THE EFFECTS OF DIFFERENT TORQUES ON DENTINAL CRACK FORMATION IN ROOT CANALS USING THE RACE ROTARY SYSTEM

Mousavi E,[1] Movahedi SM [2]

1. Assistant Professor, Department of Endodontic, Dental Science Research Center, Faculty of Dentistry, Guilan University of Medical Sciences, Rasht, IRAN..
2. General Dentist. Tehran, IRAN.

ABSTRACT

Aim: Vertical Root Fracture (VRF) is one of the incidents that can happen during root canal therapy, either during the preparation or afterward. In addition, root canal preparation could cause dentinal microcracks or crazes that could eventually lead to VRF. The use of inappropriate torque when using rotary systems to prepare the canal leads to the formation of dentinal cracks in some cases. There are several new rotary systems introduced to endodontic treatments in recent years. The RaCe Rotary System is one of them. This system seems to be more time-saving, user-friendly and safe for canal preparation. In this study, different types of torque were used during the preparation of the canal using the RaCe rotary system. This study was carried out aimed to compare the torques and determine the appropriate torque for preparing the canal with lower dentinal crack.

Materials & Method: In this study, 75 extracted mandibular premolars were used. These specimens were divided into 3 groups of 25 each, the first group (high torque: 2.6), the second group (low torque: 1.6), the third group (control group) with no canal preparation. At the end of the preparation, Specimens were sectioned in 3, 6 and 9 millimetres above apex and were observed under a stereomicroscope with a magnification of 16X. Data were analyzed using SPSS21 software based on Fisher's exact test.

Results: According to the results, there is a significant difference between the groups prepared with high torque and the group prepared with low torque. ($p<0.0001$).

Conclusion: According to the overall conclusion, the lower torque (1.6) can be considered as a more suitable torque than the higher torque (2.6) during the preparation of canal using the RaCe rotary system.

Key words: Crack, Endo rotary devices, Torque, Vertical root fracture.

Introduction

One of the most important biological and mechanical goals of root canal therapy is the effective cleaning and shaping of the root canal system. Traditionally, canal shaping is done using manual files made of stainless steel.

Manual or rotary nickel-titanium (NiTi) files are also used to achieve the mechanical goals of the preparation of the canal.[1] These instruments can have advantages compared to stainless steel files: These instruments are flexible.[2] They have higher dentin cutting rates and have been helpful in saving time.[3]

Also, nickel-titanium (NiTi) files tend to retain the original shape of the canal, and deviations from the main path of the canal are less likely.[2] RaCe Rotary file is one of the most useful rotary files used by the endodontists and general dentists. The term RaCe is derived from the words Reamer with alternating cutting edges. The superior design of the RaCe file is associated with high speed, efficiency, high flexibility and ultimately proper canal formation.[4]

The results of a number of laboratory studies that compare RaCe with other new rotary systems are available.The canals prepared using RaCe in plastic blocks and a tooth extracted have been less transportable than Protaper files.[4]

Another study has compared RaCe and Protaper files. The root canals of the premolars to the apex and up to file number 30 with 4% convergence were similarly prepared in this study. Then, the canal preparation continued up to file 40 using the rotary systems.

RaCe files prepared the canals more quickly and with lower deviations or deformations. As it is possible using any other rotary system, this is also possible in the RaCe system as a hybrid manual rotary technique.[4]

Torque is another parameter that may have a significant impact on the locking of the instrument in the canal, its deformation in the canal and breaking it. Torque is a term used to forces applied due to rotational motion, such as the force used to tighten a screw. The torque refers to the ability of the handpiece to resist rotating against lateral pressures during rotational motions without slowing down or reducing the productivity of cutting tools, and depends on the size and type of bearings used in the handpiece and the amount of energy used in it.[5]

Theoretically, a high torque tool is very active and the possibility of its deformation and breakdown increases. While a low torque tool is associated with operational errors, the ideal is to use a torque and suitable speed when working with any tool.[6]

Vertical root fracture (VRF), as well as intra-dentin cracks, may also be seen during treatment or afterward.[7] VRF is one of the errors that are often irreparable and lead to the teeth extraction. This type of fracture can occur due to the continuation of microcracks or gaps in dentin. In such a way that the subsequent stresses that affect the teeth continuously lead to extend the cracks and ultimately lead to lesions in the form of VRF.

Instrumentation and obturation of the root canals, high concentrations of sodium hypochlorite, and placing a post in the root canal is associated with increased risk of VRF. Some studies have reported the incidence of VRF by 2-5% .[8] Some studies have shown that dentin injuries (microcracks) are seen in teeth treated using Ni-Ti rotary system. For example, Bier *et al* have reported that Ni-Ti rotary systems (other than the S-Apex system) play a significant role in dentinal cracks formation.[9]

In this study, the Protaper system has formed the largest dentinal cracks, and manual files did not form any dentinal cracks.

Preparation with improper speed and torque, high force during placing posts inside the canal are significant risk factors among the factors that make root prone to vertical fracture.[10]

Due to the contradictions observed in studies on the creation of cracks by various rotary systems with different torques and according to the RaCe manufacturer's claim to reduce the formation of dentinal cracks by this system, the aim of this study was to compare the role of different torques of the RaCe rotary system to create dentinal cracks.

Materials & method

In this study, 75 healthy mandibular premolars having a single root and a single canal which were extracted for various reasons such as orthodontic treatment or periodontal treatment were selected in this study. The teeth having calcified, caries on root, defects of enamel and dentin, teeth that their root had previously been treated, as well as teeth with obvious anomalies, were excluded from the study. The selected teeth were placed in 2.5% sodium hypochlorite solution for 15 minutes and the root surfaces of the teeth were cleaned by cavitron (NSK Varios 350, Japan). Radiography was performed from the mesiodistal and buccolingual crown dimensions of the teeth (Spox Wall Mount Oral-X70 Dental X-Ray Machine, Korea), (Dentus Heraeus, Germany) to determine the width of the root canal at 15 mm from the apex and the conditions of the study were identical for all samples.

The root surfaces of the teeth were examined under a stereomicroscope (GX Microscopes, UK) to identify if there is a crack or a defect already, that it must be excluded from the study and another tooth must be selected. At this stage, the crown of the teeth was sectioned in 16 millimetres above apex and the root surface of the teeth was covered by a thin aluminium foil. And teeth were mounted in the acrylic resin (ACROPARS 200, made in Iran). The roots were then removed from the resin and the aluminium foil was removed from the root surface. The working length of the teeth was then determined using K File (TG, UK).

A light body Swiss Tec was used to fill the space created by the removal of an aluminium foil, which it acts like a periodontal ligament.

Group 1 included 25 teeth as the control group with no canal preparation. Group 2 consisted of 25 teeth that canal preparation was performed on them using a RaCe file (made in Switzerland) with a high torque of 2.6 n / cm2. Group 3 consisted of 25 teeth that canal preparation was performed on them using a RaCe file with a low torque of 1.6 n / cm2.

Preparation of the canals was performed according to the order of the manufacturer of the RaCe system up to the file of 4-50% and in the first group with a torque of 2.6 n / cm2 at a speed of 600 rpm and in the second group with a torque of 1.6 n / cm2 and a speed of 600 rpm.

The preparation process was performed completely by one person who was trained by the root canal treatment specialist. The root canal was washed after changing each file with 2.5% sodium hypochlorite solution (manufactured by Cerkamed Poland). After the root canal preparation, the samples were washed with 5 millilitres distilled water and kept in 0.9% saline solution and at room temperature.

Then, the teeth were sectioned horizontally in 2, 4, 6 and 8 mm above apex with the help of milling 6 and 1 with the cooling water. Then, the samples were washed with 0.9% saline solution.

And they were examined by a stereomicroscope (GX Microscopes) with a magnification of 16 X by an observer who was unaware of grouping the samples.

The samples were divided into 2 groups based on defects:

Group 1: No dentin crack was observed in the canal [Figure 1]

Figure 1. No dentin crack was observed in the prepared canal.

Group 2: Any dentinal cracks were observed in the canal. [Figure 2]

Figure2. Dentinal crack was observed in the canal by a stereomicroscope (16x magnification).

Finally, the amount of dentinal crack in the studied groups was examined and compared.

After data collection, data were entered into SPSS21 software. The frequency and confidence interval of 95%

was used to determine the percentage of cracks created in each group. Fishers Exact Test was used to compare the frequency of the cracks created in the three groups.

The significance level of the tests in this study was measured by $p \leq 0.05$.

Results

The number of samples in each torque was 100 (4 × 25) and in the control group 100, with a tip-apex distance of 2, 4, 6, and 8 mm.

Table1 shows the results of the study in terms of the number of dentinal cracks by cutting distances and the type of torque. According to the results of this table, the highest number of cracks is observed in the high torque, especially in tip-apex distance of 6 mm (32%) and 8 mm (32%), and the smallest cracks are observed in the low torque in tip-apex distance of 2 mm (0%) and 4 mm (0%).

				Number of cracks					
				Cracks		Without cracks		Total	
				Number	%	Number	%	Number	%
The type of torque	Low torque	Cutting distances	Tip-apex distance of 2 mm	0	0.0%	25	100.0%	25	100.0%
			Tip-apex distance of 4 mm	0	0.0%	25	100.0%	25	100.0%
			Tip-apex distance of 6 mm	1	4.0%	24	96.0%	25	100.0%
			Tip-apex distance of 8 mm	1	4.0%	24	96.0%	25	100.0%
			Total	2	2.0%	98	98.0%	100	100.0%
	High torque	Cutting distances	Tip-apex distance of 2 mm	1	4.0%	24	96.0%	25	100.0%
			Tip-apex distance of 4 mm	2	8.0%	23	92.0%	25	100.0%
			Tip-apex distance of 6 mm	8	32.0%	17	68.0%	25	100.0%
			Tip-apex distance of 8 mm	8	32.0%	17	68.0%	25	100.0%
			Total	19	19.0%	81	81.0%	100	100.0%
	Without preparation (control)	Cutting distances	Tip-apex distance of 2 mm	0	0.0%	25	100.0%	25	100.0%
			Tip-apex distance of 4 mm	0	0.0%	25	100.0%	25	100.0%
			Tip-apex distance of 6 mm	0	0.0%	25	100.0%	25	100.0%
			Tip-apex distance of 8 mm	0	0.0%	25	100.0%	25	100.0%
			Total	0	0.0%	100	100.0%	100	100.0%

Table 1: The results of the study in terms of the number of dentinal cracks by cutting distances and type of torque

The percentage of cracks based on the type of torque is listed in the table 2. Generally, the percentage of cracks in the low torque (2%) was 2 cases and in the high torque (19%) 19 cases and in the method without preparation was (0%), which this difference was significant based on the Fisher's exact test, ($p<0.0001$).

			Number of cracks		Total	P
			Cracks	Without cracks		
The type of torque	Low torque	Number	2	98	100	0.0001
		Percent	2.0%	98.0%	100.0%	
	High torque	Number	19	81	100	
		Percent	19.0%	81.0%	100.0%	
	Without Preparations (Control)	Number	0	100	100	
		Percent	0.0%	100.0%	100.0%	
Total		Number	21	279	300	
		Percent	7.0%	93.0%	100.0%	

Table 2: Comparison of the percentage of cracks based on the type of torque

The number of cracks in the distances studied by the type of torque is compared in the table 3. According to this table, the percentage of cracks at different distances of low torque (p=0.999) and no significant difference was observed in control group statistically. But the percentage of cracks in the high torque was statistically significant in terms of distances (p=0.01), so that the percentage of the cracks has been observed in the 2 mm of the apex (4%) and at 6 mm and 8 mm of the apex (32%).

Type of torque				Number of cracks		Total	P
				crack	Without crack		
Low torque	Cutting distances	Tip-apex distance of 2 mm	Number	0	25	25	0.999
			Percent	0.0%	100.0%	100.0%	
		Tip-apex distance of 4 mm	Number	0	25	25	
			Percent	0.0%	100.0%	100.0%	
		Tip-apex distance of 6 mm	Number	1	24	25	
			Percent	4.0%	96.0%	100.0%	
		Tip-apex distance of 8 mm	Number	1	24	25	
			Percent	4.0%	96.0%	100.0%	
	Total		Number	2	98	100	
			Percent	2.0%	98.0%	100.0%	
High torque	Cutting distances	Tip-apex distance of 2 mm	Number	1	24	25	.01
			Percent	4.0%	96.0%	100.0%	
		Tip-apex distance of 4 mm	Number	2	23	25	
			Percent	8.0%	92.0%	100.0%	
		Tip-apex distance of 6 mm	Number	8	17	25	
			Percent	32.0%	68.0%	100.0%	
		Tip-apex distance of 8 mm	Number	8	17	25	
			Percent	32.0%	68.0%	100.0%	
	Total		Number	19	81	100	
			Percent	19.0%	81.0%	100.0%	
Without Preparation (Control)	Cutting distances	Tip-apex distance of 2 mm	Number		25	25	-
			Percent		100.0%	100.0%	
		Tip-apex distance of 4 mm	Number		25	25	
			Percent		100.0%	100.0%	
		Tip-apex distance of 6 mm	Number		25	25	
			Percent		100.0%	100.0%	
		Tip-apex distance of 8 mm	Number		25	25	
			Percent		100.0%	100.0%	
	Total		Number		100	100	
			Percent		100.0%	100.0%	

Table 3: Comparison of the number of cracks at the distances studied by the type of torque.

The number of cracks in the distances studied by the type of torque is compared in the table 4. According to this table, the percentage of cracks in terms of the type of torque in the tip-apex distance of 2 mm (p=0.999) and 4 mm (p=0.324) was not statistically significant. But, the percentage of cracks is statistically significant in terms of the type of torque used in tip-apex distance of 6 mm (p=0.001) and 8 mm (p=0.001), so that in tip-apex distance of 6 mm and 8 mm, the percentage of cracks in the high torque has the highest value compared to the two lower torque groups and the control group.

Cutting distances				Number of cracks		Total	p
				Crack	Without cracks		
Tip-apex distance of 2 mm	Type of crack	Low torque	Number	0	25	25	.9990
			Percent	0.0%	100.0%	100.0%	
		High torque	Number	1	24	25	
			Percent	4.0%	96.0%	100.0%	
		Without Preparation(Control)	Number	0	25	25	
			Percent	0.0%	100.0%	100.0%	
	Total		Number	1	74	75	
			Percent	1.3%	98.7%	100.0%	
Tip-apex distance of 4 mm	Type of torque	Low torque	Number	0	25	25	.3240
			Percent	0.0%	100.0%	100.0%	
		High torque	Number	2	23	25	
			Percent	8.0%	92.0%	100.0%	
		Without Preparation(Control)	Number	0	25	25	
			Percent	0.0%	100.0%	100.0%	
	Total		Number	2	73	75	
			Percent	2.7%	97.3%	100.0%	
Tip-apex distance of 6 mm	Type of torque	Low torque	Number	1	24	25	.0001
			Percent	4.0%	96.0%	100.0%	
		High torque	Number	8	17	25	
			Percent	32.0%	68.0%	100.0%	
		Without Preparation(Control)	Number	0	25	25	
			Percent	0.0%	100.0%	100.0%	
	Total		Number	9	66	75	
			Percent	12.0%	88.0%	100.0%	
Tip-apex distance of 8 mm	Type of torque	Low torque	Number	1	24	25	.0001
			Percent	4.0%	96.0%	100.0%	
		High torque	Number	8	17	25	
			Percent	32.0%	68.0%	100.0%	
		Without preparation (Control)	Number	0	25	25	
			Percent	0.0%	100.0%	100.0%	
	Total		Number	9	66	75	
			Percent	12.0%	88.0%	100.0%	

Table 4. Comparison of the number of cracks by type of torque by distances.

Discussion

One of the most serious clinical challenges in the root canal treatment is Vertical root Fracture (VRF), since it will result in teeth extraction in almost all cases.[11]

However, a number of studies have shown that after root canal treatment using Ni-Ti rotary systems, cracks and microscopic gaps are created in root canal which has been reported up to 16% in some Protaper systems.[12]

The RaCe system was used in this study, in which dentinal cracks were observed in 7% of all samples, these cracks were created in the prepared group with high-torque of 19%, which most of the cracks were created in the 6 mm and at 8 mm the 8% apex end. In contrast, the smallest dentinal cracks were created in the lower torque in the tip-apex distance of at 2 mm and 8 mm.

The results of this study done in comparison with the study of the effect of torque and dentinal defects by Dane *et al.*[13] in 2016 shows that, "the effect of torque force when preparing the canal using Ni-Ti rotary systems and creating dentin damage" found that teeth prepared with high torque rotary files could create more dentinal cracks than teeth prepared with low torque and similar results can be achieved. Theoretically, the possibility of locking the tool at the end of the apex or the back of the movement decreases by applying a higher torque.

Also, applying the torque in addition to the shaping of the canal has a significant impact on the file and the surface of the tooth. Therefore, newly introduced instruments should be evaluated in different torques in order to determine their effect on root canal shaping.[14]

Also, compared to the Dane study, which was conducted in 2016, in the low torque group in our study, only 2% of the teeth were cracked, while in the Dane study, in the low torque group, 17.4% of the teeth that were prepared by the Protaper file, were cracked.

In our study, cracks were observed in 19% of the teeth in the high torque group, while in the study by Dane, cracks were observed in 29.4% in the high torque group.

It seems that RaCe files have better efficiency compared to Protaper files in terms of the absence of dentinal cracks.[13] Arslan *et al*. In 2014, [15] during a study studied the effect of canal preparation with Protaper, EndoFlare, HyFlex, Revo-S and Gates Glidden Drills files on the creating dentin cracks and from 108 Mandibular molars were used. There was no significant difference between the number of dentinal cracks produced in the prepared group using rotary files compared to the control group ($p<0.05$), and these studies were inconsistent with the results of this study. Perhaps the difference between the results of this study with the Arslan study can be attributed to the difference in the type of tooth studied and because of differences in cutting distances and methodological differences.

Also, there are also different methods for evaluation of the dental cracks formation following the use of endodontic tools. Recently De-Deus *et al.* used Microcomputed Tomography images to evaluate the defects.[16]

According to this study, tomographic images which are obtained from a method with a high precision and error-free method provide us the opportunity to examine samples before and after preparation.

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Corresponding Author

Dr. Mousavi E
Assistant Professor,
Department of Endodontic,
Dental Science Research Center,
Faculty of Dentistry,
Guilan University of Medical Sciences,
Rasht, IRAN.
Email Id: - elnaz32@gmail.com