The effect of a brushing motion inside a sequence: an *in vivo* study

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Summary

The aim of the present study was twofold: to propose a new methodology to analyze instrumentation stress *in vivo* by measuring the torque provided by an endodontic motor during the clinical use of the nickel-titanium rotary (NTR) instruments; and to compare the advantage of brushing techniques in reducing operative torque.
40 canals were divided in two groups (n=20) and prepared by a skilled endodontist using TF 35. 04. rotary instruments (KerrEndo, Orange, Ca). In one group, a 30 s brushing was previously performed with a (TF 25.06) to increase flaring. All instruments were rotated at 500 rpm with maximum torque set at 2,5 N using an endodontic motor (Kavo, Biberach, Germany), which automatically records and saves torque and speed values every 1/10 seconds. Data were recorded and statistically analyzed with the significance level set at p.
Previous coronal flaring (brushing) with the first instrument (size 25, taper 06) significantly reduced instrumentation torque (both mean and maximum torque values), time and number of steps needed by the second instruments (size 35, taper 04) to reach working length.
The development of new and more sophisticated means of analysing torque during intracanal shaping provides useful information for a better understanding of the instruments performance *in vivo*, aiming at improving efficacy and safety.

Key words: torque, speed, nickel-titanium, rotary instruments.

Introduction

The use of nickel-titanium rotary (NTR) instruments became the most effective and popular method amongst endodontists for shaping root canals, even if there are still many concerns regarding the increased risks of intracanal breakage or weakening of the instruments (1-3). As a consequence, manufacturers since 1990s started to change cross-sectional designs and geometrical traits of instruments to improve both torsional and cyclic fatigue resistance (4-7). In the last decade another strategy to achieve this goal was the use of new manufacturing processes to optimize the microstructure of NiTi, basically through innovative thermomechanical processings. NTR instruments produced with these technologies (M-wire, CM wire or Twisted Files Technology) showed better properties for the endodontic use in terms of flexibility and resistance to mechanical stresses when compared to traditional NiTi alloy (8-11). More recently, it has been introduced a new important innovation: the use of reciprocating motion instead of continuous rotation. Current literature data show that reciprocating motion can extend both torsional and cyclic fatigue resistance of the instruments when compared to continuous rotation (12, 13), mainly because it reduces instrumentation stress.
Apart from the above mentioned features which are depending on manufacturers' strategies, there are other clinical factors that significantly affect torsional and cyclic fatigue resistance of NTR instruments (14-16): the anatomic challenges, the applied pressure and the differences in the use among the various clinicians (i.e. pecking or other motions, the creation of a glide path, the tendency to force apically, brushing action, the use of torque controlled motors, etc.). All these differences are very difficult to evaluate since they are mostly related to individual skills, sensitivity and operative choices during intracanal instrumentation.
Previous studies have clearly shown that the creation of an endodontic glide-path positively reduces the risk of intracanal fracture both in continuous rotation

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and reciprocation (17, 18). It would be interesting to assess if and how much clinical performance of instruments is affected by a different clinical usage, like performing or not a brushing motion. The brushing motion is meant to increase coronal flaring and theoretically should make apical progression of the next instrument within the sequence easier and less stressful (19, 20). Therefore, the goal of this study was to analyze *in vivo* performance of TF instruments in a continuous motion, aiming at evaluating the clinical advantages of brushing motion, if any and to propose a new methodology to analyze torque values during intracanal shaping.

Materials and methods

Twenty patients (12 men, 8 women, age ranging from 19 to 67 years old), who needed endodontic treatment of first upper premolar were randomly selected for the present study. Following cavity access, all canals (n=40) were negotiated initially with a size 10 K-file and working length was established using an Apex ID digital apex locator (Kerr, Orange, CA, USA). A manual glide-path was created in all the canals up to size 20 to ensure similar canal dimensions and more predictable progression of nickel-titanium rotary (NTR) instruments to the canal terminus. Teeth exhibiting non patent canals, severe curvatures (>30) were excluded from the study and canals were randomly divided in two similar groups (n=20). For each tooth, one canal was assigned to a first group, and the other one to the second group, to avoid differences given by dentin hardness and operative position. All root canal treatments were performed by the same experienced endodontist, to avoid bias due to different hand pressure, using two TF instruments (KerrEndo, Orange, CA): size 25 and .06 taper followed by size 35 and .04 taper. All instruments were single used according to the manufacturer's instructions.

Instruments were rotated at 500 rpm with maximum torque set at 2,5 N using endodontic motor provided by Kavo (Biberach, Germany) and a Kavo 1:1 Handpiece. A prototype software provided by Kavo allowed to record instrumentation torque values automatically, and save them in a memory card. The motor was based, as every torque measuring device, on torque sensors. The accuracy of the sensors was high, being capable of detecting minute variations of 0.05 N. The capability of measuring torque every 0.1 s also provided a large data set, ensuring a precise record of values during intracanal progression, and not only peak torque values (Figs. 1, 2). Root canals were then filled with a warm gutta-percha technique and the teeth restored by a composite filling.

TF size 35 and .04 taper instruments were manipulated until they reached the working length using a slight pecking motion without forcing the instruments apically. After each cycle of pecking motion, the instrument was removed from the canal and the flutes cleaned to remove debris. Irrigation was performed with syringe using the same amount (6 ml) of 5% Sodium Hypochlorite in each canal, 17% EDTA was used as lubricant. In the first group no brushing was performed with the 25.06 instrument; in the second group 30 seconds of brushing motion was performed using the previous instrument, to increase coronal flaring. Instrumentation torque was recorded only during negotiation with the second instrument (35.04) for both groups and data saved in an excel file. The following data recorded in 40 canals were statistically analysed: mean instrumentation time, number of steps, mean torque values, maximum torque values. One -way ANOVA test was used to assess differences between the two groups for the four abovementioned parameters. The significance level was set at $P<0.05$.

Results

The results showed (Table 1) present the descriptive data for TF 35. 04 instrumentation in both. Data was normally distributed (Shapiro-Wilk's test, $p > 0.05$), and there was homogeneity of variances (Levene's test, $p > 0.05$). The one-way ANOVA showed a significant difference between groups regarding the mean instrumentation time, number of steps, mean torque values, and maximum torque values ($p<0.05$).

Table 1. Comparison between the two groups (TF size 35 taper 04 instrumentation).

		Previous Brushing		**No brushing**	
	n	**Mean**	**SD**	**Mean**	**SD**
Mean Torque	20	0. 12^{a}	0.05	0.29^{b}	0.14
Max. Torque	20	0.73^{a}	0.19	0.99^{b}	0.38
Instrumentation time	20	3.34^{a}	1.56	6,16^{b}	2.61
Number of steps	10	2,8^{a}	0,4	5,2^{b}	1,6

Different superscript letter indicates statistical significance ($p<0.05$).

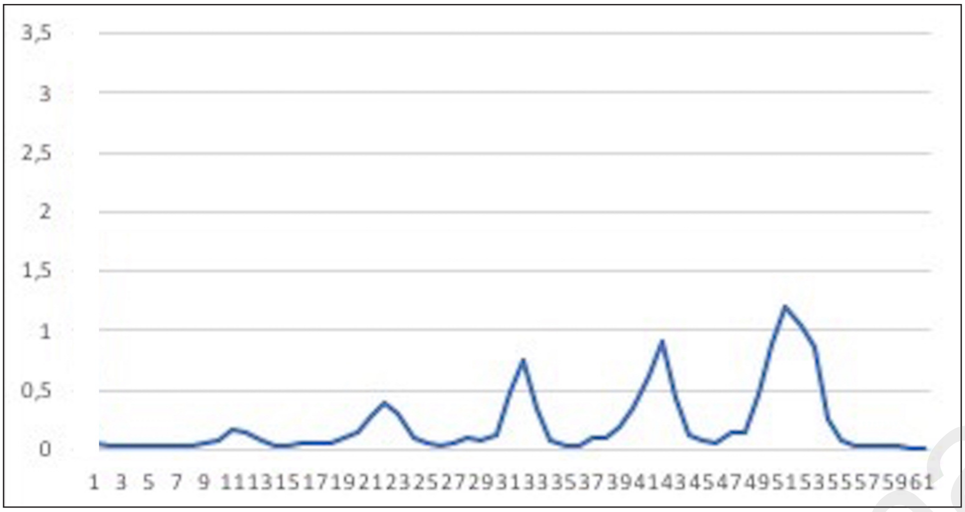

Figure 1. ML3 without brushing before.

Discussion

In the last decades, custom designed torque platforms were proposed to perform *in vitro* dynamic torque tests for NTR instruments, instead of using the ISO Standard static torque testing, but only few studies were published. The complexity of such dynamic devices and the difficulties in recording and storing a massive amount of data is involved in this kind of issue (21-23). The recent progresses in the mechanical, motors and sensors, and computer, software and storage, technologies allowed to build new endodontic motors, which can visualize or record *in vivo* instrumentation torque.

In the present study a new device for dynamic torque measurements was used, aiming at precisely analyzing performance of NTR instruments during their intracanal use *in vivo*. The motor allowed precise and easy recording of dynamic torque, storage and saving of all data, by using a memory card and an excel file. The images showed (Figs, 1, 2) are examples of how the proposed methodology can be useful in the analysis of clinical performance of NTR instruments. They show the torque generated during the *in vivo* instrumentation of one canal using. 04 35 TF NTR instruments. The graph provides a detailed reflection of the performance of the NTR instruments and the low torque values produced, much smaller than the preset torque values of 2.5 Ncm. These low torque values are an ideal clinical situation since ISO3630-1 testing has revealed that torsional failure for size 35.04 tapered instruments is approximately 1N/cm (24). Even if the ISO test is more challenging, since the tip is blocked 3 mm from the tip, the lower the

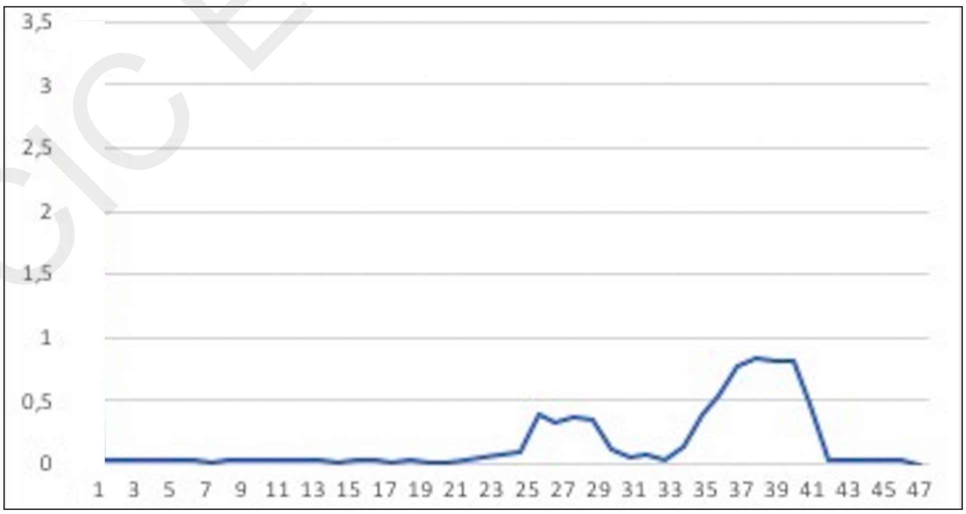

Figure 2. ML3 with brushing before.

torque, the lower the torsional stress, the safer the instrumentation. Both figures clearly show that intracranal progression was performed by steps with a pecking motion, continuously changing the engagement of the instrument against the canal walls and consequently the variation in the torque generated. The amplitude of the motion is a function of how easy was the progression of the instrument inside the canal: smaller values reflecting easier progression. In the first part of the graph the operator was enlarging the coronal and middle portion of the canal, which required less torque. In the apical part of the canal the smaller diameters required more torque, even if the maximum values reached can be still considered safe. Overall, the performance of the instrument allowed the working length to be achieved smoothly, without the tip locking, without excessive torque and in a relatively short time. However, in the brushing group the amount of steps, instrumentation time and torque values were lower, as comparison of the two different graphs can clearly illustrate.

Results from this study showed that previous coronal flaring (brushing) with the first instrument (size 25, taper 06) significantly reduced instrumentation torque (both mean and maximum torque values), time and number of steps needed by the second instruments (size 35, taper 04) to reach working length. These improvements not only made clinical negotiation easier and faster, but also reduced the instrumentation stress. The latter advantage may result in a significant reduction of the risk of intracanal breakage or a possible increase of NTR the instrument lifespan, allowing safer re-use of the instruments (25, 26).

The present study also confirmed previous ones showing that instruments within a sequence are subjected to different intracanal stresses, due to different dimensions and different blade engagement (28). These factors, however, are not only dependent on design and dimensions, but can be related to the clinical method of use (27). The increased coronal flaring provided by brushing with the first NTR instrument (size 25, taper 06) reduced blade engagement in the coronal/middle part of the second NTR instrument (size 35, taper 04), and consequently the torque needed to reach the working length (28).

A previous *in vitro* study on used instruments also demonstrated that the coronal flaring provided by the brushing action of the first NTR instrument reduced instrumentation stress on the second NTR instrument within the sequence. Resistance to both torsional stress (determined by the percentage of flutes deformation) and flexural stress (determined by *in vitro* resistance to cyclic fatigue of used instruments) was enhanced by the use of a brushing technique (27). The advantages related to an increased coronal flaring can be also clinically perceived by clinicians; nevertheless, the present article is the first that demonstrate and quantify *in vivo* the efficacy of brushing technique in reducing NTR intracanal instrumentation stress. Moreover, it can estimate the improvements with a massive amount of data.

The proposed methodology is therefore considered a useful tool to analyze the instrument and the techniques during their use in patients, providing useful information on how to maximize efficiency of NTR instrumentation and minimize the risk of breakage or metal fatigue during intracanal use.

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