Apical Transportation, Centering Ability, and Cleaning Effectiveness of Reciprocating Single-file System Associated with Different Glide Path Techniques

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Abstract

Introduction: The aim of this study was to evaluate the apical transportation, the centering ability, and the cleaning effectiveness of a reciprocating single-file system associated to different glide path techniques. **Methods:** The mesial root canals of 52 mandibular molars were randomly distributed into 4 groups (n = 13) according to the different glide path techniques used before biomechanical preparation with Reciproc System (RS): KF/RS (sizes 10 and 15 K-files), NGP/RS (no glide path, only reciprocating system), PF/RS (sizes 13, 16, and 19 PathFile instruments), and NP (no preparation). Cone-beam computed tomography analysis was performed before and after instrumentation for apical third images acquisition. Apical transportation and its direction were evaluated by using the formula D = (X1 − X2) – (Y1 − Y2), and the centering ability was analyzed by the formula CC = (X1 − X2/Y1 − Y2 or Y1 − Y2/X1 − X2). The samples were submitted to histologic processing and analyzed under a digital microscope for debris quantification. The values were statistically analyzed (Kruskal-Wallis, the Dunn multiple comparisons test, $P < .05$). **Results:** All groups had similar apical transportation values, with no significant difference among them ($P > .05$). Groups had a tendency toward transportation in the mesial direction. No technique had perfect centering ability (=1.0), with no significant difference among them. KF/RS had larger amount of debris, with statistically significant difference in comparison with NGP/RS ($P > .05$). **Conclusions:** The different glide path techniques promoted minimal apical transportation, and the reciprocating single-file system tested remained relatively centralized within the root canal. Also, the different techniques interfered in the cleaning effectiveness of the reciprocating system. *(J Endod 2015;41:2045–2049)*

Key Words

Apical transportation, centering ability, cleaning effectiveness, glide path, reciprocating motion

Biomechanical preparation is the step responsible for root canal system cleaning and shaping, gradually increasing its diameter by action of several instruments (1). For years such preparation was performed with stainless steel hand instruments, which had a number of limitations mainly in curved and flat canals, leading to deviations, zip formations, and perforations (2).

Such limitations led to the development of nickel-titanium instruments with increased flexibility and cutting efficiency, favoring the treatment of curved canals and making the clinical procedure faster and safe (3). Constantly, new techniques and instruments have been proposed to reduce the difficulties in endodontic therapy (4, 5). Reciprocating systems, which are able to perform biomechanical preparation with only 1 instrument, are the latest innovations (4, 5).

Because of the reduced number of files used for root canal preparation, a glide path must be created before instrumentation to ensure the continuously free advancement of instruments throughout the entire working length (5–7).

Following the concept of reduced number of instruments for root canal preparation, glide path creation has also followed this trend of being performed with few instruments or a single file (8, 9). Thus, studies to better define the action of these instruments in the root canal's anatomy, when associated with reciprocating systems, are needed.

The aim of this study was to evaluate the apical transportation, the centering ability, and the cleaning effectiveness of a reciprocating single-file system associated to different glide path techniques. The null hypothesis tested was that the different glide path techniques would not interfere in the reciprocating single-file system performance.

Materials and Methods

Sample Selection

For this study, 52 freshly extracted mandibular molars, donated by the Bank of Teeth of the Amazonas State University, with prior approval from the Research Ethics Committee (Protocol. CAAE n° 23700713.7.0000.5020) were selected. The selected teeth had 16-mm length, completely formed roots, closed apex, and 2 mesial root

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canals with independent foramina. Moreover, only roots with angle of curvature ranging from 20° to 30° and radius of curvature ≤10 mm were selected for the study. The angle and radius of curvature were calculated according to the methods of Schneider (10) and Pruett et al (11), respectively.

After sample selection, the teeth were disinfected by immersing them in a 0.5% chloramine-T solution at a temperature of 4°C for 48 hours and then washed under running water for 24 hours. Next, the teeth were stored in receptacles containing distilled water at a temperature of 5°C until use.

Coronal opening was performed with spherical diamond-coated bur no. 1015 (KG Sorensen, Cotia, SP, Brazil) coupled to a high-speed handpiece (Extra Torque 605C; Kavo, Joinville, SC, Brazil) under constant water cooling. Afterwards, size 10 K-files (Dentsply Maillefer, Ballaigues, Switzerland) were introduced in the mesial canals in apical direction to determine the working length. The working length of mesial canals was standardized at 14 mm, and only mesial canals with an initial apical size correspondent to a size 10 K-file were selected for this study.

Biomechanical Preparation

To standardize the teeth position during biomechanical preparation, the distal portions of the teeth were embedded in colorless self-curing acrylic resin (Jet Classic; São Paulo, SP, Brazil) to form a resin block. After polymerization, the 52 blocks were randomly distributed into 4 groups (n = 13) according to the different glide path techniques performed before root canal preparation. In KF/RS group, glide path was created with sizes 10 and 15 K-files (KF) (Dentsply Maillefer) to the working length, followed by preparation with R25 instrument (size 25.08/21 mm) of Reciproc System (RS) (VDW GmbH, Munich, Germany) in reciprocating motion with a 6:1 contra-angle handpiece (VDW Silver Reciproc; Sirona Dental Systems GmbH, Bensheim, Germany) powered by an electric motor (VDW Silver Reciproc Motor; Sirona Dental Systems) in mode "RECIPROC ALL", according to the manufacturer's recommendations. The instrument was gradually inserted in a slow in-and-out pecking motion with a 3-mm amplitude limit for 3 pecking movements. Glyde File Prep (Dentsply Maillefer) was used as lubricant during root canal preparation. In NGP/RS group, glide path was not created. The root canals were prepared in the same manner as described in KF/RS group. In PF/RS group, glide path was created with PathFile (PF) rotary instruments (Dentsply Maillefer) sizes 13, 16, and 19. Next, the root canals were prepared in the same manner as described in KF/RS and NGP/RS groups. In NP group, no preparation was performed (negative control).

Each instrument was used to prepare only 1 root canal. After each insertion, the instruments were removed for cleaning with sterile gauze, and the root canals were irrigated with 2 mL 2.5% NaOCl solution (Rio Química, São José do Rio Preto, SP, Brazil) with a 30-gauge needle (NaviTip; Ultradent Products Inc, South Jordan, UT) 3 mm short of the working length. At the end of the biomechanical preparation, 1 mL 17% EDTA (Biodinâmica, Ibiporã, PR, Brazil) was applied for 3 minutes, and the canals were irrigated again with 2 mL 2.5% NaOCl (Rio Química). The resulting solution was aspirated (CapillaryTip; Ultradent Products Inc), and the teeth were stored in a humid environment at a temperature of 5°C. All procedures were performed by a single operator who is a specialist in endodontics.

Apical Transportation

To evaluate the apical transportation, an initial cone-beam computed tomography (CBCT) analysis was performed for image acquisition of mesial root canals. The resin blocks containing the teeth were coupled to a polystyrene platform (2.0 × 2.0 × 2.0 cm), with the mesial root canals parallel to the horizontal plane to standardize the teeth position before and after preparation. The platform/resin block set was adapted to the table of the CBCT scanner (i-CAT Cone Beam 3D; Dental Imaging System, Salt Lake City, UT) with the following specifications: x-ray source with valve voltage 120 kVp, valve current 3–7 mA, and focal point of 0.5 mm. The protocol Mand 6 cm, 40 sec, 0.2 voxel MaxRes was used for image acquisition.

For apical transportation analysis, the second and third millimeters of the apical third were selected, totaling 4 axial images of 1 mm for each mesial root canal. The apical transportation was calculated with the aid of the OsiriX software (OsiriX Imaging Software, http://dwww.osirix-viewer.com). The extension of the pre-preparation and post-preparation root canal diameters was measured in a blind manner by a calibrated examiner, according to the following formula:

$$D = (X1 - X2) - (Y1 - Y2)$$

X1 and X2 represented the measurement of the mesial external wall of the non-instrumented and instrumented root canals, respectively. Y1 and Y2 represented the measurement of the distal external wall of the non-instrumented and instrumented root canals, respectively (Fig. 1). Apical transportation equal to 0 means that no transportation occurred, a negative value means that transportation occurred in the distal direction, and a positive value indicates transportation in the mesial direction.

Centering Ability

The centering ability index was calculated for the second and third millimeters of the apical third by using the values obtained during apical transportation measurement, following the formula:

$$X1 - X2/Y1 - Y2 \text{ or } Y1 - Y2/X1 - X2$$

The formula adopted for the centering ability calculation depends on the value obtained by the enumerator, which should always be lower than the values obtained by the differences. Therefore, values equal to 1 indicated perfect centering ability of the instrument, and values closer to 0 indicated lower instrument's ability to maintain to the central axis of the root canal.

Cleaning Effectiveness

After CBCT analysis, the mesial root was separated from the whole structure of each tooth by using a double-faced diamond disk coupled to a low-speed handpiece (Dabi Atlante, Ribeirão Preto, SP, Brazil) and fixed in 4% formalin solution (Merck, Darmstadt, Germany) for 48 hours. Next, the mesial roots were washed in running water for 24 hours and immersed in Morse solution for 4 weeks for decalcification. Afterwards, the apical third of each mesial root was sectioned, washed in running water for 24 hours, and submitted to dehydration in alcohol (70%, 90%, 95%, and 100%), followed by diaphanization in xylene (Merck) for further paraffin embedding at 60°C. Semi-serial sections (10 semi-serial sections per specimen) of 5-μm thickness were cut and stained with hematoxylin-eosin (Merck).

The histologic sections were analyzed under a digital microscope (Dino-Lite Plus AM313 T; AnMo Electronics Corporation, New Taipei City, Taiwan) at ×60 and ×230 magnifications. With the aid of the Image Tool 3.0 software (San Antonio, TX), an integration grid (28 × 21) was superimposed over the histologic images to perform quantification of the points in the root canal that coincided with either clean areas or areas containing debris (Fig. 2). After quantification of the points present in the clean area and points in the areas containing debris, the

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