Analysis of apical deviation promoted by three endodontic systems: manual, rotary and reciprocating

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ABSTRACT

Objective: This study aimed to analyze apical deviation occurrence after preparation with three systems: manual, rotary and reciprocating. **Material and Methods:** Thirty simulated curved root canals 16 mm in length and a 35 degree angle were used. Canals were divided into three experimental groups, according to the system used: manual, rotary and reciprocating. The canals in the manual group were prepared by the crowndown technique, stainless steel #30 memory files were used. In the rotary and reciprocating groups, canals were instrumented by the rotary and reciprocating systems, respectively (Wizard NavigatorTM and UniconeTM) both engine-driven. For apical deviation analysis, before and after preparation, canals were filled with Indian ink and photographed in a standard manner on a platform.

Subsequently, the images were manipulated by Adobe PhotoshopTM software, with superimposition of pre- and postoperative images. The occurrence of deviation was measured 1 mm and 3 mm short of the working length (WL) with the aid of a ruler tool. Data were subject to analysis of variance (ANOVA), followed by post hoc Turkey's test, with significance set at 5%. **Results:** The occurrence of apical deviations in the manual group was significantly higher when compared to the other groups. In all three groups, mean deviation 1 mm short of the WL was significantly greater than that 3 mm short of the WL. **Conclusion:** The manual technique provided a larger amount of apical deviation compared to the rotary and reciprocating systems. A high number of deviations was observed 1 mm short of the WL.

Keywords: Endodontics. Root canal preparation. Computer-assisted image processing.

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Introduction

The aim of mechanical instrumentation is to form a continuously tapered shape canal with the smallest apical foramen diameter and the largest cervical third diameter possible,¹ while respecting root canal anatomy, without deviations from the original trajectory, mainly in curved and thin canals.²

The use of stainless steel endodontic instruments allows safe instrumentation in straight portions of the root canal. However, there is a risk of accidents, such as canal transportation, as the degree of root curvature increases. Stainless steel instruments have limitations due to being little flexible and having a tendency towards straightening curved canals during instrumentation.

For this reason, NiTi alloy began to be used for the manufacture of endodontic instruments.³ NiTi properties make instrumentation easier and allow instruments to follow the curvature of the root canal, thus minimizing the risk of apical transportation and potential changes in root canal original form.

In 1995, Serene et al⁴ compared stainless steel with NiTi instruments and found that steel instruments require higher loading to be bent in relation to NiTi ones.

Aware of the advantages of NiTi files, such as maintaining the original canal trajectory and being less likely to cause apical transportation, Yared⁵ proposed a technique using only one instrument of the ProTaperTM Universal system: Finishing File #2 under reciprocating movement. The aim of this technique would be to promote a reduction in instrument fatigue and reduce the time required for instrumentation,⁶ based on the balanced forces of Roane et al.⁷ Many authors conducted studies comparing the use of reciprocating and rotary motion, evaluating the cyclic and flexural fatigue of NiTi instruments used under reciprocating motion, proving their greater resistance when compared with conventional rotation,⁸ longer lifetime duration of the instrument⁹ and greater centering ability.¹⁰

Thus, this study aimed to analyze the occurrence of apical deviation after preparation of simulated canals with three different types of endodontic preparation: manual, rotary and reciprocating.

Material and Methods

Thirty blocks of simulated canals (Dentsply Maillefer, Ballaigues, VD, Switzerland), with 35° of curvature, 16 mm in length from the orifice and apical diameter of 0.15 mm were used. The simulated canals were randomly divided into three experimental groups.

During canal preparation, the simulated blocks were secured to a benchtop lathe to facilitate instrumentation, with the direction of root canal curvature standardly positioned towards the operator's right hand. The working length (WL) was standardized in 15 mm.

Canal preparation in the three experimental groups was performed by a single operator, and each set of instruments was used to prepare five simulated canals.

Prior to and during preparation of the three experimental groups, at every change of endodontic instrument, the canals were irrigated with distilled water (Iodontosul - Industrial Odontológica do Sul Ltda., Porto Alegre, Brazil) to remove resin debris, followed by anionic detergent irrigation with Tergensol (Inodon, Porto Alegre, Brazil) to lubricate the canals. Both irrigants were stored in a 10-mL disposable syringe (Plastipak Indústria Cirúrgica Ltda., Curitiba, Paraná, Brazil), coupled to a 25 x .04cm hypodermic needle (Ultradent do Brasil Produtos Odontológicos Ltda., Indaiatuba, São Paulo, Brazil). Aspiration was performed with a point coupled to a cannula size 40-20 (Ibrás CBO Indústria Cirúrgica e Óptica S.A., Campinas, São Paulo, Brazil) adapted to the suction unit of the dental chair (Dabi Atlante Ltda., Ribeirão Preto, São Paulo, Brazil).

For the manual preparation of the simulated canals, stainless steel Flexofile (#15 to #40) and K-file (#45 and #50) (Dentsply Maillefer, Ballaigues, VD, Switzerland) instruments were used. Instruments were used in the following sequence: #50, #45, #40, #35, #30, #25 and #20 up to the WL. Subsequently, apical preparation was executed with the following sequence of instrument: #20, #30, #35, all up to the WL. Instrument size #30 was standardized as the memory instrument. The step back technique was used to finish preparation, reducing 1 mm at each change of instrument, sizes #35, #40 and #45.

In the rotary group, preparation was performed with Wizard Navigator[™] (Medin, Nové Město na Moravě, Czech Republic) under continuous rotary movement. The sequence used was #25.07 for cervical preparation, followed by #10.04, #15.04, #20.06,

#25.06 and #30.06 up to the WL. A #15 instrument was used to check for patency. Instruments were driven by an electric X-Smart motor (Dentsply Maillefer, Ballaigues, VD, Switzerland) at constant rotation of 300 rpm and 2.5N of torque.

In the reciprocating group, the canals were prepared with Unicone[™] (Medin, Nové Město na Moravě, Czech Republic) instruments under reciprocating movement. The following sequence was applied: #20.06 and #25.06. Instruments were driven by an electric VDW Silver motor with Reciproc[™] update (VDW GmbH, Munich, Germany) at speed and torque previously calibrated by the calibration function (CAL).

At every change of instrument, a #15 endodontic instrument (Dentsply/Maillefer, Ballaigues, Switzerland) was manually inserted up to the WL to promote resin debris removal from the canal apical area.

To analyze apical deviation, before and after preparation, the simulated canals were positioned onto a glass platform and photographed with a digital camera, always with the same object-to-focus distance. To improve photograph visualization contrast, Indian ink (Trident Indústria Precisão Ltda., Itapuí, São Paulo, Brazil) was injected into the root canals.

Thereafter, the obtained images were manipulated by Adobe PhotoshopTM version 6.0. To transform the image in millimeters, the original length of the canal was associated with the image length on the computer screen. Consequently, the image pixels were not reduced, thus maintaining image sharpness. With the aid of the same software, the images were submitted to contrast adjustment. Each post-operative image was transformed into a 50% transparence layer, and each one was superimposed to the preoperative image. Therefore, we observed, through transparence, both images superimposed.

Subsequently, the ruler tool was used to locate accurately the images sites where the deviations would be measured. This analysis was predetermined at 1 mm and 3 mm short of the WL.

Deviation measurement was performed with the aid of the ruler tool onto both points to be analyzed. Distances measured were: from the internal face (IF) of the original canal to the internal face of the prepared canal and from de external face (EF) of the original canal to the external face of the prepared canal. Data were subject to statistical analysis.

Data obtained were submitted to ANOVA statistical analysis, complemented by Tukey multiple comparison test at a 5% significance level. Analyses were conducted with SPSS version 22.0 (SPSS Inc, Chicago, IL, USA).

Results

Results are shown in Table 1. In each one of the positions analyzed, the mean obtained in the manual group was higher comparing to the other two experimental groups. Furthermore, for each group, the deviation mean at 1 mm from the CT was significantly higher than 3 mm from the CT.

	Positions analyzed in the simulated canals				
Experimental group	1 mm		3 mm		p*
	Mean	SD	Mean	SD	
Manual	0.066 ^A	0.024	0.041 ^A	0.012	< 0.001
Rotary	0.025 ^в	0.016	0.014 ^B	0.007	0.007
Reciprocating	0.024 ^B	0.016	0.014 ^B	0.007	0.015

Table 1. Analysis of apical deviation comparing the three experimental groups regarding the two positions analyzed in simulated canals.

Means followed by different letters in the column differ significantly in Analysis of Variance complemented by Tukey's multiple comparison test at a significance level of 5%.

p = minimum level of significance of Analysis of Variance.

 p^* = minimum level of significance of t-test for paired data.

SD = standard deviation.

Discussion

One of the objectives of the evolution of endodontic instruments is to maintain the path of root canal during instrumentation. A number studies¹¹⁻¹⁴ also analyzed the effects of mechanical root canal preparation regarding accidents such as apical deviation.

In order to have a standardized sample in terms of root canal curvature and diameter, as well as hardness of the walls, simulated canals were used based on previous studies.^{15,16,17} The area analyzed in the apical third of the canal (1 mm from the WL) was determined due to the fact that this is where deviations normally occur. As for the middle of the curvature (3 mm from the WL) was chosen due to the higher tensile and compression load that the instrument suffers inside a curved root canal.

Other studies^{18,19} also performed the same analysis by overlapping images and measuring deviations with the aid of Adobe Photoshop[™]. However, this method of analysis has some limitations regarding measurement taking, as it conducts two-dimensional measurement taking of a tridimensional structure. In order to avoid such trouble, some authors^{6,9,14} used computed microtomographic analysis which allows the centering ability and the direction of deviation apical to be measured.

A greater deviation is observed in the canals prepared by the manual technique when compared to the ones prepared with the automated technique, thus agreeing with the studies by Pires et al²⁰ who used ProfileTM and RaceTM rotary instruments, and Gergi et al²¹ with ProtaperTM Universal and TwistedTM file systems. Analysis of results explains the condition by the difference between the alloys of instruments used. Stainless steel instruments used for manual preparation did not have good elastic memory as NiTi instruments did, in addition to having less flexibility when endodontic preparation was performed with instruments larger in diameter, which tends to straighten curved root canals, agreeing with Serene et al.⁴ According to the literature, only the study by Hartmann et al²² showed a smaller deviation rate for manual preparation performed with K-file instruments compared to oscillatory preparation with the same instrument and with rotary preparation with ProtaperTM Universal system.

However, due to being a new system, in the study by Bügel et al,²³ Wizard NavigatorTM showed no difference in terms of centering ability when compared to a well-known endodontic system: BioRaceTM.

The similarity in apical deviation observed in the two mechanical systems (rotary and reciprocating) is in accordance with other studies.^{24,25,26} However, in some studies,^{27,28} the reciprocating system proved more effective than continuous rotation. According to Castelló-Escrivá et al,²⁹ stress generated to instruments during reciprocating motion is smaller than the stress generated by continuous rotation; thus, instruments show higher resistance³⁰ and higher lifetime duration.⁹

Finding a greater deviation at 1 mm from de WL in relation to the other point analyzed in the middle of the curvature (3 mm from the WL), regardless of the system used for preparation, could be explained by the higher tensile strength suffered by the instrument in the apical third. Additionally, at 1 mm from the WL, there is a greater degree of curvature when compared to 3 mm from the WL.

Conclusion

According to the results, it can be concluded that:

» Canal preparation with the manual method had higher apical deviation values when compared with canals instrumented with the rotary and reciprocating systems.

» The location at 1 mm from the WL had higher apical deviation values when compared with the location at 3 mm from the WL.

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