Original Article

Comparative Evaluation of Dentinal Microcrack Incidence After Root Canal Preparation by BioRaCe and Edge Taper Platinum

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ABSTRACT

Background and Aim: Preparation of root canal with rotary nickel-titanium (NiTi) instruments may potentially create microcracks that can lead to vertical root fracture. This study aimed to compare the incidence of crack formation by BioRaCe and Edge Taper Platinum systems in the mesiobuccal canals of extracted first mandibular molars.

Materials and Methods: In this experimental study, 50 first mandibular molars, which met all the inclusion criteria, with a canal curve of 25-35 degrees, were selected and randomly divided into two groups of 24. Each specimen was mounted in a resin block and a thin layer of silicone impression to simulate the periodontal ligament (PDL) while the apex was exposed. Group A was prepared by BioRaCe, and group B was prepared by Edge Taper Platinum. Two teeth were left unprepared and served as the control. The roots were sectioned horizontally at 3, 6, and 9mm from the apex and evaluated under a stereomicroscope at ×20 magnification. The presence of dentinal defects was examined and analyzed using Mann-Whitney test.

Result: BioRaCe rotary files showed more cracks (47.3%) than Edge Taper Platinum (19.5%) at all three levels with a significant difference (P=0.038). No statistically significant difference was found between these two systems at the coronal (9mm from the apex) and apical (3mm from the apex) levels but a significant difference was found between BioRaCe and Edge Taper Platinum in the midroot (6mm from the apex; P=0.014).

Conclusion: It seems that the Edge Taper Platinum system causes fewer cracks in curved dentinal walls compared to the BioRaCe system.

Keywords: Dentin, Endodontics, Tooth Fractures, Root Canal Preparation

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Introduction:

Rotary nickel-titanium (NiTi) shaping techniques provide simplicity, speed, and most importantly, more efficacy in root canal treatment.[1,2] NiTi rotary instruments not only decrease the clinician's fatigue and risk of procedural errors but also allow faster root canal treatment compared to hand files.[3]

Root canal preparation by NiTi rotary instruments may cause damage to root dentin, which initiates craze lines, complete and incomplete dentinal cracks, and root fractures, leading to treatment failure.[4,5]

The development of NiTi rotary instruments in the last two decades has led to the introduction of various canal preparation techniques; however, these techniques still seem to have a high risk of cracking and root fracture when used.[6] In recent years, several studies have reported the correlation between root canal preparation by NiTi rotary files and dentinal microcracks that may lead to vertical root fractures.[7,8]

The BioRaCe system (FKG Dentaire, La Chaux-de-Fonds, Switzerland) is one of the second-generation NiTi rotary files that prepares root canals by continuous motion rotation using six files.[9]

The Edge Taper Platinum system (EdgeEndo, Albuquerque, NM, USA) has been recently introduced. The instrument is made of an annealed heat-treated (AHT) NiTi alloy brand named firewire, which has continuous motion rotation. All files are constant taper and have non-cutting tips, which can reduce the occurrence of cracks. [10]

The aim of this study was to evaluate and compare dentinal microcrack formation after root canal preparation by BioRaCe and Edge Taper Platinum systems.

Materials and Methods:

This in-vitro experimental study was conducted on 50 extracted mandibular first molars. The teeth were extracted for reasons not relevant to this research. The teeth were kept an hour in 5.25% sodium hypochlorite (NaOCl) solution for disinfection and then stored in sodium chloride (NaCl) solution.

Radiographs were taken in the buccolingual direction from all teeth. Teeth with pulp stones, calcified canals, root caries, internal or external root resorption, former root canal treatment, open apices, and severely curved canals were excluded from this study. Fifty mesiobuccal root canals with curvatures between 25-35 degrees and a radius between 4-8 mm were selected using the Pruett method.[11] The teeth were observed under a stereomicroscope at ×20 magnification to exclude roots with visible external cracks.[1,3,12-15] The teeth were decoronated at the cementoenamel junction (CEJ). Distal roots were also cut, and mesial roots with a 16±1mm length were kept. Canals were negotiated with #15 K-files (Mani, Tochigi, Japan). The roots were covered with a single layer of aluminum foil and embedded in acrylic resin blocks while the 3mm apical part was exposed, followed by the removal of roots from the blocks and replacement of the foil by a light body silicone-based material.

Next, the specimens were divided into three groups (24 teeth in the experimental groups and two teeth in the control group), as follows:

1. BioRaCe group
2. Edge Taper Platinum group
3. Negative control group

The working length was established by advancing a #10 hand K-file into the canal until it was visible at the apical foramen and then subtracting 1 mm from it. The preparation in each group was performed with the NSK Endo Mate DT Motor (Unicorn Denmart Ltd., Japan) according to the manufacturer's instructions.

Group 1 (BioRaCe):

A #15 hand K-file was taken to the working length. BR0(25/.08), BR1(15/.05), BR2(25/.04), BR3(25/.06), and BR4(35/.04) NiTi rotary instruments were used at 600 rounds per minute (rpm) and 1.2 Ncm in a crown-down manner up to the working length using a gentle in-and-out pecking motion. After three steady strokes, the file was removed and cleaned.

Group 2 (Edge Taper Platinum):

S1(17/.04), S2(17/.06), F1(20/.06), F2(25/.06), and F3(30/.06) NiTi rotary instruments were used at 400 rpm and 3 Ncm in a crown-down manner up to the working length using a gentle in-and-out pecking motion.

Group 3 (negative control group): No preparation.

Irrigation was performed using 2.5% NaOCl (Kimia Tehran Acid, Tehran, Iran). Apical patency was confirmed using a #10 K-file after each file use. All roots were cut horizontally at three levels (3, 6, and 9mm) from the apex with a diamond disc (D&Z, Wellington, New Zealand) under constant water cooling. The sections were viewed under a stereomicroscope (SZX9, Olympus, Tokyo, Japan) at ×20 magnification (Figure 1). Digital images were captured with a digital camera (Nikon, SMZ1000, Japan) attached to the stereomicroscope. Each sample was inspected by two experienced operators for the presence of dentinal microcracks.

Data were analyzed using SPSS (Version 25, SPSS Inc., Chicago, IL, USA) via Mann-Whitney test. The level of significance was set at $P<0.05$.

A B C

Figure 1. Samples instrumented with rotary systems under a stereomicroscope at ×20 magnification; A) Presence of a complete crack; B) Presence of an incomplete crack; C) Absence of crack

Results

The control group presented no cracks. BioRaCe rotary files showed more cracks (40.2%) than Edge Taper Platinum (19.5%) at all three levels with a significant difference (P=0.038). In the BioRaCe group, most cracks were found at the coronal (n=11) and midroot (6mm from the apex; n=11) levels while in the Edge Taper Platinum group, most cracks were at the coronal level (n=9). No statistically significant differences were found between these two systems at the coronal and apical (3mm from the apex) levels (P>0.05). Significant differences were found between BioRaCe and Edge Taper Platinum at the midroot (P=0.014) and in total (P=0.038; Table 1).

Table 1: Quantity of microcracks in each group at each level

Presence of crack / Rotary system	Apical (3mm from the apex)			Midroot (6mm from the apex)			Coronal (9mm from the apex)			Total		
	Complete	Incomplete	No crack	Complete	Incomplete	No crack	Complete	Incomplete	No crack	Complete	Incomplete	No crack
BioRaCe	2 8.3%	5 20.8%	17 70.8%	7 29.1%	4 16.6%	13 54.1%	9 37.5%	2 8.3%	13 54.1%	18 25%	11 15.2%	43 59.7%
Edge Taper Platinum	2 8.3%	0 0%	22 91.6%	2 8.3%	1 4.1%	21 87.5%	8 33.3%	1 4.1%	15 62.5%	12 16.6%	2 2.7%	58 80.5%
P-Value		0.095			0.014			0.627			0.038	

Discussion:

This study showed that both systems caused dentinal cracks after root canal preparation. The BioRaCe system showed more complete and incomplete cracks than the Edge Taper Platinum system. This result may be due to the special features of the Edge Taper Platinum system. Heat-treated fire-wire NiTi provides great flexibility capable of 90-degree curves; it does not bounce back to preserve apical anatomy, and its cyclic fatigue is two times greater than that of the ProTaper Gold. [10] in both systems, most of the cracks were at the midroot level. This result is similar to that found by Versluis et al, who reported that the stresses at the apical level were one-third of the stresses at the coronal level.[16] According to the findings of previous studies, [5,7,17] which have reported that defect formation may be related to the tip design, cross-section geometry, constant or progressive taper type, and flute form, the Edge Taper Platinum file system has a bloated triangular cross-section with a progressive changing taper that may lead to fewer cracks.[10]

Another difference between these two systems is their rotation speed and torque value, which is 600 rpm and 1.2 Ncm for the BioRace system and 400 rpm and 3 Ncm for the Edge Taper Platinum system; the higher torque leads to more crack formation; however, the result of this study does not support this fact.[18] Nonetheless, there is no well-controlled study evaluating the effect of rotation speed on crack formation in root dentinal walls.

Curved roots with wide faciolingual and narrow mesiodistal cross-sections, like mandibular incisors and mesial roots of mandibular and maxillary molars and maxillary second premolars, are particularly susceptible to fracture.[19] In this study, we used the mesiobuccal canal of mandibular first molars. In some previous studies, mandibular premolars [4,14,20,21] or mandibular central incisors [15,22] have been used whereas, in other studies, similar to the current study, mandibular first molars [1,5,13,23] have been used to compare the incidence of crack formation.

In some studies, straight canals [3,4,15,21] or curved canals in the range of 10-20 degrees [1,12] have been used while some studies have not declared the canal curvature used. [5,19,20,23]) In the current study, mesiobuccal canal curvatures between 25-35 degrees and a radius between 4-8 mm were used, which are not similar to what has been used in other studies; therefore, the results might be useful.

All the specimens were viewed under a stereomicroscope to rule out cracks on the outer surface of the roots. [3,4,13-15,21,22]

To simulate the PDL, the roots were covered with a silicone-based material.[4,13-15,21]. Jacob et al declared the absence of the natural PDL as a significant limitation.[23] However, there is no consistent or standard experimental design to simulate the PDL.[23] Soros et al stated that elastomeric impression materials are inadequate to precisely represent the natural PDL and what may be present in vivo. Elastomeric materials can collapse and cause direct tooth-to-acrylic socket contact, which never occurs in vivo with bone. [24]

Several studies have shown that the incidence of crack formation in canals prepared with hand files is less than that prepared by rotary files. [4,14,15]

In this study, cracks were divided into complete and incomplete types, similar to the study by Bürklein et al. [25]

Zuolo et al evaluated dentinal microcracks after root canal preparation with several rotary systems, including the BioRaCe, using microcomputed tomography (micro-CT).[8] They observed specimens before and after preparation by micro-CT to see if a new crack was created. Among 5826 specimens prepared by the BioRaCe, 32.9% cracks were seen, which were present before preparation up to BR3.[8]

De-Deus et al [12] evaluated dentinal microcracks after root canal preparation with several rotary systems, including the BioRaCe, using micro-CT, similar to Zuolo et al, [8] to see if a new crack was created. Among 5169 sections prepared by the BioRaCe system, 7.91% cracks were seen, which were also present before the preparation. They concluded that the preparation process does not correlate to crack formation.[12] The result of the present study is contrary to these two studies.[8,12] One of the most important reasons for this controversy can be the evaluation of specimens by a stereomicroscope in the present study and the use of micro-CT in the cited two studies. It is difficult to rule out cracks by a stereomicroscope before the preparation because cracks may be internal and not visible from the outside.[4] Another limitation of a stereomicroscope is that teeth must be sectioned to see internal cracks, and because cutting has a destructive effect, cracks may occur during the sectioning process.[12,13]

Some authors have stated that three sources of stress in dentin may cause dentinal defects: 1. The mechanical preparation, 2. The chemical attack with NaOCl-based irrigation, and 3. The sectioning procedures.[12,26]

Micro-CT nondestructive technology provides the possibility to examine the dentinal tissue before any root canal procedure. It also presents several advantages over the well-established root-sectioning approach. The highly accurate micro-CT method permits the evaluation of hundreds of slices per tooth.[1,8,12]

Micro-CT has a higher resolution and may be more accurate for the detection of dentinal defects in comparison with a stereomicroscope.

However, according to Ceyhanli et al, image superimposition does not show a perfect match for pre- and post-instrumentation images.[27] Micro-CT makes hundreds of slices, which are not easy to assess, and some microcracks may be overlooked.[13,27]

It is vital to consider that an increased temperature because of the use of high-resolution micro-CT scans can induce dehydration of the specimens, leading to crack augmentation and affecting the results.[4]

Versiani et al indicated that it is rather unlikely that, in the clinical setting, some ordinary canal procedures could cause microcracks in a range of 40-80% as reported by most studies.[28] Bier et al stated that craze lines might develop into fractures during retreatment or after long-term functional stresses, such as chewing. [7]

Conclusion:

Based on the results of this study, both rotary systems caused microcracks in dentinal walls. It seems that Edge Taper Platinum causes fewer cracks than BioRaCe.

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