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Centering and transportation: *in vitro* evaluation of continuous and reciprocating systems in curved root canals

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Abstract

Context:

One of the goals of endodontic therapy is the shaping and cleaning of the root canal system. In recent years, there has been multiple systems instrumentation, and changes in their dynamics are central to maintain the original shape of the canal after preparation.

Aims:

The aim of this study was to evaluate centering and transportation in curved root canals after using ProTaper® and MTwo® in continuous rotation, Reciproc® in reciprocating motion, and a step-down manual instrumentation technique.

Settings and Design:

Mesiobuccal roots of human extracted the first and second maxillary molars were selected and the canals (n = 60) were divided into four groups according to the preparation techniques: PT-ProTaper®; MT-MTwo®; RE-Reciproc®; MI-manual instrumentation.

Subjects and Methods:

The final apical diameter was standardized to a size 25. Centering and transportation were evaluated by cone-beam computed tomography and Adobe Photoshop 8.0 software.

Statistical Analysis Used:

The data were statistically analyzed by ANOVA and Tukey *post hoc*.

Results:

Results of transportation showed no statistical differences ($P > 0.05$) between groups, and significantly, difference ($P < 0.05$) between ProTaper® and Reciproc® was found when evaluating centering ability in the apical third.

Conclusions:

We concluded that there were no differences in transportation between the evaluated systems for the preparation of curved root canals with an apical instrumentation diameter of #25. For centering ability, in the apical third, ProTaper® presented worst behavior when compared to Reciproc®.

Keywords: Cone-beam computed tomography, endodontics, nickel-titanium alloy, root canal preparation

INTRODUCTION

One of the purposes of endodontic therapy is to achieve cleaning and shaping of root canal system. The preparation of the anatomical canal, giving it a cylindrical-conical shape, should respect the original features while also maintaining the integrity of the apical foramen.[1]

Shaping of curved canals has been offset by a tendency for all preparation techniques to deviate the prepared canal from its original axis.[2] Thus, several thermomechanical processes and manufacturing technologies were developed to improve the microstructure of nickel-titanium alloys, making them more flexible,[3] resistant[4] and with an increased cutting power.[2]

Centering ability is influenced by the design of the instrument (taper, flexibility, and type of alloy) and the root canal anatomy.[5] With the aim of simplifying the preparation procedures and decreasing the canal transportation, a single instrument associated to reciprocal motion was proposed.[6,7] This movement was developed to relieve torsional and flexural stress, to improve centralization, and to reduce the risk of canal deformation during preparation.[8]

The aim of this study was to evaluate centering ability and transportation in curved root canals after using ProTaper® and MTwo® in continuous rotation, Reciproc® in reciprocating motion, and a step-down manual instrumentation technique by means of cone-beam computed tomography (CBCT) evaluation. The null hypothesis is that there is no difference among the evaluated systems regarding apical transportation and centering ability.

SUBJECTS AND METHODS

After approval from the Research Ethics Committee, sixty maxillary first and second molar teeth, obtained from a Teeth Bank by a written consent, with complete root formation and similar root shapes were selected for the study. Each tooth was sectioned through furcation and the mesiobuccal root was used. Periapical radiographs were taken to confirm complete root canal formation, canal curvature, absence of calcifications, resorptions, and previous root canal treatment.

Sample

Root canals were randomly divided into four groups (n = 15) according to the degree and radius of canal curvature.[9,10] Curvatures between 20° and 40° and radius < 10 mm comprised the sample. After endodontic access, the canals were irrigated with 2.5% sodium hypochlorite solution (NaOCl; Farmácia Marcela, Porto Alegre, RS, Brazil) using a plastic syringe with a NaviTip needle (NaviTip 31-gauge sideport; Ultradent, South Jordan, UT, USA) and explored with a #10 Triple Flex file (SybronEndo, Glendora, CA, USA) fitted snugly in the apical foramen. Working length was determined by subtracting 1 mm from the total length. Apices were sealed with sticky wax and fixed in an acrylic block, except for the first 2 mm of the cervical third.. The roots were fixed to an acrylic board to maintain its position during the acquisition of the preoperative and postoperative images and root canal preparation.

Root canal instrumentation

One experienced operator carried out the canal preparation. In all groups, canals were irrigated with 2 mL of 2.5% NaOCl before each instrument was inserted. Recapitulation was performed after each instrument with a #10 Triple Flex file (SybronEndo, Glendora, CA, USA). Final irrigation was performed with 2 mL of 17% ethylenediaminetetraacetic acid (Farmácia Marcela, Porto Alegre, RS, Brazil) during 3 min, followed by 2 mL of 2.5% NaOCl. Canals were then dried with sterilized paper points. Mechanical operation of the instruments was performed with a reducing contra-angle 6:1 Sirona (VDW GmbH, Munich, Germany) coupled to micro-motor SM 16845 (VDW GmbH, Munich, Germany) connected to an electric motor VDW Silver with VDW update Reciproc® (VDW GmbH, Munich, Germany).

The groups were nominated as follows: PT-ProTaper®; MT-MTwo®; RE-Reciproc®; MI-manual instrumentation. ProTaper® instruments were used in a crown-down manner and continuous rotary motion. Preparation of coronal and middle thirds was carried out by S1 and SX files. Then, S1 file was used to the working length followed by S2. Instrumentation was completed with the F1 and F2 instruments, in this order, to obtain a final apical size #25. Brushing movements were used for S files and in-and-out motion for F files. For Mtwo®, the sequence used was 10.04, 15.05, 20.06, and 25.06 at the working length using a careful in-and-out motion with continuous rotary. Reciproc® file (size 25.08) was used in a reciprocating, slow in-and-out pecking motion according to the manufacturer's instructions. Preparation was divided into three stages (coronal, middle, and apical thirds) and the instrument was cleaned after three pecks. For manual instrumentation, the canal was instrumented using crown-down technique, and the canals were prepared until the working length of a #25 K-file (SybronEndo, Glendora, CA, USA). Except for Reciproc®, at each instrument change, irrigation and recapitulation with a #10 Triple Flex (SybronEndo, Glendora, CA, USA) file at the length of work were performed. Each instrument was used to prepare three root canals and then discarded. If, during use, instrument fracture happened, it was replaced. Information related to the instrument type and number of users was noted on a worksheet.

Cone-beam computed tomography evaluation

CBCT images were obtained before and after instrumentation. At the end of instrumentation, the prepared roots were replaced in the acrylic device, in the same exact position, to perform a new scan using the same parameters. The scanner i-CAT (Imaging Sciences International, Hatfield, PA, USA) was used according to the automatic image capture parameters of the i-CAT Vision System (Imaging Sciences International, Hatfield, PA, USA) software. This device has a radiation source of high frequency, 120 kVp, 3–8 mA, 14 bit – grayscale, and voxel size of 0.4 mm. The snapshot was performed in a single rotation of 360° with scanning time of 20 s. Two axial sections of each sample, one in the coronal third (at 9 mm from the apex) and another in the apical third (at 3 mm from the apex), before and after preparation, were selected. The selected images were transferred to Adobe Photoshop 8.0 software (Adobe Systems, San Jose, CA, USA).

One operator, trained and calibrated, performed the measurements. To evaluate the transport and centering ability, the method described by Gambill *et al*.[11] and Stern *et al*.[12] was adopted. Transportation was calculated as follows: $(X_1 - X_2) - (Y_1 - Y_2)$. X_1 represents the shortest distance from the furcal (distal) aspect of the root to the periphery of the uninstrumented canal. X_2 represents the shortest distance from the furcal (distal) aspect of the root to the periphery of the prepared canal. Y_1 represents the shortest distance from the mesial aspect of the root to the periphery of the uninstrumented canal. Y_2 represents the shortest distance from the mesial aspect of the root to the periphery of the prepared canal. A result of zero indicated no canal transportation; a positive result indicated transportation toward the furcal (distal) aspect of the root; a negative result indicated transportation toward the mesial aspect of the root. Centering ability was calculated by the formula: $(X_1 - X_2)/(Y_1 - Y_2)$ or $(Y_1 - Y_2)/(X_1 - X_2)$.[11] A result of one would indicate perfect centering ability; the closer the result is to zero, the worse the ability is of the instrument to remain centered.

Statistical analysis

Data were presented by mean and standard deviation. Results were analyzed by ANOVA and Tukey *post hoc* tests by means of the software SPSS Statistics 19.0 (SPSS IBM Corporation, Armonk, NY, USA) with a significance level of 5%.

RESULTS

All evaluated systems showed no difference for centering ability in the cervical portion ($P > 0.05$). Reciproc® presented a worse behavior, in the apical third ($P = 0.032$), when compared to ProTaper® [Table 1]. Regarding canal transportation, there were no significant statistical differences among the experimental groups in both apical and cervical thirds ($P > 0.05$) [Table 2]. One #10 MTwo® instrument fractured during its third use, and one #25 Reciproc® instrument presented alterations at the end of the active portion after three uses. Considering the results, the null hypothesis is rejected.

DISCUSSION

During the preparation of root canals, there is the intention to maintain its original shape and position. Trajectory deviation can be caused by instrumentation, leading to difficulties in obtaining the correct cleaning and subsequent filling, threatening the success of endodontic treatment.[13] Historically, studies evaluating the instrumentation of root canals have been conducted by means of radiographic analysis, serial sections, diafanization, clinical and scanning electron microscopy.[14,15,16,17,18] Nevertheless, none of these methods are able to analyze the specimen without altering it, beyond the impossibility to evaluate it in three dimensions.[19] Computed tomography is a noninvasive technique that allows assessment of structures and is frequently used to evaluate the canal morphology before and after instrumentation,[20] being considered the gold standard in studies ex-live.[21]

Nazari Moghadam *et al*.[5] emphasizes that apical transportations that are > 0.3 mm can jeopardize the outcome of treatment due to the significant decrease in the sealing ability of root filling material; thus, studies that evaluate apical deviation are important tools to improve clinical practice. The centralization of instruments in root canals is also an important factor to be considered for the evaluation of possible deviations arising from the instrumentation.[22] Results showed that the kinematics of movements and the file sequences influenced the centering ability. In the apical third, the single-instrument system, Reciproc®, showed the different behavior when compared to ProTaper® but did not differ from manual and MTwo® groups. Maitin *et al*.[4] also observed different behavior for ProTaper® when compared to MTwo®. Furthermore, it must be considered that cervical preparation can influence the outcome. In addition, the thermomechanical treatment developed to modify the NiTi alloy in reciprocating instruments to increase the flexibility may not have improved their performance.[2]

Peters[23] defined transportation as any undesirable deviation from the natural path of the canal. Several authors show that rotary systems promote less canal transportation than manual instrumentation.[24,25] In our study, the values obtained for transport in the apical third were very close to zero, indicating no canal transportation for all groups. This result is probably due to the small apical diameter used during canals preparation (#25) as they are narrow and curved. Regarding canal transportation in the coronal root third, even with no statistically significant difference, ProTaper® showed transportation toward the furcal aspect, also reported in previous studies.[4] This might be attributed to the brushing motion during rotary instrumentation.

Stern *et al*.[12] evaluated the centering and the shaping ability of ProTaper® used in reciprocating motion and in continuous rotary motion observing no differences between the techniques, corroborating with our results. These results were also described by Nazari Moghadam *et al*.,[5] when comparing Reciproc® with a rotary motion system (Twisted File®). In this study, there was a separation of one #10 MTwo® instrument in its third use and one #25 Reciproc® instrument showed alterations at the end of the active portion after three uses. These changes may be related to the absence of cervical preflaring in these experimental groups.

In the search for new instruments and systems that contribute for the simplification of endodontic procedures, it is a risk to consider valid only the arguments used by manufacturers, which can confuse simplification with simplicity. Technological development has contributed to the improvement of technical procedures, and there is a faint line between clinical significance and research findings published.

CONCLUSION

From the results of this study, it can be concluded that there was no difference in transportation between systems of continuous rotation (ProTaper® and MTwo®), reciprocating motion (Reciproc®), and manual crown-down instrumentation for the preparation of curved root canals when using the apical instrumentation diameter #25.

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Conflicts of interest

There are no conflicts of interest.

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Figures and Tables

Table 1

Group	Cervical	Apical
PT	0.58±0.30	0.83±0.35[a]
MT	0.78±0.68	0.56±0.30[ab]
RE	0.54±0.26	0.49±0.37[b]
MI	0.54±0.24	0.80±0.27[ab]

In column: Mean values followed by different superscript letters are significantly different.
PT: ProTaper®, MT: MTwo®, RE: Reciproc®, MI: Manual instrumentation

Means and standard deviations of centering ratio

Table 2

Group	Cervical	Apical
PT	0.19±0.78	−0.06±0.27
MT	−0.31±0.80	0.0±0.11
RE	−0.07±0.80	0.07±0.25
MI	−0.28±0.84	−0.05±0.08

PT: ProTaper®, MT: MTwo®, RE: Reciproc®, MI: Manual instrumentation

Means and standard deviations of canal transportation (mm)