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IN-VITRO-EVALUATION-OF-APICAL-DEBRIS-EXTRUSION-BETWEEN-5-MECHANIZED-SYSTEMS

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INTRODUCTION

Endodontic treatment, in many situations, is associated with pain and discomfort during and especially after treatment (flare-up). Most of these situations are caused by acute apical pericementitis. It can be defined as an acute inflammation of the apical periodontal ligament[1]. Its prevalence during the first 24-48 h approaches 40–65%, and 7 days later, it drops to 11%[2]. The occurrence of pain is influenced by several factors, such as preoperative pain; occlusal trauma; chemical and mechanical trauma; lack of operator skill; presence of bacterial lesion and extrusion of dentin particles, pulp tissue, microorganisms and irrigants (debris). These debris can be compacted along the walls of the root canal system, increasing the possibility of bacterial colonization, reducing the action of irrigating substances or obstructing the apical foramen with a consequent reduction in the sealing promoted by the filling or even extruded into the periapex.[3,4]. Debris extrusion, in turn, is influenced by the working length, instrument kinematics, apical diameter, volume and type of irrigating solution[5]. Most authors suggest that debris extrusion is inevitable, with some preparation systems promoting greater extrusion than others [6-8].

After the incorporation of mechanized instruments with rotational and mainly reciprocating kinematics, which use only one file to prepare the canal system, it was expected that this decrease in the number of instruments could reduce the apical extrusion of debris[4]. However, studies have presented inconsistent results, which suggests that the instrument design also influences debris extrusion[9].

The purpose of this study was to evaluate in vitro the amount of debris produced by 5 mechanized root canal system preparation systems: Reciproc® (VDW, Munich, Germany), WaveOne Gold® (Dentsply Maillefer, Ballaigues, Switzerland), Prodesing R® (``Easy Equipamentos Odontológicas``, Belo Horizonte, Brazil) (reciprocating) and ProTaper Next® (Dentsply Maillefer, Ballaigues, Switzerland), Prodesing S® (``Easy Equipamentos Odontológicas``, Belo Horizonte, Brazil) (rotational) using the method proposed by Myers, Montgomery[10].

MATERIAL AND METHOD

75 lower incisors obtained through the XXXXXXXXXXXXXXX (XXXX) Tooth Bank were randomly selected. The work began after approval from the XXXX Research Ethics Committee (1,715,802). The teeth were x-rayed to confirm the presence of a single canal and a fully formed apex.

The chosen teeth were cleaned with an ultrasound tip and stored in a 0.2% thymol solution at 4ºC. They had the crowns removed with a 0.10 X 22mm double-sided diamond disc (7020, KG Sorensen, Cotia, SP, Brazil) at low speed under water cooling, to establish a standard length of 15 mm for all roots, starting from the apex.

Distilled water was used as an irrigating substance throughout the preparation of the root canal system. A #15 K file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced until visualization through the apical foramen to confirm the previously established root length.

The samples were randomly divided into 5 groups according to the type of instrument used in preparation (table 1):

Groups	Instrument used	Number of specimens
G REC	Reciproc	15
G WAO	Wave One Gold	15
G PRR	Prodesing	15
G PRT	ProTaper Next	15
G PRS	Prodesing S	15

Table 1: Experimental groups

REC Group: the Reciproc® #25.08 instrument (VDW, Munich, Germany) was used on 2/3 of the tooth length, i.e., 10mm. It was inserted slowly through 3 pecking movements of 5mm amplitude in the cervical third, and the same was done in the middle third. Next, the apical third was instrumented, using the same kinematics as the preparation of the cervical and middle thirds, 1 mm from the root apex, that is, 14 mm [11].

WAO group: the WaveOne Gold® #25.07 (Primary) instrument (Dentsply, Tulsa, USA) was used on 2/3 of the tooth length, i.e., 10 mm. It was inserted slowly through 3 pecking movements of 5mm amplitude in the cervical third, and the same was done in the middle third. Next, the apical third was instrumented, using the same kinematics as the preparation of the cervical and middle thirds, 1 mm from the root apex, that is, 14 mm.

G PRR: the Prodesing R® #25.06 instrument (Easy Produtos Odontológicas, Belo Horizonte, MG, Brazil) was used on 2/3 of the tooth length, that is, 10 mm. It was inserted slowly through 3 pecking movements of 5mm amplitude in the cervical third, and the same was done in the middle third. Next, the apical third was instrumented, using the same kinematics as the preparation of the cervical and middle thirds, 1 mm from the root apex, that is, 14 mm.

G PRT: preparation began with instrument X1 (#17.04), followed by X2 (#25.06), X3 (#30.07) and X4 (#40.06); used in CT, i.e. 14 mm. The X1 file was introduced into the canal until little resistance was felt. Subsequently, the aforementioned instrument was activated, removed and a #10 K file was used to maintain patency. The same procedure was repeated until the X1 file arrived at the CT. A similar protocol was maintained when using all other instruments in this system[12].

G PRS: following the manufacturer's instructions, initially the #25.01 file was used for the length of the tooth (15 mm). Next, instrument #30.10 was used on 1/3 of the sample length (5 mm) to prepare the cervical third. The #25.08 file was used to prepare the middle third of the canal, working on 2/3 of the tooth length (10 mm). The #25.01 file was used again, this time, 1 mm beyond the apex and finally, the #20.06 instrument at 1 mm from the apex, to prepare the apical third.

In all samples, patency was maintained by using a K#15 file (Dentsply, Maillefer, Ballaigues, Switzerland) 1 mm beyond the apical foramen between each prepared third. Irrigation was performed with 1.5 mL of distilled water, 0.5 mL after preparation of each third, using 5 mL disposable plastic syringes (Ultradent Products Inc., South Jordan, UT, USA) with a steel needle. 31 G stainless steel NaviTips (Ultradent Products Inc., South Jordan, UT, USA) inserted as far as possible into the canal.

Debris collection was carried out using the method proposed by Myers, Montgomery10. An eppendorf was numbered for each sample, and its lid was pierced with a heated instrument. Each eppendorf was weighed on an analytical balance (AY 220, Shymadzu, Kyoto, Japan). From that moment on, the eppendorfs were handled only with gloves and/or tongs to prevent their weight from changing. This procedure was repeated a total of 5 times, with the lowest and highest values discarded. A simple arithmetic average was performed with the remaining 3 values, thus obtaining the initial weight of the eppendorf. Subsequently, each sample was positioned in the hole made in the eppendorf lid, which was then placed in a bottle covered with aluminum foil to prevent the operator from viewing the debris during the instrumentation process (figure 2). A 27 G needle was inserted into the eppendorf cap to balance its pressure. After collecting the debris, the eppendorf was separated from the set and, without the sample, it was placed in a dry heat oven (SP 400, SP Labor, Presidente Prudente, SP, Brazil) at 140º C for 5 hours so that the evaporation of the irrigant. Next, weighings were carried out using methodology similar to those used to determine the initial weight of the eppendorf, thus defining the final weight.

Figure 1: debris collection method proposed by Myers, Montgomery[10]

RESULTS

The results are presented in tables 2 and 3.

SAMPLE	G REC	G WAO	G PRR	G PRT	G PRS
1	0,0005	0,0182	0,0005	0,0006	0,0071
2	0,0017	1,9637	0,0006	0,0044	0,0023
3	0,0107	0,0246	0,0004	0,0015	0,0682
4	0,0003	0,0088	0,0003	0,0009	0,0161
5	0,001	0,0469	0,0008	0,0015	0,0025
6	0,0005	1,9635	0,0008	0,0002	0,0081
7	0,0006	0,0363	0,0002	0,0003	0,0172
8	0,0002	0,0238	0,0002	0,0042	0,0011
9	0,0022	0,0132	0,0001	0,0016	0,0187
10	0,0021	0,0208	0,0001	0,0013	0,0018
11	0,0037	0,0425	0,0005	0,0001	0,0027
12	0,0011	0,0213	0,0008	0,0016	0,0111
13	0,0114	0,0221	0,0009	0,0024	0,0035
14	0,0019	0,0126	0,0007	0,0026	0,0211
15	0,0009	0,0194	0,0004	0,0003	0,0101

Table 2: mass values found in each sample after the measurement procedures.

Comparison among groups	p	Statistical significance
G REC X G WAO	<0,0001	Yes
G REC X G PRR	0,9964	No
G REC X G PRT	>0,9999	No
G REC X G PRS	0,0123	Yes
G WAO X G PRR	<0,0001	Yes
G WAO X G PRT	<0,0001	Yes
G WAO X G PRS	<0,0001	Yes
G PRR X G PRT	0,9868	No
G PRR X G PRS	0,0028	Yes
G PRT X G PRS	0,0126	Yes

Table 3: p values found when comparing experimental groups statistical significance

DISCUSSION

Based on the results presented, the null hypothesis that there would be no difference between systems with the same kinematics was rejected.

The debris formed and extruded during the biomechanical preparation of the root canal system can lead to various complications, such as edema, pain and *flare-up*[13]. All instrumentation systems, whether manual or mechanized, produce extrusion of debris in variable quantities[6,11].

The choice of the method proposed by Myers and Montgomery [10] for collecting debris is supported in the literature. In addition to being the most used due to its easy execution and practicality, it eliminates the possibility of contamination of the sample with your fingers, altering the measured masses. As the masses of extruded debris are small, contact with wet or greasy fingers can significantly alter the final result[14]. However, the debris collection method used in this study has the limitation of not being able to provide pulp pressure similar to that of vital tissue[15].

The results demonstrated that, in absolute values, the smallest masses of extruded debris were observed in G PRR followed by G REC, with no statistical difference between them.

These data could indicate that reciprocating instruments would cause less debris extrusion, however, when we evaluated the extruded masses in the G WAO (larger than all the groups evaluated) we observed that the kinematics analyzed in isolation must not be the only variable involved. This assumption is raised by studies that found higher values of debris produced with rotary instruments in relation to reciprocating instruments[4,16]. The issue of kinematics becomes even more dubious when it is evident that there were no significant statistical differences between G REC X G PRR; G REC X G PRT; G PRR These results are in line with others presented in previous studies [17-19].

When we evaluate the kinematics of the system together with other factors, such as the number and cross-section of the instrument, we can have more grounded theories to explain the results found. The reciprocating systems evaluated use only one instrument to prepare the root canal system, whereas the rotary systems used 4 files each. Using just 1 file could cause less debris extrusion than using 4, but the results did not demonstrate this. Again, we must not use just the variable "number of instruments" to evaluate the results. Although the reciprocating movement extrudes debris, especially when the instrument is moved in a non-cutting direction, the smaller number of files used in preparation would minimize this effect[20].

On the other hand, the rotational movement would favor the exit of debris through the channel mouth, which could explain why there is less debris extruded by the G PRS (rotatory) and mainly the G PRT (rotatory) in relation to the G WAO (reciprocating) [21].

The cross-section of the instruments and the taper are other factors that must be analyzed to interpret the results. G REC instruments have an "S" shaped cross section with 2 cutting edges and a constant taper along the active part. According to data from the manufacturer, G WAO files have varying conicity along the active part, with their cross section being in the shape of a parallelogram, with 2 cutting edges. The system used in the G PRR, according to the manufacturer, has a double helix cross section, 2 cutting edges and a constant taper along the active part. The G PRT instruments, in accordance with the manufacturer, have a decentralized quadrangular cross-section, an active part with variable conicity and 2 cutting edges. The G PRS files have particular characteristics: depending on the manufacturer, each of the 4 instruments has a different taper and cross section, varying from 1% to 10% conicity and a double or triple helix cross section. Although the instruments used in the aforementioned groups have the same caliber, with small variation in the taper, the cross sections are different between G WAO and G REC/G PRR (the same). The section of the instruments used in G WAO promotes greater contact between the file and the canal walls and could have caused both the low incidence of extruded debris in G REC and G PRR, as well as their statistical difference with G WAO. Likewise, the transverse section of the G PRT would allow greater space for debris, which together with the rotational kinematics, would cause greater debris exit through the channel mouth[22].

Increasing the instrument taper normally causes an increase in the mass of extruded debris[12,15,19]. Among the groups where reciprocating instruments were used (G REC, G WAO and G PRR), the taper variation was small (1% for each group), which reduces the possibility of its influence on the results. However, when we compare the groups where reciprocating files were used with those where rotary instruments were used (G PRT and G PRS), we observed greater taper variations (6% to 10%). In these groups, the *taper* could have influenced the results more, which would partly explain the greater extruded mass.

Although it was not the objective of this study to evaluate the influence of working length on debris extrusion, it is worth highlighting that the working length used was 1 mm short of the root apex, as previous studies that used this same apical limit reported lower debris extrusion. than when the canal was instrumented to the foramen[10,23].

The caliber of the apical preparation could influence the results of the evaluations, as it had great variation in G PRT: #40, in relation to the others: G REC: #25, G WAO: #25, G PRR: #25, G PRS: #20. However, this was not observed in the analysis of the results, as the G PRT was the one that presented the smallest masses of extruded debris. Bringing this result to the clinic, there appears to be no significant difference in the amount of apically extruded bacteria with different calibers of apical preparation24. However, for better knowledge, there is no data on extrusion of apical debris using a single reciprocating file system and different sizes of apical preparation. Therefore, the use of larger files for better disinfection of the root canal in the apical third is more limited to the root anatomy than to the extrusion of debris[25].

CONCLUSION

From the results presented, we can conclude that the system that produced the least debris was Prodesign R®, followed by Reciproc®. The worst evaluated system was Wave One Gold®. The production of debris is not determined by just one factor, and the choice of the system that produces the least amount of debris must be guided by several factors such as: kinematics, cross section, *taper* and caliber. It is suggested that ex vivo studies be carried out so that the behavior of the systems studied can be evaluated in conditions closer to clinical reality.

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