acting in the preparation of the channel up to the working length spends a shorter interval of time, it probably promotes less debris, and thus less probability of extrusion may occur [21].

As noted, the reciprocating systems tested in the study (WaveOne Gold and Reciproc Blue) demonstrated safe instrumentation in the scope of apical extrusion and, still, spending less time to prepare the root canal.

V. CONCLUSION

According to the methodology employed, it was possible to conclude that the reciprocating systems represented by WaveOne Gold and Reciproc Blue extruded less debris through the apical foramen during instrumentation, as well as being faster in the question of instrumentation of curved mesial root canals of mandibular molars compared to Protaper Next rotary system.

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