CANAL TRANSPORT INDEX AND ROOT CANAL CENTRALIZATION CAPACITY PROMOTED BY THE BIORACE, V-FILE, AND PROTAPER NEXT SYSTEMS: A CBCT STUDY

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ABSTRACT

Objective: This study aims to analyze the transport index (TI) and centralization capacity (CC) of root canal preparation using different nickel-titanium instruments, based on images obtained by cone beam computed tomography (CBCT). Material and Methods: Forty-five mesiobuccal canals of lower molars were prototyped. Groups: The canals were randomly distributed into three groups (n=15) according to the rotary instrument used: G1: BioRace®, G2: V-File®, G3: Protaper Next®. CBCT images were obtained before and after canal preparation. Measurements were performed by two examiners using OsiriX® DICOM Viewer software. The analyses were performed 3 mm below the furcation of the teeth. The IT and CC were evaluated according to the methodology proposed by Gambill et al. (1996). The data obtained were analyzed using the Kruskal-Wallis test, with a significance level of 5%. Results: All instruments analyzed caused root canal transport and decentralization. BioRace® and V-File®: Tendency toward distal transport. Protaper Next®: Tendency toward mesial transport. No significant differences were found between the groups in terms of IT and CC (p<0.05). None of the instruments tested showed perfect centralization capacity (=1.0). Conclusion: None of the instruments, whether operated in continuous rotation or reciprocating kinematics, showed no transport or ideal centralization capacity of the root canal. All instruments evaluated caused some degree of transport and decentralization of the canals.

Keywords: Root canal preparation; Endodontics; Cone beam computed tomography; Treatment failure.

INTRODUCTION

Root canal cleaning and shaping are crucial steps in endodontic treatment, essential for controlling infection and ensuring treatment effectiveness. The main objective of these steps is to preserve the original shape of the canal and the position of the apical opening, while establishing a tapered preparation within the dental canal. However, clinical practice often faces challenges in maintaining these principles, resulting in common errors during shaping, such as zips, transport,

decentralized preparations, and even perforations, especially in curved canals. The introduction of nickel-titanium (NiTi) instruments revolutionized root canal shaping, providing significant advances in the quality of preparation. These instruments are designed with different characteristics that can influence the preservation of canal geometry, including instrument design, cross- sectional area, taper, cutting angle, penetration guide, cyclic fatigue resistance, and number of uses. These factors can impact the transport index (TI) and centralization capacity (CC) of the canal. Several studies have addressed the evaluation of TR and CC of root canal preparation using various analysis methods, such as scanning electron microscopy, microcomputed tomography, high-resolution computed tomography, and cone beam computed tomography (CBCT). CBCT, in particular, allows detailed three-dimensional visualization of the root canal system, offering superior accuracy and resolution, which facilitates the obtaining of more accurate numerical measurements. Based on the above, the aim of this study was to evaluate the TI and CC promoted by the BioRace®, V-File®, and Protaper Next® instrument systems using CBCT images. The null hypothesis tested was that TI and CC do not vary according to the type of instrument used in root canal preparation.

METHOD

Forty-five prototyped lower molars (IM do Brasil Ltda., São Paulo, SP, Brazil) with coronary opening already performed were randomly distributed into three experimental groups (n=15), according to the rotary system used: Group 1. BioRace® (FKG Dentaire, Switzerland); Group 2. V-File® (TDKaFile, Mexico City, Mexico); Group 3. Protaper Next® (Dentsply Maillefer, Ballaigues, Switzerland).

CT images were obtained before and after canal preparation. Measurements were performed by two examiners using OsiriX® DICOM Viewer software. Analyses were performed 3 mm below the furcation of the teeth.

Root canal preparation: a total of 45 mesiovestibular canals constituted the sample of the present study. The canals were explored and emptied using K#10 and #15 files (Dentsply Maillefer, Ballaigues, Switzerland). The working length was determined using a K#15 file (Dentsply Maillefer) until the endodontic instrument was visible through the apical foramen. From this length, one millimeter was retracted to obtain the working length (WL). The canals were prepared with the aid of the X-Smart Plus® motor (Dentsply Maillefer) and followed the technical specifications for torque (N), speed (rpm), and instrument sequence proposed by each manufacturer. The root canals were irrigated with distilled water using a Navitip irrigation cannula (Ultradent Products Inc., South Jordan, USA) coupled to a 5 mL Ultradent irrigation syringe (Ultradent Products Inc.). After instrumentation, the root canals were dried with absorbent paper cones (Dentsply Maillefer, Petrópolis, RJ, Brazil) of a caliber corresponding to the last instrument used. Each endodontic instrument was used to prepare five root canals.

Root canal transport analysis: Image analysis to determine TI was performed using the methodology proposed by Gambill et al. (1996). TI was determined in the mesiodistal (MD) direction at the level already described and corresponded to the variation, in millimeters, of the deviation of the central axis of the root canal after instrumentation. Root canal transport was determined by measuring the shortest distance between the images of the mesial and distal walls of the root canal and the mesial and distal root external surface before (M1 and D1) and after (M2 and D2) root canal preparation (Figure 1). The TI was calculated using the following formula: TI (MD) = (M1 – M2) – (D1 – D2).

Figure 1- Schematic representation of the measurement of the mesiodistal distances to determine the root canal transport index before (A) (M1 and D1) and after (B) (M2 and D2) root canal preparation.

To perform the measurements, OsiriX® DICOM Viewer version 8.0.2 (Pixmeo SARL, Bernex, Switzerland) software was used. When the application of the formula resulted in a negative TI value, root canal transport in the distal direction was considered, a positive value indicated transport in the mesial direction, and when equal to zero, no transport was considered.

Analysis of the centralization capacity of root canal preparation: The CC of root canal preparation was also determined according to the methodology proposed by Gambill et al.17(1996). The CC was determined based on the values obtained from the measurements of the distances used in the calculation of the TI. To establish the CC of root canal preparation in the mesiodistal direction, the following formula was used: CC (MD)= M1 - M2 / D1 - D2 or CC (MD)= D1 - D2 / M1 - M2. In the formula used, the smallest value of the differences between the measurements of the distances before and after preparation was selected as the numerator. The result of applying this formula when equal to one (CC=1) indicated perfect centralization of the root canal preparation in the mesiodistal direction, and the closer to zero (0≥ CC≤ 0.999), the lower the ability of the instrument to remain in the central axis of the root canal. The agreement for the changes identified by the two examiners was evaluated using the Kappa test.

RESULTS

The Kappa value obtained was 0.87, indicating an excellent degree of agreement between the two examiners. The mean results and standard deviation for TI (in millimeters) and CC after root canal preparation with the different instruments are detailed. The analysis revealed that all instruments tested caused some degree of root canal transport and decentralization. BioRace® and V-File: Both systems showed a tendency for canal transport in the distal direction. Protaper Next®: Demonstrated an opposite tendency, with predominant transport in the mesial direction, but no differences were found between the groups (p>0.05). No instrument achieved perfect CC (=1.0).

CONCLUSION

None of the instruments evaluated showed absence of transport or canal centralization capacity.

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