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RESEARCH ARTICLE

Evaluation of apical extrusion of debris after instrumentation with two reciprocating systems: RC Blue and Reciproc Blue

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ABSTRACT

Introduction: The aim of this study was to quantify the debris extruded after instrumentation with two reciprocating systems.

Materials and Methods: Thirty-six mandibular premolars with a single straight root canal and apical diameter compatible with a size 15 K-file were randomly divided into two groups (n = 18) according to the instrument used: RC Blue (Perfect, China) and Reciproc Blue (VDW; Munich, Germany). The dental roots were inserted into Eppendorf tubes up to the cement-enamel junction and weighed before instrumentation. The teeth were instrumented with one of the two systems up to a predetermined working length (20 mm). The root canals were instrumented by root thirds. In each instrumented third, the canal was irrigated with 3 mL of distilled water. The tubes were weighed again three times, and the amount of extruded debris was calculated by subtracting the average initial weight from the average final weight. The results were analyzed using Biostat 5.3 and subjected to the Shapiro-Wilk normality test. The sample exhibited non-normal behavior and was analyzed using the Kruskal-Wallis test (Student-Newman-Keuls) with a significance level of 5%.

Results: No significant difference was observed in the extrusion of debris between the RC Blue and Reciproc Blue systems ($p > 0.05$).

Conclusion: Both tested reciprocating systems produced equivalent amounts of debris extruded apically after instrumentation of the mandibular premolars.

Keywords: Debris; Distilled water; Reciprocating files; Endodontics; Root canals.

Introduction

The treatment of root canal systems is directly related to the control of intracanal infection and the prevention of apical extrusion of bacteria and debris, a situation that can occur in all instrumentation techniques

During chemical-mechanical preparation, fragments of pulpal tissue, whether vital or necrotic, as well as bacteria and their byproducts, can be extruded through the apical foramen. This extrusion is undesirable and regarded as one of the main causes of postoperative pain [2]. Additionally, infected debris extruded apically can become a source of extraradicular infection, thereby compromising the success of endodontic treatment [1]. his can lead to inflammation in the area, resulting in pain for the patient, delaying apical healing, and causing postoperative inflammation/infection, a phenomenon known in the literature as "flare-up" [3–5].

The amount of debris extrusion can vary according to the type of instrument, design, instrumentation technique, number of files, apical size of the preparation, and the degree of file rotation [6]. Reciprocating systems were introduced to reduce the number of clinical steps and the number of files needed to achieve satisfactory canal shaping. Previous research has indicated that reciprocating systems cause greater extrusion of debris and irrigants beyond the apex, as they can remove larger amounts of dentin in a single use [7]. However, other studies [8,9] have reported opposite results.

The Reciproc Blue reciprocating system (VDW, Munich, Germany) has a lower bending resistance compared to the original Reciproc instruments, with no significant differences in the roughness pattern. However, Reciproc Blue exhibits lower microhardness. When compared to conventional superelastic M-Wire nickel-titanium, Reciproc Blue demonstrates better flexibility and cyclic fatigue resistance while maintaining similar surface characteristics and reduced microhardness [10].

The RC Blue system (Dental Perfect, China) was launched in Endodontics, and there are no studies comparing the extrusion of debris from this file with Reciproc Blue. Therefore, it is important to evaluate the performance of RC Blue during canal instrumentation, considering that debris extrusion is an impacting factor in endodontic treatment.

The present study aimed to evaluate the volume of debris extruded apically after instrumentation with the Reciproc Blue and RC Blue files. The null hypothesis tested was that the use of different reciprocating files would result in equivalent volumes of debris extruded apically.

Materials and Methods

This study was approved by the local Ethics Committee, CAAE 72939023.7.0000.5374. The sample size calculation was based on the work of Uslu et al. [11], considering a significance level of 5% and a power of 80% using the analysis of variance model. The G*Power 3.1.9.4 program indicated the need for 18 teeth in each group.

Selection of specimens

Inclusion criteria

The study included 36 extracted human lower premolars with a curvature degree ranging from 0° to 5° [12] a radius of curvature less than 6 mm [13] and which were evaluated radiographically. Teeth with an anatomical foramen diameter compatible with a size 15/.02 manual file (Dentsply, Maillefer, Ballaigues, Switzerland) were used, with the canals being circular.

Exclusion criteria

Teeth with incomplete apex formation, previous endodontic treatment, more than one canal, root caries, internal and external resorption, obliterations and/or calcifications, cracks, and fractures were excluded.

Initial preparation

The teeth were kept in a 0.1% thymol solution (Farmatheke, Itupeva, Brazil) for 6 months until the start of the research. At the beginning of the

experiment, the roots were rinsed in running water to eliminate any potential residues of the thymol solution, then dried with an air jet and gauze. The teeth were radiographed in the mesio-distal and vestibulo-lingual directions to verify the presence of only one canal and to measure the root canal length from the canal entrance to the radiographic apex.

The removal of organic and inorganic material from the external surface of the roots was performed with periodontal curettes (Golgran Ind. e Com. de Instrumental Odontológico, Ltda, São Paulo, Brazil). In this study, the crowns were kept intact without sectioning them. The coronal access was performed with a high-speed bur no. 1014HL (KG Sorensen Indústria e Comércio Ltda., São Paulo, Brazil), using cooling.

Sample assembly

5 mL Eppendorf tubes (CRAL Artigos para Laboratório Ltda, Cotia, Brazil) were used, with the tops removed using scissors. A hole was created in the center of the Eppendorf tube cap with a diamond-coated spherical bur 1016 at high speed, aiming to create an opening with a diameter similar to that of the cervical part of the remaining dental root to be used in the experiment. The teeth were inserted into the holes of the Eppendorf tube caps up to the cement-enamel junction, with 14mm of root below the cap and 6mm of the coronal remnant above the cap. The space between the cap and the tooth was hermetically sealed with cyanoacrylate (Super Bonder, Loctite, Henkel Ltda., Brazilian Industry), and a gingival barrier Topdam (FGM, Joinville, Brazil) was placed over the cyanoacrylate for protection and to prevent liquid from leaking into the tube during root canal preparation. The cap/tooth assemblies were weighed, and this weight was designated as weight 1 (P1). All weights were measured three times on a high-precision electronic balance (RADWAG, Radom, Poland), and average values were calculated and recorded.

Distribution of Groups and Instrumentation Technique

Thirty-six mandibular premolars were randomly distributed into two groups (n=18):

RC Group: instrumentation using the 25.08 RC Blue file (Dental Perfect, China).

RCB Group: instrumentation using the 25.08 Reciproc Blue file (VDW, Munich, Germany).

The root canal length (CL) was measured by direct visual method, introducing a #10.02 C-Pilot manual file (VDW, Munich, Germany) into the root canal, passing 1 mm beyond the foramen, and retracting until the tip of the file was visible at the apical foramen. The working length (WL) was determined at 20 mm, precisely where the file was visible in the apical foramen, and the total length (CL) was considered the WL. The canals were instrumented by the same operator, who had experience in Endodontics. The files were operated on the E-Connect Pro motor using the reciprocating programming for both systems. The files were operated using the E-Connect Pro motor with the reciprocating program for both systems. The rotation angle was set to 150° counterclockwise and 30° clockwise. Each file system was used to prepare up to three canals before being discarded.

The instrument was used in a back-and-forth motion with approximately 3mm of amplitude for each movement. After every three penetration and withdrawal movements of the file, the instrument was removed and cleaned with sterile gauze soaked in 70% alcohol. Patency was verified with a K10 file inserted 1 mm beyond the foramen (21 mm). Preparation was conducted in the cervical and middle thirds (4 mm below CT) with irrigation of 2 mL of distilled water between each file change. Next, the canal was irrigated with an additional 2 mL of distilled water, with the needle inserted to the end of the middle third. The preparation of the apical third was performed up to the foramen (20mm).

For irrigation, a Navitip 30G needle, 21mm (Ultradent Products Inc, South Jordan, Utah, USA),

was used, connected to a peristaltic irrigation pump (Irriflow, MK Life, Medical and Dental Products, Porto Alegre, Brazil) with a flow rate of 5 mL/minute, aiming to replace the conventional irrigation syringe, enhancing the standardization of the volume and flow of the irrigant. The volume of the irrigant was previously determined through a pilot procedure that evaluated the flow provided by the peristaltic pump and the diameter of the selected irrigation cannula. The total irrigation volume was 20mL per tooth.

After the chemical-mechanical preparation, the canals were irrigated with 5mL of 17% ethylenediaminetetraacetic acid (EDTA) for 1 minute, followed by a final irrigation with 5 mL of distilled water. The agitation of the irrigating solutions, both the EDTA and the distilled water, was performed 3 mm below the total length of the tooth using the ultrasonic tip E1-Irrisonic (Helse Ultrasonic, Santa Rosa de Viterbo-SP), with the Advance View 1 ultrasonic device (Microdont) set at 20% power, as recommended by the manufacturer. Final aspiration was performed using capillary tips (Ultradent, South Jordan, Utah, USA), and then the canals were dried with paper points size 25 (MK Life, Porto Alegre-RS).

Analysis of Debris Extrusion

The experimental model used in this study was proposed by Myers and Montgomery. For this, each Eppendorf tube was weighed three times on a high-precision analytical balance (0.0001 g) (Shimadzu, ATY 224 (P1)). A disposable needle 25 x 07mm (Precision Glide, BD, Juiz de Fora, Minas Gerais, Brazil) was inserted into a glass container to equalize internal and external pressures.

After the mechanical preparation was completed, the Eppendorf tubes were removed from the glass containers, and the tube/tooth assembly was carefully separated. Then, the external surfaces of the dental roots were irrigated with distilled water to collect the debris that adhered to the apical region of the roots. For 5 days, the tubes were incubated at 60°C to allow for the evaporation of the distilled water, leaving only the debris extruded during the instrumentation.

Finally, the tubes were weighed three times to confirm the data, which was used to validate the obtained value (P2 = tube + debris), which was subtracted from P1, resulting in the weight of debris extruded during the preparation.

Statistical Analysis

The results were analyzed using Biostat 5.3 and subjected to the Shapiro-Wilk normality test. The sample exhibited a non-normal distribution and was analyzed using the Kruskal-Wallis test (Student-Newman-Keuls) with a significance level of 5%.

Results

There was no statistically significant difference between weights 1, 2, and 3 of the groups (Table 1).

Table 1. Medians, interquartile ranges, and Kruskal-Wallis statistical test (Student-Newman-Keuls) of weights (g).

	RC BLUE	RCB BLUE	(p-value)
Weight 1 (g)	0.6089[a]	0.6087[a]	0.8377
Weight 2 (g)	0.6127[a]	0.6205[a]	0.7234
Weight 3 (g)	0.0015[a]	0.0064[a]	0.5800

Caption: Weight 1 – pre-instrumentation; Weight 2 – post-instrumentation with the volume of extruded debris; Weight 3 – difference between the two weights.

Discussion

The present study evaluated the use of two different reciprocating files in the extrusion of debris during endodontic treatments. The tested files promoted debris extrusion without a statistically significant difference; therefore, the null hypothesis was accepted.

Mandibular premolars with a single straight root canal were chosen to prevent the loss of working length during canal preparation, thus avoiding the generation of additional debris. However, no distinction was made between the first and second premolars[14].

The selection of teeth was meticulous, considering type, size, canal curvature, number of canals, and working length, ensuring the standardization of samples. The working length was defined by the actual length of the canal (0.0), based on a previous study indicating that instrumentation up to the apical foramen or 1 mm short does not affect debris extrusion[15].

The apical preparation size was standardized at 25.08, following evidence suggesting that the preparation size does not impact debris extrusion [15]. addition to having the same tip diameter, the RC Blue and Reciproc Blue instruments have the same S-shaped cross-section. This design feature improves the cutting efficiency of the instrument but also reduces the volume of the core along the active part, which may increase the collection of dentin chips during preparation, resulting in a decrease in the amount of debris that can be extruded apically[16].

Previous studies have quantified extruded debris using micro-computed tomography[17], molecular methods[17], and colony-forming unit (CFU) counts[18,19]. The weighing method[20] was utilized in this study due to its broad acceptance in the literature. Although it does not replicate the resistance of periapical tissues, this method is widely accepted and allows for the comparison of instruments in a laboratory setting[14,21]. Other techniques that simulate the periodontal ligament have been proposed[22], however, this configuration also has disadvantages, such as the absorption of irrigant and debris, which in quantitative studies may interfere with results.

Distilled water was used instead of sodium hypochlorite (NaOCl) as an irrigant, as NaOCl reaches its boiling point and forms crystals that cannot be separated from the debris, interfering with the results[21]. To avoid interference from a potential embolic effect of the irrigant[23] a peristaltic pump was used with a flow rate of 5 mL per minute. High flow and irrigation pressure are associated with greater debris extrusion[17], highlighting the importance of standardization.

Our results indicated that apical debris extrusion occurred regardless of the type of reciprocating instrument used, corroborating previous studies[14,24]; since during the instrumentation of the root canal, the walls affected by the irrigant are cut by the instruments, thus resulting in the production of debris. Unlike this study, Reciproc Blue extruded more debris than Hyflex EDM and XP-Shape[11], although the sample in the referenced article was similar to that of this study, they utilized a modification of the method proposed by Lu et al.[22], applying Teflon bands on the root surfaces and injecting agar gel into Eppendorf tubes.

Other studies comparing Reciproc Blue with different instruments observed that it extruded more debris than other systems, both in studies with mandibular premolars[25], in acrylic blocks[26], and in mandibular molars[27].

A direct comparison with previous studies was not possible due to the divergent results from different research regarding apical debris extrusion, which arose from the use of different systems and instrumentation methods. Furthermore, no study in the literature has evaluated the same instruments used in this study regarding debris extrusion.

The transfer of the obtained results to clinical practice should be conducted with caution,

considering the absence of physical resistance provided by periapical tissues. The methodology used did not resemble a closed system. The experimental setup had no resistance, and gravity may have influenced the extrusion of debris outside the canal. This limitation of the laboratory model has already been addressed by Myers & Montgomery[20] and in a recent study conducted under similar experimental conditions (28).

Additional in vivo studies will be necessary to investigate debris extrusion concerning the success of endodontic treatment and the incidence of postoperative pain.

Conclusion

From this study, it can be concluded that both RC Blue and Reciproc Blue files tested in this experiment promoted apical debris extrusion equivalently.

Conflict of Interest:

The authors have no conflicts of interest to declare.

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