

Debris Apically Extruded by Two Reciprocating Systems: A Comparative Quantitative Study

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Abstract

Objective The objective of this study was to quantify the amount of debris apically extruded after instrumentation with two reciprocating systems.

Materials and Methods Forty-two single-rooted mandibular premolars with only one straight root canal and apical diameter compatible with a no. 15 K-file were randomly divided into two groups ($n = 21$) according to the instrument used: ProDesign R (Easy Equipamentos; Belo Horizonte, Minas Gerais, Brazil) and Reciproc Blue (VDW; Munich, Germany). Dry Eppendorf tubes were weighed three consecutive times for the initial mean weight. A silicone stopper was then fitted into the mouth of the tube. Each tooth was inserted through the stopper up to the cemento-enamel junction and instrumented with one of the two systems to the predetermined working length (18 mm). The root canals were instrumented per root thirds. At each instrumented root third, the canal was irrigated with 3 mL of double-distilled water, followed by patency control. Each stopper was then separated from the tube and tubes were incubated at 70°C for 5 days. Tubes were again weighed, and the amount of extruded debris was calculated by subtracting the initial mean weight from the final mean weight.

Statistical Analysis Results were analyzed using the Mann–Whitney test at a 5% significance level.

Results No significant difference was observed in debris extrusion between the ProDesign R and Reciproc Blue systems ($p = 0.7557$).

Conclusions The two reciprocating systems tested produced similar amounts of postinstrumentation apically extruded debris.

Keywords

- ▶ apical extrusion
- ▶ root canal preparation
- ▶ endodontics

Introduction

During root canal preparation, a critical step in reducing bacterial load, apical extrusion of pulp tissue remnants, microorganisms, irrigants, and dentin chips into the periradicular tissues may occur,^{1,2} resulting in undesirable consequences such as flare-up, postoperative pain, and delayed periapical healing.³ Although authors agree that the extrusion of a certain amount of debris is inevitable,^{2,4–7} smaller amounts have been reported for some systems than for others.^{8–10}

Many variables may influence the occurrence of more or less apical extrusion of debris, such as root canal curvature, anatomic variations, patency approach, working length, increased apical preparation size, number of instruments used, and movement kinematics during instrumentation.^{1,11,12} However, with the development of different designs and heat treatments for nickel-titanium alloys and their consequent superelasticity, faster access to the foramen, and possible foraminal enlargement became important factors to be considered in the amount of debris that can be apically extruded.¹³

With the introduction of different reciprocating single-file instrumentation systems, it is important to analyze the behavior of these instruments during root canal preparation, and an aspect lacking scientific evidence is the amount of extruded debris.¹³ Therefore, this study aimed to quantify the amount of debris apically extruded after instrumentation with ProDesign R (Easy Equipamentos; Belo Horizonte, Minas Gerais, Brazil) and Reciproc Blue (VDW; Munich, Germany) reciprocating systems. The null hypothesis was that the two systems would not differ in the quantity of apically extruded debris.

Materials and Methods

The study was approved by the institutional research ethics committee (approval number 2.379.989). Extracted human single-rooted mandibular premolars were selected for the study. All teeth were extracted for therapeutic reasons, and written informed consent was obtained from all patients prior to tooth donation.

Forty-two teeth were used in the study. The sample size was calculated using linear correlation analysis with a correlation coefficient of 0.5848, number of treatments of two, statistical power of 0.80, and α of 0.05.

For inclusion, the teeth were examined visually and radiographically using a digital X-ray sensor (FIT; Micro Imagem, Indaiatuba, São Paulo, Brazil). Only teeth with only one straight root canal and one apical foramen as shown in buccolingual and mesiodistal radiographs, no visible fractures or cracks, no pulp calcifications, no internal or external root resorption, with single fully formed apices with diameter compatible with a no. 15 K-file, and root curvature $<10^\circ$, according to Schneider,¹⁴ were included.

Teeth were stored in 0.9% saline (ADV Farma; Nova Odessa, São Paulo, Brazil) until use. To remove any periodontal ligament remnants, the surface of the roots was scraped and smoothed with a G1-ultrasonic insert (MMOptics, Jardim São Carlos, São Paulo, Brazil) coupled to an ultrasound system (Emisonic 230; MMOptics).

A no. 1014 round diamond bur (KG Sorensen; Barueri, São Paulo, Brazil) was used to make coronal access cavities, followed by a no. 3082 round diamond bur (KG Sorensen) to remove the roof of the pulp chamber, coupled to a high-speed turbine (EXTRAatorque 505C Turbine; Kavo, Joinville, Santa Catarina, Brazil) under air water spray cooling. The crown cusps were ground with high-speed diamond discs (KG Sorensen) to standardize tooth length at 19 mm. Root length was measured using an analog caliper (Paquímetro Universal 125MEB-6/150; Starrett, Itu, São Paulo, Brazil). Working length was determined 1 mm short of the measurement made by introducing a no. 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the root canal until its tip became visible at the apical foramen. Apical patency was confirmed using the same file.

We used the experimental model proposed by Myers and Montgomery.¹⁵ Each dry Eppendorf tube was weighed 3 times on a precision balance (Adventurer Precision; Ohaus Corporation, Parsippany, New Jersey, United States) with an accuracy of 10 g, and the average was calculated and recorded

as the initial mean weight. A silicone stopper was then fitted into the mouth of the tube. Each tooth was inserted through the stopper up to the cemento-enamel junction, and a 25×0.7 mm disposable hypodermic needle (PrecisionGlide; BD, Juiz de Fora, Minas Gerais, Brazil) was also inserted into the stopper to equalize the air pressure. Each tube was then held securely in a flask, which was covered with foil to blind the operator for debris extrusion during instrumentation and to avoid manual contact with the tube.

Teeth were randomly divided into two groups ($n=21$) (www.random.org).

ProDesign R group: A no. 25 ProDesign R instrument was used in reciprocating motion, coupled to an endodontic motor (VDW Silver; VDW) set to operate in the “Reciproc ALL” mode. After three in-and-out movements (pecks), limited to one-third of the canal or 6 mm, we removed the instrument, cleaned its flutes with gauze, and irrigated the canal with 3 mL of double-distilled water produced in the laboratory (with needle insertion limited to half of the instrumented root third). Patency was then controlled with a no. 10 K-file, introduced into the root canal until its tip became visible at the apical foramen. We reintroduced the instrument into the canal, limited to three pecks per root third, followed by irrigation and patency control until reaching the predetermined working length.

Reciproc Blue group: A no. 25 Reciproc Blue file was used in a reciprocating motion with in-and-out movements (pecks), coupled to an endodontic motor (VDW Silver; VDW) set to operate in the “Reciproc ALL” mode as previously described for the ProDesign R group.

Each instrument prepared only one root canal. One operator completed all root canal preparations. A total of 9 mL of double-distilled water was used to irrigate each specimen, dispensed into the canal using a 3-mL syringe with sterile needle (Plastipak; BD), divided into three stages or root thirds (6 mm). Once instrumentation had been completed, the stopper set-up was separated from the tube. The root was then washed with 1 mL of double-distilled water to collect the debris adhering to the root surface.

Tubes were incubated at 70°C for 5 days to evaporate the double-distilled water. An examiner blinded to group assignment weighed three times the tubes containing extruded debris, and the average was calculated and recorded as the final mean weight. The initial mean weight was subtracted from the final mean weight, and the result was recorded as the amount of extruded debris.

Statistical analysis was performed using BioStat 4.0 (Sociedade Mamirauá, Universidade Federal do Pará, Belém, Brazil). All data were tested for normality using the Shapiro–Wilk test. The sample showed a non-normal distribution, and the results were analyzed using the Mann–Whitney test at a 5% significance level.

Results

There was no significant difference between the ProDesign R and Reciproc Blue groups in postinstrumentation debris extrusion ($p = 0.7557$) (► **Table 1**, ► **Fig. 1**).

Table 1 Amount of apically extruded debris (g) obtained after instrumentation with two reciprocating systems

	ProDesign R	Reciproc Blue	p-Value
Mean (SD)	0.0011 (0.0019)	0.0028 (0.0079)	0.7557
Median (IQD)	0.0008 (0.0005)	0.0007 (0.0007)	

Abbreviations: IQD, interquartile deviation; SD, standard deviation.

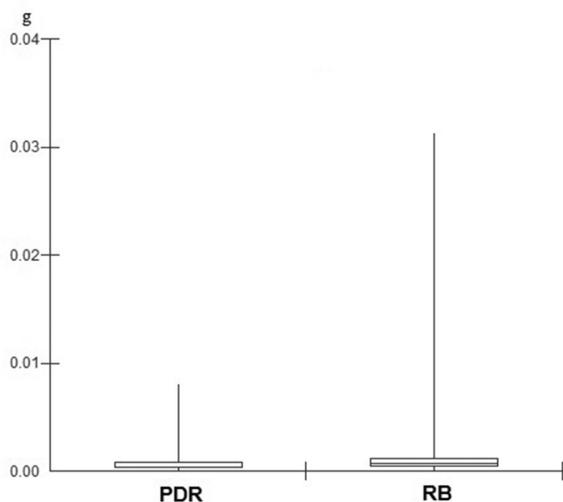


Fig. 1 Box-Plot: apically extruded debris (g) after instrumentation with ProDesign R (PDR) and Reciproc Blue (RB) reciprocating systems.

► **Table 1** shows mean (standard deviation) and median (interquartile deviation) values for the amount of apically extruded debris after instrumentation. ► **Fig. 1** shows the mean and median values in the two groups.

Discussion

Based on the present results, the null hypothesis was accepted as the ProDesign R and Reciproc Blue systems did not differ in the quantity of postinstrumentation apically extruded debris.

Mandibular premolars with only one straight root canal were used to prevent loss of the working length during root canal preparation, which could result in disruption of the apical constriction and more debris. However, no distinction was made between first and second mandibular premolars to ensure some degree of anatomical variation among specimens, as in previous studies.^{6,16,17}

Instruments with a no. 25 apical diameter at D0 were selected from both systems, because this size is closer to the mean anatomical size of the foramen in mandibular premolars, of ~330 μm .¹⁸ The choice of instrument diameter is consistent with a previous study comparing apical debris extrusion with the WaveOne Gold system (Dentsply Tulsa Dental; Tulsa, Oklahoma, United States), the Twisted File Adaptive system (SybronEndo; Orange, California, United States), and manual files, all with a no. 25 apical diameter at D0¹⁹ although in that study the sample consisted of root

canals of mandibular molars. In addition to the same tip diameter, the ProDesign R and Reciproc Blue instruments share the same S-shaped cross-section. This design feature increases the cutting efficiency of the instrument but also reduces the core volume along its active part, which may increase dentin chip collection during preparation and the flexibility of intermediate portions,²⁰ thus reducing the amount of debris that can be apically extruded.

This study used double-distilled water as an irrigant, in agreement with previous studies,^{8,19} because sodium hypochlorite undergoes crystallization during evaporation in the incubator, contributing to an increase in the weight of debris because of the sodium crystals become attached to the debris. The apically extruded debris was quantitatively evaluated using a previously described method.¹⁵ Despite the shortcoming of failing to reproduce resistance of periapical tissues, this method is widely accepted and allows the comparison of systems in the laboratory setting.^{8,17,19} There are other techniques that use foam to simulate periapical resistance.^{21,22} However, this set-up also has shortcomings such as irrigant and debris absorption, which, in a quantitative study, may interfere with the results.

Our results indicate that apical extrusion of debris occurs regardless of the type of reciprocating instrument used, in agreement with previous studies,^{1,6,9,11} since, during root canal instrumentation, the walls reached by the irrigant are cut by the instruments, thereby producing debris. Although the design of these instruments (smaller core, high super-elasticity, and deep helical channels) contribute positively to reduce this effect, some degree of extrusion is inevitable.

Frota et al¹³ tested reciprocating instruments made of thermally treated alloys (Reciproc, WaveOne, and ProDesign R) and concluded that significantly less apical debris was extruded by ProDesign R than by the other systems, in contrast to the results of the present study, in which no significant difference was observed between the systems. However, in the present study, a high standard deviation was observed in the Reciproc Blue group, which may be explained by the greater taper and its variation along the active part of the instrument, leading to heterogenous dentin removal with substantial variation in extruded debris between the samples in this experimental group.

Another point that needs to be emphasized is that the heat treatment to which the files tested in the present study were subjected probably did not influence the results, since the sample consisted of mandibular premolars with root curvature <10°. Frota et al¹³ used a sample of mesial root canals of mandibular molars with foramen diameters lower than 200 μm and working lengths different from that used in the

present study. Another possible explanation for this difference is the different standardization process of the foramina, which, despite using the same reference instrument (no. 15 file), is not as accurate as microscopic and/or digital analyses. In addition, the cross-sections of the test systems selected by Frota et al¹³ differed from each other, leading to changes in flexibility, cutting efficiency, and consequently in debris extrusion.

Uslu et al²³ tested the Reciproc Blue, HyFlex EDM (Coltene/Whaledent, Altstätten, Switzerland), and XP-endo Shaper (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) systems and concluded that Reciproc Blue extruded more debris than the other systems. Although their sample was similar to ours, they used a modification of the method proposed by Lu et al,²² by using Teflon bands on the surface of the roots and injecting agar gel into Eppendorf tubes.

A single operator, experienced in the systems tested in the present study, completed all root canal preparations. This may have contributed to the similar results in terms of debris extrusion obtained with the Reciproc Blue and Prodesig R systems, regardless of differences in taper and heat treatment between the instruments.

Within the limitations of an in vitro study, it can be concluded that the two test reciprocating systems produced similar amounts of apically extruded debris. Further studies are required to confirm these results.

Conflict of Interest

None declared.

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