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ORIGINAL ARTICLE

Apically extruded dentin debris by reciprocating single-file and multi-file rotary system

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Abstract
Objectives This study aims to evaluate the apical extrusion of debris by the two reciprocating single-file systems: WaveOne and Reciproc. Conventional multi-file rotary system was used as a reference for comparison. The hypotheses tested were (i) the reciprocating single-file systems extrude more than conventional multi-file rotary system and (ii) the reciprocating single-file systems extrude similar amounts of dentin debris.
Materials and methods After solid selection criteria, 80 mesial roots of lower molars were included in the present study. The use of four different instrumentation techniques resulted in four groups (n=20): G1 (hand-file technique), G2 (ProTaper), G3 (WaveOne), and G4 (Reciproc). The apparatus used to evaluate the collection of apically extruded debris was typical double-chamber collector. Statistical analysis was performed for multiple comparisons.
Results No significant difference was found in the amount of the debris extruded between the two reciprocating systems. In contrast, conventional multi-file rotary system group extruded significantly more debris than both reciprocating groups. Hand instrumentation group extruded significantly more debris than all other groups.
Conclusion The present results yielded favorable input for both reciprocation single-file systems, inasmuch as they showed an improved control of apically extruded debris.
Clinical relevance Apical extrusion of debris has been studied extensively because of its clinical relevance, particularly since it may cause flare-ups, originated by the introduction of bacteria, pulpal tissue, and irrigating solutions into the periapical tissues.

Keywords Apical extrusion · Debris · Instrumentation · Reciprocating movement

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Introduction

The idea of a single NiTi instrument to enlarge the root canal into a minimum acceptable taper size is indeed appealing by technical procedure oversimplification [1]. Moreover, no doubt exists that, under a cost-effective perspective, the use of only one NiTi instrument is advantageous over conventional multi-file systems; also, the first clinical and experimental impressions of the reciprocating systems appear promising [1–3]. Nonetheless, some doubts related to the reciprocating systems came up just as the amount of the dentin chips, irrigants, remaining pulp tissue, bacteria, and their by-products that may be extruded into the periradicular tissues [4, 5]. The recent worldwide rise of the single-file reciprocating systems led to the hypothesis that faster mechanical preparations, with a reduced number of instruments—but able to cut significant amounts of dentin in short periods of time—are prone to force more debris and irrigants through the apex. In other words, in theory, conventional rotary multi-file systems, which involve more technical steps tends to extrude less debris and irrigants. Additionally, it can be conjectured that the movement kinematics itself may play a role in packing the debris into the irregularities of the root canal space and pushing them beyond the apex. The basis for this assumption is the overall clinical impression that the reciprocation is a forceful movement, which may act as a mechanical piston, pumping debris and irrigants through the apex. However, to some measure, this assumption may not have a well-built background, since reciprocation tries to mimic the balanced force technique kinematics, which is well known as being a pressureless movement pushing less material periapically [6].

Two recent studies have assessed the material pushed periapically by the Reciproc and WaveOne single-file systems. Caviedes-Bucheli and co-authors [7] concluded that Reciproc system produced lower neuropeptide expression than WaveOne system and hand-filing instrumentation. On the other hand, Burklein and Schafer [5] found no differences in the amount of apically extruded debris between the WaveOne and Reciproc single-file reciprocating systems; however, a full sequence of rotary instrumentation was related to less debris extrusion. Within this background came out the purpose of the present study, which was to evaluate the apical extrusion of debris by the two reciprocating single-file systems—WaveOne and Reciproc. Conventional multi-file rotary system was used as a reference for comparison. The hypotheses tested were (i) the reciprocating single-file systems extrude more than conventional multi-file rotary system and (ii) the reciprocating single-file systems extrude similar amounts of dentin debris.

Material and methods

Specimen selection

Three hundred left and right mandibular first molar teeth were used as initial sampling. In order to select only moderately curved mesial roots, radiographs of each tooth were taken, digitized, and stored electronically. Root canal curvature was determined based on the angle of curvature initiated at the coronal aspect of the apical third of the root using Schneider's method [8]. Angles of curvature were measured using an image analysis program (AxioVision 4.5, Carl Zeiss Vision Gmbh, Hallbergmoos, Germany). Only those roots with angles of curvature ranging between 10° and 20° (moderate curvatures) were selected. In addition, only mesial root canals with an initial apical size equivalent to a size 10 K-file were selected for the study. It means that only teeth in which an ISO file 10 fits tight to the root canal, but was able to get the apical patency, were included in the present study. As a result of the stringent inclusion criteria, only 84 mesial molar roots entirely fulfilled the above-mentioned standardization conditions. In order to create four equal groups with 20 specimens in each one, four teeth were discarded, leaving a total sample size of 80 mesial roots. The teeth were disinfected in 0.5 % of chloramine T, stored in distilled water at 4 °C, and used within 6 months after extraction.

The use of different instrumentation techniques resulted in four groups with 20 specimens each. The groups were randomly distributed using a computer algorithm (http://www.random.org). Each tooth was labeled with a random five-digit alphanumeric code corresponding to one of the three experimental groups to remove potential operator bias.

Common irrigation and preparation parameters

Working length was established at the apex, and length of all mesial roots was standardized to 13 mm. A single experienced operator, specialist in endodontics, performed all treatments. Irrigation was performed in exactly the same manner for all specimens using a 5-mL disposable plastic syringe (Ultradent Products Inc., South Jordan, UT, USA) with 30-gauge Endo-Eze Tips (Ultradent) placed passively into the canal, up to 5 mm from the apical foramen without binding. Aspiration was performed using SurgiTip tips (Ultradent) attached to a high-speed suction pump. Between each file, root canals were irrigated with 0.5 mL of bi-distilled and deionized water for 1 min. The flow of irrigation (1 mL/min) was determined with an automatic syringe pump (SP100i, World Precision Instruments, Sarasota, FL, USA). At the end of the instrumentation, each tooth was flushed with 2 mL of irrigant to remove any debris adhered to the root canal walls.

Instrumentation

For all groups, a stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) scouted the canal up to working length. In this way, a glide path was created to assure smooth preliminary preparation rendering the canal predictably negotiable.

Group 1: hand-file technique

The coronal and middle third of each canal was prepared using Gates Glidden drills (Dentsply/Maillefer), sizes 4, 3, and 2 up to the beginning of the canal curvature. The apical third was prepared with Flexofiles® (Dentsply, Maillefer), sizes 50, 45, 40, 35, 30, and 25 at working length using the balanced force movement [9]. Therefore, the canals in this group were instrumented with nine instruments.

Group 2: ProTaper rotary system

ProTaper Universal files were driven at 300 rpm with an endodontic micromotor (XSmart, Dentsply-Maillefer) in a conventional rotary movement as follows: (1) S1 file (1/3 of the WL), (2) SX file (1/2 of the WL), (3) S2 file (2/3 of the WL), and (4) F1 and (5) F2 files (full WL). As a result of the ProTaper sequence, all the canals in this group were instrumented with five NiTi instruments.

Group 3: WaveOne system

A medium WaveOne instrument (Dentsply-Maillefer) was gradually advanced in the root canal until reaching two thirds of the previously estimated WL. The medium WaveOne instrument was moved in a slow and gentle in-and-out pecking motion with a 3 mm amplitude limit. After each three complete pecking movements, the instrument was removed from the canal and its flutes were cleaned off by insertion into a spoon box.

Group 4: Reciproc system

The R25 instruments (VDW, Munich, Germany) were used just like in group 3 description.

Debris collection

The apparatus used to evaluate the collection of apically extruded debris had very minor adaptations from that described previously [4] (Fig. 1). Briefly, a 10-mL ampoule with a rubber stopper was adjusted for use in this experiment. The plastic assay tubes were individually pre-weighed three times with a 10^{-5} g precision analytic microbalance (model 1101, ElbaTech Srl, Isola d'Elba, Italy) to obtain the mean weight of each one. By using a heated instrument, a hole was made through the center of every rubber stopper in which the root was adapted by using pressure. A 30-g needle was inserted into the rubber stopper to balance internal and external pressures, allowing for debris extrusion. All of the plastic assay tubes were covered with black tape in order to blind the operator during canal instrumentation.

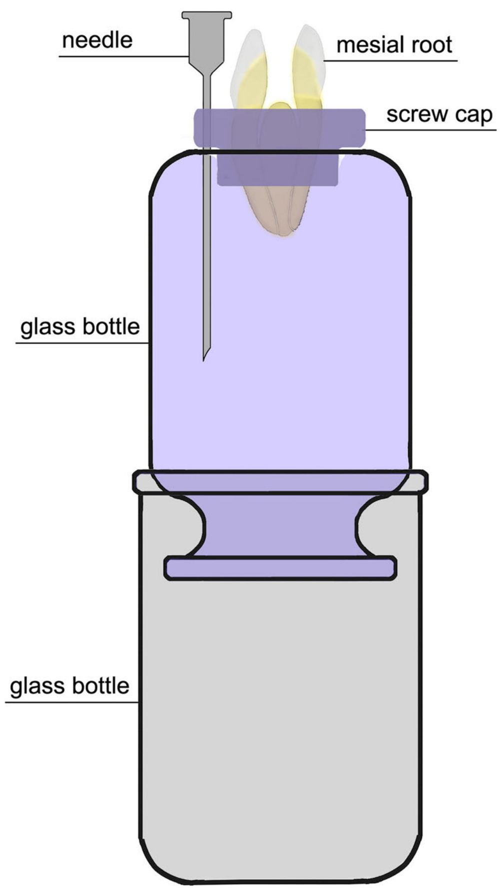

Fig. 1 Schematic illustration of the modified apparatus used to evaluate the collection of apically extruded debris

All of the teeth were instrumented into the collection assembly. In order to avoid the possibility of some type of contamination, there was no direct contact between assembly and operator's fingertips throughout all experimental procedure [4]. After instrumentation, collection assembly was placed in a dry-heat oven at a constant temperature of 140 °C for 5 h, allowing for irrigant evaporation. Three consecutive weight measurements were taken for each collection assembly, with the mean value recorded. The weight of the extruded debris was determined by subtracting the weight of the pre-weighed collection assembly from the final weight of the collection assembly.

Statistical analysis

As the preliminary analysis of the raw pooled data revealed a bell-shaped distribution (D'Agostino and Person omnibus normality test), statistical analysis was performed using parametric methods—one-way analysis of variance (ANOVA). Post hoc pair-wise comparisons were performed using Tukey multiple comparisons. The alpha-type error was set at 0.05.

Results

No significant difference was found in the amount of the debris extruded between the two reciprocating systems ($P>0.05$). On the other hand, conventional multi-file rotary system group extruded significantly more debris than both of the other two reciprocating groups ($P<0.05$). Hand instrumentation group extruded significantly more debris than rotary and reciprocation systems ($P<0.05$). The median, minimal,

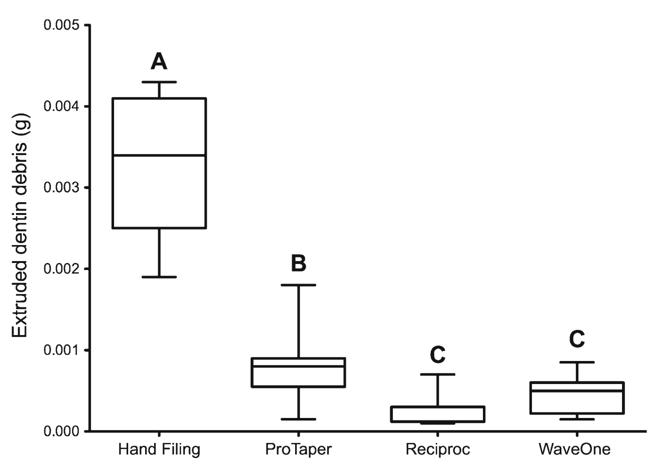

Fig. 2 *Box plots* of the amount of extruded debris, which illustrate the median, minimal, and maximal values, as well as the standard deviation data of each experimental group

and maximal values, as well as the standard deviation data of each experimental group are shown in Fig. 2.

Discussion

The main result of this study revealed that both reciprocating systems extruded less debris apically than the reference group—conventional multi-file rotary system. Therefore, the first hypothesis was plainly rejected. It is important to stress that the improved control of apically extruded debris promoted by both single-file reciprocating systems found in the current study does not represent a consensus in the recent specific literature; this highlights the necessity of gathering further in-depth evidence. For instance, Burklein and Schafer [5] conclude that the full sequence of the rotary instrumentation was related to less debris extrusion than reciprocation single-file systems. This marked contrast can be explained by differences in the experimental setup, design, and type of teeth used. Among several hand instrumentation kinematics, the balanced force technique is regarded to have the better control of apically extruded debris [6]. Hence, as reciprocation is a sort of automatized balanced force pressureless technique, the rationale can be used to support the better performance of the single-file systems found in the present study. Therefore, in a general manner, the interplay among several factors such as instrument design, improved alloy, fewer instruments, high cutting ability, and reciprocation kinematics of both the WaveOne and Reciproc systems can be used to support their improved control of apically extruded debris found in the current study.

The secondary result of the present study showed no significant difference in the amount of apically extruded debris between the two reciprocation systems. Consequently, the second hypothesis was accepted. In line with the current result, there appears the study by Burklein and Schafer [5] where WaveOne and Reciproc single-file reciprocating systems have performed similarly. Contradictorily, in other report, the Reciproc single-file reciprocating system has outperformed the WaveOne as it produced lower levels of neuropeptide expression [7].

It is important to quote that the current results can be regarded as a consequence of the interplay between two known variables: (i) the number of files of each system and (ii) movement kinematics. For that reason, it is not possible to segregate the influence of each of these variables per se from overall results. However, this experimental design is fitting, since the general purpose of the current study was not to find out some potential correlation between the number of files or the movement kinematics and the control ability of apically extruded debris. In short, the present study was unable to determine the weight of the movement kinematics per se in the control ability of apically extruded debris; an experiment specifically designed is required for that.

To the best of the current author's knowledge, there has been no study in which molar teeth were used to assess the amount of dentin debris extruded with reciprocating systems. Single-root teeth were used in most studies on apically extruded debris mainly because of the ease in setting up the collector apparatus as well as of the greater predictability of the cleaning and shaping procedures [4]. Nonetheless, the use of single-root teeth should be avoid since logic dictates that the more intricate the root canal space anatomy, the bigger the amount of apically extruded debris. The use of mesial roots of mandibular molars for the current evaluation has the understandable purpose of shorting the distance from laboratorial setting to challenging real-life clinical situation [4]. However, in the current experimental setup, teeth are tested with the apexes suspended in the air; this means zero back pressure and, to some measure, this lack of a physical barrier provided by periapical tissues likely has a degree of influence on the overall results.

Standing at a practical perspective, the present results are favorable for reciprocation single-file systems inasmuch as they showed an improved control of apically extruded debris. Nevertheless, from a purely clinical viewpoint, cautiousness is necessary to read the present result as the clinical significance of the range amount of apically extruded debris shown herein has not yet been determined. In fact, the rationale which claims that the greater the extruded debris weight, the greater will be the inflammatory response severity [10] is not obvious and straight. Elmsallati and co-authors [10] explained very well that "it is likely that not only the quantity of debris but also the type and virulence of bacteria bound to debris and the resistance of host tissue are important." Moreover, on a more general perspective, apical control of extruded debris is just one aspect desirable to be determined concerning an instrumentation technique. Other factors related to the overall root canal preparation quality with the single-file reciprocation systems still entail denser laboratorial evaluations and clinical evidence.

Conflict of interest The authors deny any conflict of interest.

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