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Influence of Rotation Speed of Mtwo Files on Root Canal Instrumentation Time with Different Canal Curvatures

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ABSTRACT

Introduction: The aim of this study was to analyze the effect of rotation speed on the instrumentation time of root canals with different curvatures using Mtwo NiTi rotary instruments. **Methods and Materials:** Forty root canals were selected and divided into 2 groups, according to the angle of curvature (group A>30°, group B<30°). Both groups were divided into 2 subgroups (n=10), according to the rotational speed used for root canal instrumentation (150 rpm: group A1 and B1; 250 rpm: group A2 and B2). The total instrumentation time and the total number of instrumentation cycles (NCI) required to complete root canal preparation were registered for each canal. The mean and standard deviation were then calculated. Data were then statistically analyzed using two-way ANOVA and interaction effect P-values ($P<0.05$). **Results:** During root canal instrumentation, there were no file fractures. Total instrumentation time of the low speed groups A1 (150 rpm) and B1 (150 rpm) were significantly higher ($P<0.05$) than that of the high speed groups, A2 (250 rpm) and B2 (250 rpm); however, there was no statistically significant difference in terms of NCI between the different groups ($P>0.05$). Statistical difference was not found between the different angles of curvature, group A1 *vs* B1 and A2 *vs* B2 in terms of total instrumentation time ($P>0.05$) and NCI ($P>0.05$). **Conclusions:** This *ex-vivo* study showed that canal preparation with M*two* rotary files could be completed safely with an increase of the instrumentation time at low rotational speed independently of the root canal curvature.

Keywords: Mtwo Rotary System; Nickel-titanium; Root Canal Preparation; Root Canal Therapy

Introduction

Nickle Titanium (NiTi) rotary instruments may fracture due to two different modalities: accumulation of cyclic fatigue or torsional failure [1]. Clinically, cyclic fatigue seems to be more prevalent in curved root canals, while torsional failure could happen in tight root canals [2]. The combination of both factors may also play an important role [3]. Fatigue fracture occurs because of metal fatigue. The Ni-Ti rotary instrument does not lock in the root canal but it freely rotates in a curved canal. At the point of maximum curvature, the instrument flexes until fracture occurs [4]. Torsional fracture occurs when the tip or any part of the instrument is locked in a canal while the shaft continues to rotate; the instrument exceeds the elastic limit of the metal and shows plastic deformation followed by fracture [5]. This type of fracture may be associated with excessive apical force during instrumentation [6].

Many factors may influence the fracture of Ni-Ti rotary instruments, including root canal anatomy [7], the type of canal curvature in terms of angle and radius, the dimensions (tip size and taper), the design of the instrument used [8], and the rotational speed at which the instrument is operated [9].

Most of the studies conducted regarding the influence of rotational speed on cyclic fatigue resistance of NiTi mechanical files reported that the number of rotations to fracture was not related to the rotational speed at which the files were used [10, 11]. Despite the rotational speed did not influence the pure mechanical behavior of NiTi files, it may have played a role from a clinical standpoint, as during root canal instrumentation used at a higher rotational speed may reach its maximum numbers of rotations until it fractures in less time. In fact, two studies conducted in extracted teeth [12, 13] demonstrated that the files used at a higher rotational speed were more likely to fracture and/or distort than those used at a lower rotational speed. Another study also showed that preparation time was significantly shorter when files were used at 350 and 250 rpm than at 150 rpm [9]. Therefore, the effect of the rotational speed of root canal instrumentation still remains uncertain [6].

Another important factor that may influence the resistance to fracture of Ni-Ti rotary files is the type of canal curvature to be prepared, in terms of angle and radius of curvature. It has been widely demonstrated that a smaller radius and a higher angle of canal curvature reduce the lifespan of the instruments tested for cyclic fatigue [8, 14].

Many different guidelines have been suggested throughout the years to prevent instrument fracture [15] and most of them are related to the operator experience using rotary files [16]. Experience of file separation was found to differ not only between different dental practitioners, but also at different times for the same practitioner [17].

Ni-Ti Mtwo instruments were used in a simultaneous technique without early coronal enlargement [8]. Instruments were each taken to working length with light apical pressure. As soon as the clinician felt a binding sensation, the instrument was withdrawn 1-2 mm so that it could be worked in a brushing action to selectively remove the interferences and to advance towards the apex. The instruments were used with lateral pressure in order to obtain a circumferential cut and only allowed to rotate at length for a few seconds. The aim of the present study is to analyze the influence of rotational speed of the mechanical instrumentation of root canals with different canal curvatures with Mtwo NiTi rotary instruments (VDW, Munich, Germany).

Materials and Methods

In the present *ex-vivo* experimental study, a total of 40 root canals of extracted intact completely formed human maxillary and mandibular molars were randomly selected on the angle of curvature calculated using the method described by Schneider [18]. Root canals were divided into two groups according to whether the angle of curvature was greater than 30 degrees (group A) or lesser than 30 degrees (group B).

Both groups were divided into 2 subgroups (n=10) according to the rotational speed used for root canal instrumentation (150 rpm: groups A1 and B1; 250 rpm: groups A2 and B2). Teeth were stored in 0.1% thymol solution during all phases of the experiment. After, the access to the pulp chamber was created, the orifice of each canal was located and negotiation was performed to the apex using .08 and .10 stainless-steel K-files (Micro-Mega, Bessancon, France). Root canals in which it was not possible to reach the apical foramen were excluded from the study and replaced. The working length of each root canal was established 0.5mm short of the point where the file appeared at the apical foramen and the coronal portion of each tooth was flattened using a diamond coated bur under water cooling to obtain similar lengths.

The specimens were then divided into 4 different subgroups (n=10). In group A1 (>30°/150 rpm) and B1 (<30°/150 rpm), root canals were instrumented with Mtwo rotary files up to a final size of preparation of tip size 25/0.06 taper. NiTi Mtwo instruments were used in a 16:1 hand-piece (Anthogyr, Sallanches, France) in conjunction with a high torque endodontic electric motor (E-Go, Sweden & Martina, Padova, Italy) at 150 rpm in a simultaneous technique [19]. Instruments were each taken to working length with light apical pressure. As soon as the clinician felt a binding sensation, the instrument was withdrawn 1-2 mm so that it could be worked in a brushing action to selectively remove the interferences and to advance towards the apex. The instruments were used with lateral pressure in order to obtain a circumferential cut and only allowed to rotate at length for three strokes. During shaping, each canal was irrigated between each successive instrument with 2.5 mL of 5.25% NaOCl using an endodontic syringe (Navi tip, Ultradent, South Jordan, UT, USA) placed as far into the root canal as possible without binding. The final flush was performed with 5 mL of 17% EDTA solution rinsed out with 5 mL of saline solution. In group A2 (>30°/250 rpm) and B2 (<30°/250 rpm), root canals were instrumented with Mtwo rotary files as in group A1 and B1 but at a rotational speed of 250 rpm. All the canals were instrumented by a student with new instruments for the four groups and the same instrument has been used in all ten canals of each group. All the instruments have been measured to check for any fractures after each were tested under an optical microscope at 16× magnification (Carl Zeiss, LLC, Oberkochen, Germany).

A digital chronometer was used to record the total instrumentation time for each root canal. The chronometer started when each of the four files used in the sequence for the instrumentation (tip size 10/0.04 taper, 15/0.05, 20/0.06 and 25/0.06) was inserted in the canal and stopped when they were removed from the root canal after reaching the working length, thus not calculating the time needed for the irrigation procedures. The total instrumentation time in seconds was obtained for each root canal by summing the instrumentation time of the four instruments used to complete the root canal preparation. The total number of instrumentation cycles (NCI) of each root canal was also calculated multiplying the total instrumentation time by the number of rpm. Mean values were then calculated.

Statistical analyses

Data were statistically analyzed using the two-way ANOVA test and the level of significance was set at 0.05.

Results

The mean angle of curvature of root canal was homogeneous in all the groups tested: A1=54°, A2=58.5°, B1=14.9° and B2=14.1°. No fractures have been found after the preparation of each root canal for each of the instruments tested. A total of 16 instruments used in the study, only one 10/.04 of A2 group (angle > 30°-250 rpm), deformations of the last mm of the turns have been documented under an optical microscope at 15×. Mean and standard deviation of instrumentation time (sec) and NCI for each group are reported in Table 1.

Total instrumentation time of the groups low speed A1 (>30°/150 rpm) and B1 (<30°/150 rpm) was significantly higher (P<0.05) than that of the groups high speed A2 (>30°/250 rpm) and B2 (<30°/250 rpm); on the contrary there was no statistically significant difference for the NCI values between the same groups (P> 0.05). No statistically significant difference was found between different angle of curvature group A1 (>30°/150 rpm) *vs* B1 (<30°/150 rpm) and A2 (>30°/250 rpm) *vs* B2 (<30°/250 rpm) in terms of total instrumentation time (seconds) and NCI (P>0.05).

In groups where significance has been found, to quantify the advantage following the use of increased rpm, the difference between the means of the total instrumentation time between group A1 and A2 and between the group B1 and B2, was also calculated: respectively 67 and 48 sec.

Discussion

In the present study, all canals were shaped according to the clinical protocol recommended using the simultaneous technique [19], no fracture was found. After instrumentation, only one deformation of the last mm of the turns have been documented under an optical microscope under 15×, without separation. This is the first instrument of the series, Mtwo 10/0.04, used in A2 group with the largest angle of curvature and high speed.

One of the major concerns in the use of rotary instruments in root canals is their fracture, with unfavorable outcomes for tooth survival [20, 21]. The clinical skills and the experience of the operator seem to be important clinical factors for root canal instrumentation [16]. Many studies showed the importance of improving operator competence through learning and experience [17, 22]. Novice operators with minimal training typically have the tendency to exert excess apical pressure and/or use rotary instruments for a long period of time in the canal and, consequently, the instrument may be subjected to higher-levels of stress [23]. In the past, due to a higher rate of deformation and fracture during clinical use, some authors have suggested the use of the Mtwo as single-use instruments [24].

A previous study showed a low accumulation of fatigue after clinical use for Mtwo files used to clean and shape 10 root canals of molar teeth, thus demonstrating that these files could be safely used in clinical conditions up to 10 times in curved canal of molar teeth [19]. This study is confirmed in the present study in which new instruments were used for the four groups and the same instrument has been used in all ten canals of each group. In the present study, the Mtwo instruments were used according to the simultaneous technique (manufacturer); some authors suggest the crown-down technique, as it did not interfere with resistance to cyclic fatigue and it showed a reduction in the instrumentation time of files 10/0.04 and 15/0.05 and this could reduce the fracture risk in the case of reuse of these instruments [25].

The use of Mtwo instruments in extracted primary molars significantly reduced instrumentation time compared to stainless steel instruments K-files up to #25-30 [26]. In the present study, #08-15 K-files (Micro-Mega, Bessancon, France) was performed before instrumentation with Mtwo system to create a glide path, measurement of total instrumentation time with mechanical instruments did not include it. Torres *et al.* [27] have not found statistically significant differences in the angle of canal curvature, apical transportation, and the working time between groups Mtwo instrumentation with glide path and no glide path.

Table1. Instrumentation time (seconds) and number of instrumentation cycles (NCI) of the four experimental groups, mean (SD), minimum (Min), and maximum (Max), which were statistically analyzed by two-way ANOVA

		Instrumentation time (seconds)			Number cycles instrumentation (NCI)		
		Mean (SD)	**Min**	**Max**	**Mean (SD)**	**Min**	**Max**
Group A (angle>30°)	**A1 150 rpm**	190.29 (84.13)	87.6	306.91	475.73 (210.33)	219	767.27
	A2 250 rpm	123.39 (31.97)	66.7	185.66	514.12 (133.23)	277.92	773.58
Group B (angle<30°)	**B1 150 rpm**	146.33 (50.08)	76.66	234.08	365.83 (125.20)	191.65	585.2
	B2 250 rpm	98.11 (49.34)	31.5	174.96	408.77 (205.58)	131.25	729

Instrumentation time: A1 vs B1/A2 vs B2 (P>0.05), A1 vs A2/B1 vs B2 (P<0.05); NCI: A1 vs B1/A2 vs B2 (P>0.05), A1 vs A2/B1 vs B2 (P>0.05)

On the contrary, establishing a glide path for preparing curved canals with reciprocating instruments increased the total instrumentation time [28].

Mtwo files can be used safely both in severely curved and relatively straight root canals following the recommended guidelines of usage [29], but they are in contrast with a study conducted on other instruments (K3 and ProTaper), in which several fractures occurred in curved root canals [13]. This difference may be mainly attributed to the different characteristics of the different instruments used, being Mtwo files more flexible, resistant to fatigue and efficient in cutting than K3 and ProTaper files [8]. The cutting and cleaning efficiency of Mtwo was better than ProTaper in the apical third, in a study performed on curved roots of extracted teeth [30].

No fracture of 0.04 and 0.06 taper ProFile instruments was reported in a study of mesial roots of mandibular molars [31]. Different results were obtained in another study using ProFile instruments, reporting statistically significant difference of instrument separations between the speed of 150 rpm and that of 350 rpm [32]; in the same way as the present study, the root canals were also divided by the degree of curvature, greater or less than 30 degrees. Unlike the present study, it was shown that in addition to speed, the curvature of the canal also seems to be a most important factor that increases the risk of the instrument breakage. The difference in the results may be due to the structure and the more flexible design of the Mtwo instruments [8].

The rotation speed of an instrument is an interesting aspect; more so as it has been not studied well. In some root canals, the severity of the curves prevents instruments to advance in rotation and significant improvements can be obtained by manually advancing Mtwo instruments [33]. On the contrary, Alapati *et al.* [34] suggested not to lower the instrumentation speed too much (never under 150 rpm) because the torque value is increased. The presence of dentinal cracks caused by the instrumentation [35] is a very important aspect that could be influenced by the rotation speed but in this study it was not evaluated. It is also important to underline that the mtwo instruments are instruments with conventional NiTi. In other types of instruments with different design it has been shown that a heat treatment increased resistance to cyclic fatigue [36].

The Mtwo instrument has a design that in continuous rotation allows the instrument to spontaneously advance inside the canal, and the operator's pressure must be minimal [23, 29]. High efficiency, reported, probably allows an action within the canal with variable RPM depending on the clinical conditions from 0 rpm (manual use) to 250 rpm [33].

The time of the instrumentation is another variable to consider. The results of the present study highlight that a higher rotational speed (250 rpm) reduced the mean total instrumentation time in both groups of different curvatures tested (statistically significant), thus confirming data already presented in another previously published study [9]. The main explanation for these findings may be due to an increased cutting efficiency of the files when used at a higher rotational speed, both in curved and in relatively straight root canals.

In the present study, the instrumentation of curved canals required more time in both groups of rotational speed, especially when lower speed was used, but it was completed safely in all the groups tested. In the high-speed groups, the reduction in total instrumentation time averaged only 67 and 48 sec for the higher and lower curvature canals, respectively. A better control and a higher tactile feedback on the file can be exerted when a lower rotational speed is used, at the expense of a slight increase in total instrumentation times. If the reduction of the rotational speed is unnecessary in relatively straight canals, it could be helpful during the instrumentation of severely curved root canals, whereas the instrumentation was completed with Mtwo files effectively and with no statistical differences in the number of rotations needed to complete the instrumentation phase.

This feature provides the dentist to work with greater control in shaping severely curved root canals. Therefore, rotational speed may be used by the operator as a dynamic and variable parameter.

Conclusions

Based on this *ex vivo* experimental study, root canal preparation with M*two* rotary files could be completed safely, with an increase in the instrumentation time at low rotational speed, independently of the root canal curvature.

Conflict of Interest: 'None declared'.

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