Analysis of apical deviation by type of system used to drive NRT® MANI rotary instruments

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ABSTRACT

Purpose: One of the major challenges encountered in treatment of curved canals is maintaining their original features. This study aimed to examine whether the type of system used with NRT® rotary instruments might influence the occurrence of deviation in the apical region.

Methods: Twenty simulated curved canals were divided into two experimental groups. In Group 1, canal preparation was performed with the pneumatic hand piece, using constant speed, but without torque control. In Group 2, an electric motor with constant speed and torque control was used. The simulated blocks were photographed before and after preparation using a platform to maintain the same position in both photographs. Images were manipulated in Adobe Photoshop® to evaluate deviation at 1 mm and 3 mm from the working length (WL). The *t* test was used for statistical analysis of data. The significance level was set at 1%.

Results and Conclusion: Group 2 (electric motor) had lower values for deviation at both locations analyzed (1 mm and 3 mm from the WL). In both groups, sites 3 mm from the WL had lower mean deviation than sites 1 mm from WL.

Keywords: Endodontics, Root Canal Preparation, Dental Equipment, Complications.

Análise do desvio apical de acordo com o tipo de sistema utilizado para acionamento dos instrumentos rotatórios NRT® MANI

RESUMO

Objetivo: Um dos grandes desafios no tratamento de canais curvos é manter suas características originais. Este estudo teve como objetivo examinar se o tipo de sistema utilizado com

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os instrumentos rotatórios NRT® poderia influenciar a ocorrência de desvio na região apical.

Métodos: Vinte canais curvos simulados foram divididos em dois grupos experimentais. No Grupo 1, a preparação dos canais foi realizada com um sistema pneumático, com velocidade constante mas sem controle de torque. No Grupo 2, utilizou-se um motor elétrico com velocidade constante e controle de torque. Os blocos simulados foram fotografados antes e após a preparação utilizando uma plataforma para que a mesma posição fosse mantida nas duas fotografias. As imagens foram manipuladas no software Adobe Photoshop® para avaliar o desvio a 1 mm e a 3 mm do comprimento de trabalho. O teste *t* foi usado para fazer a análise estatística dos dados. O nível de significância foi estabelecido em 1%.

Resultados e conclusão: O Grupo 2 (motor elétrico) mostrou valores menores de desvio nos dois pontos analisados (1 mm e 3 mm do comprimento de trabalho). Em ambos os grupos, as áreas localizadas a 3 mm do comprimento de trabalho apresentaram desvio médio menor do que as áreas localizadas a 1 mm do comprimento de trabalho.

Palavras-chave: Endodontia, Preparação de Canais Radiculares, Equipamentos Dentários, Complicações.

INTRODUCTION

The challenging when performing chemo-mechanical preparation of canals is to conduct endodontic instrumentation to enlarge the root canal that maintains its shape without causing deformation or deviation.

According to Schäfer et al. (1) anatomical changes (deviations during root canals instrumentation) imposed on curved root canals during endodontic instrumentation may influence the prognosis of endodontic treatment success. Apical deviation compromises cleaning and elimination of microorganisms from the canal system, and this is particularly true of the apical third.

With the advent of rotary nickel-titanium instruments (NiTi), occurrence of these accidents has been reduced. The reduction in such accidents is due to the properties of the alloy, such as flexibility, torsional resistance and shape memory (2,3).

Studies by Thompson and Dummer (4), Chen and Messer (5) and Schäfer et al. (6) showed that canal preparations performed with rotary NiTi instruments were more centralized in curved canals, in comparison with preparation performed with manual instruments. Additionally, the same authors demonstrated that it took less time to finish complete preparation when Ni-Ti instruments were used.

However, some studies have shown that even using NiTi instruments it is not guaranteed that there will be no deviations during root canal preparation, given that other factors such as the experience of the operator (7), and the speed and the torque to which the electric motor used in activation is programmed can also have an influence.

Rotary instruments are used at low speed and are driven by electric or pneumatic systems. Electric motors, commonly available on the market, provide accurate and constant control of speed and torque. However, Bortnik et al. (8) and Buchanan (9) have shown that there is no difference between electric and the compressed-air drive in terms of deformation or fracture of endodontic instruments.

Therefore, the objective of this study was to examine whether the type of system used with NRT® rotary instruments might have an influence on the occurrence of deviation in the apical third of simulated canals.

MATERIALS AND METHODS

Twenty simulated canal blocks were used (Dentsply Maillefer, Ballaigues, VD, Switzerland), with 35º curvature, 16 mm length from the orifice and apical diameter of 0.15 mm.

Canals were prepared with NRT® system rotary endodontic instruments (MANI Inc., Toshigi, Japan) in both experimental groups and the only variation in the preparation protocol was the choice of one of the two motors analyzed in the study (Table 1).

TABLE 1 – Experimental groups.

Group	n	Rotary system	Type of drive employed
G1	10	NRT® MANI	Pneumatic
G2	10	NRT® MANI	Electric

During the canal preparation, simulated blocks were fixed to a counter mini clamp to facilitate instrumentation, with the direction of root canal curvature standardized as toward the operator’s right hand. The working length (WL) was standardized at 15 mm.

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

Prior to and during preparation of the two experimental groups, canals were irrigated with distilled water at every change of endodontic instrument, (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 canal. Both irrigants were stored in a 10 mL disposable syringe (Plastipak Indústria Cirúrgica Ltda., Curitiba, Paraná, Brazil), fitted to a 25 x 04 hypodermic needle (Becton-Dickinson Indústria Cirúrgica Ltda., Curitiba, Paraná, Brazil). Aspiration was performed with a tip fitted to a size 40-20 cannula (Ibrás CBO Indústria Cirúrgica e Óptica S.A., Campinas, São Paulo, Brazil) which was in turn fitted to the suction unit of the dental chair (Gnatus Equipamentos Médico-Odontológicos Ltda., São Paulo, São Paulo, Brazil).

The protocol for preparation of the simulated canals was the same in both experimental groups. Initially, cervical preparation was performed with stainless steel instruments, first #35/12 was taken to 5 mm, followed by #35/10 up to 7 mm from the entrance of the canal. Next, #25/06 and #30/06 were used at 3 mm from WL and then instruments #25/04 and #30/04 were used calibrated to the WL.

In G1, the preparation of simulated canals was done with NRT® rotary instruments driven by an Endo Duo 40: 1 pneumatic piece (Adiel®, Ribeirão Preto, São Paulo, Brazil) coupled to a handpiece (Dabi Atlante, Ribeirão Preto, São Paulo, Brazil), with constant rotation of 250 rpm and no torque control.

In the G2 group, canals were prepared with rotary NRT® instruments driven by an X-Smart electrical motor (Dentsply / Maillefer, Ballaigues, Switzerland), with constant rotation of 300 rpm and torque of 1.5 N and 3 N for instruments with tapers of 0.04 and 0.06, respectively. Instruments for cervical preparation with 0.10 and 0.12 tapers were used at a torque of 5 N, according to the manufacturer's recommendations.

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

Apical deviation was analyzed before and after preparation by positioning canal blocks on a platform and photographing them with a digital camera, always using the same object-to-focus distance. Indian ink was injected into root canals to improve the photographic contrast and aid viewing.

Next, the images acquired were manipulated on Adobe Photoshop®, version 6.0. Images were transformed into millimeters by relating the original length of the canal to the image length on the computer screen, thereby avoiding reduction of the image pixels, maintaining the image's sharpness.

The same software was used to adjust the contrast of the images. Each post-operative image was transformed into a layer with 50% transparency and then each one was superimposed onto the preoperative image. We were therefore able to observed both images superimposed as a result of the transparency.

Next, the ruler tool was employed to locate the exact sites on the image at which deviations would be measured. These analysis points were pre-determined at 1 mm short of WL (Figure 1) and 3 mm short of WL (Figure 2).

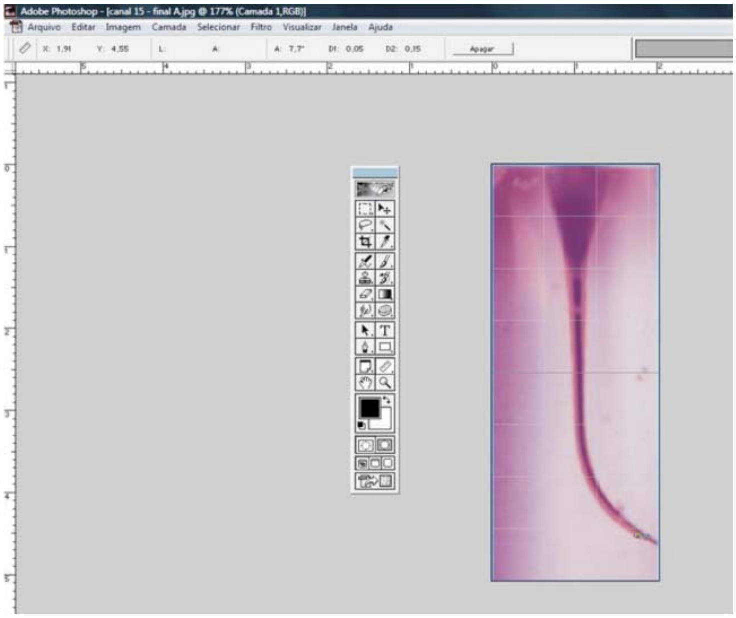

FIGURE 1 – Image illustrating analysis of deviation at 1 mm short of WL by superimposition of images from before and after root canal preparation, in group A.

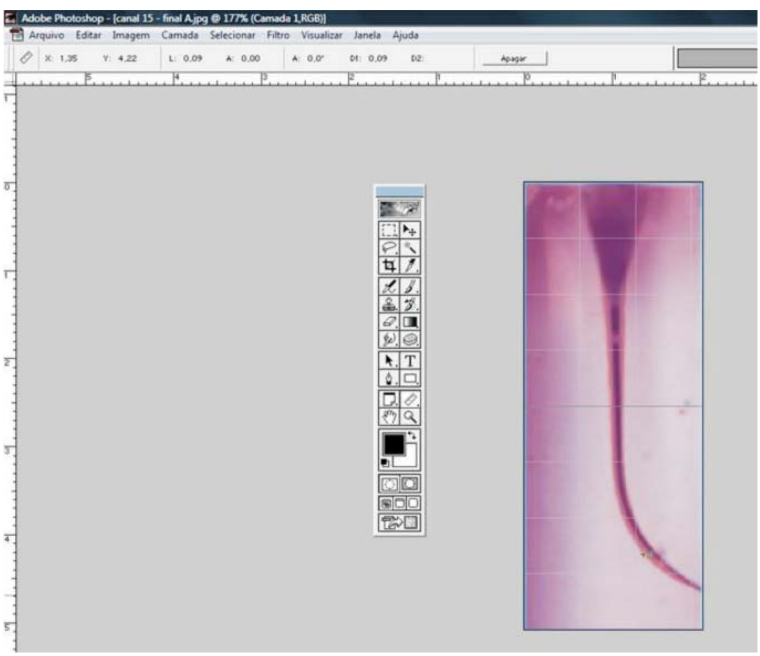

FIGURE 2 – Image illustrating analysis of deviation at 3 mm short of WL by superimposition of images from before and after root canal preparation, in group A.

Deviations were measured at both points to be analyzed with the aid of the ruler tool. Distances were measured from the internal face (IF) of the original canal to the IF of the prepared canal and from the external face (EF) of the original canal to the EF of the prepared canal. Data were subjected to statistical analysis.

RESULTS

According to the *t* test, the group in which canals were prepared using an electric motor exhibited, on average, lower deviation at both analysis sites (3 mm and 1 mm of WL), when compared to canals instrumented with the pneumatic piece, to a 1% significance level (Table 2).

TABLE 2 – Means and standard errors for the two experimental groups.

	G1 (Pneumatic)		G2 (Electric)		
Analysis points	**Mean**	**SE**	**Mean**	**SE**	**p***
1 mm	0.079	0.008	0.032	0.006	< 0.001
3 mm	0.047	0.008	0.019	0.004	0.007
$p^{\dagger}$	< 0.001		0.001		

SE = standard error.
* *t* test for independent observations; † *t* test for paired observations

The *t* test for paired observations showed that the site 3 mm from the WL had significantly lower mean deviation than the site at 1 mm from WL, to a 1% significance level (Figure 3).

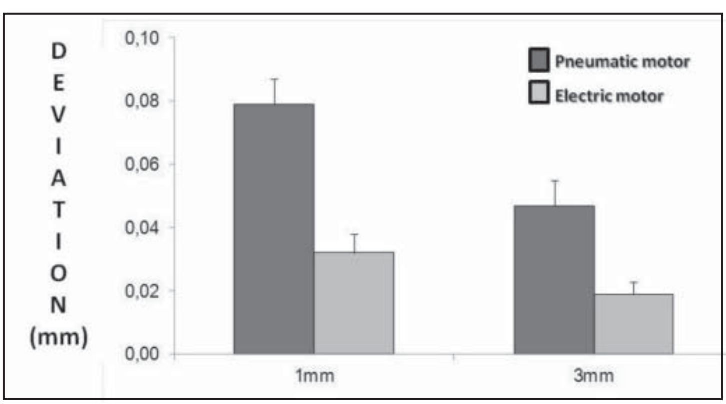

FIGURE 3 – Results for comparison of occurrence of deviation in the region analyzed in the two groups.

DISCUSSION

During canal preparation one of the major challenges that dentists face is to maintain the original anatomy of the curved root canal and also the position of the apical foramen. Based on this challenge, the present study investigated whether the type of motor used to drive the NRT® system affects apical deviation in simulated canals.

The use of ten samples in each group is in line with other studies, such as Thompson and Dummer (4) and Melo et al. (10). These authors also used simulated canals. One advantage of using simulated canals made from resin blocks is the possibility of standardizing the curvature, diameter and other features of the canals, such as, for example, the length of the straight part of the canal. This standardization reduces the possibility of bias in the results.

For the present study, canals with 35 degrees of curvature were chosen, in common with a study by Schäfer et al. (6). Other studies have also used canals with abrupt curves, varying from 20 to 40 degrees (11-14). It is important and useful to exaggerate the clinical situation in order to assess how an endodontic instrument performs during preparation of severely curved canals.

Comparison of the apical deviation in the two experimental groups showed that instruments driven by a pneumatic hand piece caused greater deviation than instruments driven by an electric motor. This finding could be explained by the fact that the electric motor allows an exact torque and speed to be chosen. In contrast, the pneumatic hand piece does not offer this choice of torque and speed, which may have directly influenced the higher values for apical deviation in Group 1.

It is well known that many factors related to the properties of endodontic rotary instruments may act as adjuvants to apical deviation, such as, for example, the design of the instrument, its metallurgic composition, and variations in its tip diameter and taper (15). Based on this, our study is able to show that the rotary system is safer than the pneumatic system in terms of apical deviation, because of the ability to control the speed of rotation and torque, as reported by Limongi et al. (16) and López et al. (17).

However, our findings are in disagreement with other autors, who showed that apical transportation and the ability to center the instrumented canal were not influenced by the type of instruments or type of movement: rotary or oscilatory (18,19). Capar et al. (20) also support this point of view, because they found that six different systems (including rotary and reciprocating) were similar in terms of the ability to center the instrumented canal and the likelihood of apical deviation. Additionally, Saber and Sadat (21) observed reduced apical transportation and better centered canals in molars that had been instrumented using WaveOne®.

According to Dietz et al. (22), Yared et al. (23), Zelada et al. (24) and Gao et al. (25), when instruments are operated at higher activation speeds, there is increased risk of accidents during chemo-mechanical preparation of root canals and of damage to the rotary instrument, such as deformities and fractures.

Safe use of devices (hand pieces) without speed controls to instrument canals is dependent on the operator's experience and mastery of the technique. According to Al-Omari et al. (26), an expert operator is able to prepare root canals with Rotary Ni-Ti instruments more quickly and more safely than non-expert dentists. Mandel et al. (27) highlight the need of previous mastery and training by the operator in relation to the chosen instruments and technique if canals are to be instrumented sucessfully. In-depth knowledge of how instruments should be used allied to previous experience may reduce endodontic acidentes and anatomic canal aberrations.

The higher degree of apical deviation at 1 mm from the WL is in accordance with a study by Hata et al. (28). In this regard, Melo et al. (10) used the oscilating system and found higher mean deviation at 1 mm from the WL, compared with the deviation in the medium third of the canal (in the middle of the curvature). The literature has continued to show that the apical third, especially at 1 mm from the root end (or from the WL), is where the majority of apical deviation occurs.

Therefore, it is very important to have in-depth knowledge about the instruments and the motor device chosen to instrument the canal. If it is not possible to control torque and speed during instrumentation of curved canals, then it will be very difficult to maintain the original shape of the canal.

CONCLUSIONS

According to the results of this study, it can be observed that:

- Canal preparation with a pneumatic motor resulted in greater apical deviation when compared with canals instrumented using the electric motor.

- The site at 1 mm from the WL exhibited greater apical deviation than the site at 3 mm from the WL.

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