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THE INCIDENCE OF DENTINAL MICRO-CRACKS ASSOCIATED WITH ROOT CANAL PREPARATION WITH DIFFERENT NICKEL TITANIUM ROTARY SYSTEMS: AN IN-VITRO STUDY

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ABSTRACT

Objective: The current study's goal was to evaluate the incidence of dentinal micro-cracks in root canal dentin following root canal preparation with ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland), TruNatomy (Dentsply Maillefer, Ballaigues, Switzerland), and Race Evo (FKG Dentaire SA, La Chaux-de- Fonds, Switzerland) rotary systems.

Methods: A total of 60 single rooted maxillary premolars with single canal were selected. Teeth were decoronated and roots lengths were standardized to 14mm. Roots were then randomly allocated into four groups (n=15) according to root canal preparation system that had been used; one negative control group that hadn't been prepared and three experimental groups; ProTaper Next group, Race Evo group and TruNatomy group. At 3, 6, and 9 mm from the apex, all of the roots were sectioned perpendicular to the long axis after root canal preparation, and each section was examined under a stereomicroscope at 25 X magnification (Leica microsystems Ltd, Germany).

Results: The negative control group did not show any cracks. At 3mm ,6mm and 9mm root levels ProTaper Next showed the highest prevalence of micro-cracks followed by Race Evo then TruNatomy with a statistically significant difference between systems (p-value =0.006,0.042,0.018) respectively.

Conclusion: TruNatomy and Race Evo rotary systems showed lower incidence of dentinal microcracks in comparison to ProTaper Next rotary system.

KEYWORDS: Protaper next; Trunatomy; Race Evo; Dentinal cracks

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INTRODUCTION

One of the crucial phases to a successful root canal procedure is root canal preparation. Although nickel-titanium (NiTi) rotary systems have facilitated root canal preparation, their using in root canal preparation had been reported to initiate dentinal crack formation [1,2].

As rotary motion during root canal preparation caused high friction between instrument and dentinal wall which created stresses within dentin wall that may initiate crack formation which may lead to serious complications [3]. As vertical root fracture (VRF) isn't momentary event but instead it is a result of propagation of dentinal microcracks after functional loading of teeth [4]. VRF is an infuriating complication of root canal therapy as the affected tooth has poor prognosis [5].

Lately, technological developments in rotary NiTi instruments have revolutionized root canal preparation [6].

ProTaper Next (PTN) (Dentsply Maillefer, Ballaigues, Switzerland) NiTi files have asymmetric rectangular cross section and progressive taper [7], which minimize the effect of a certain file's screw, taper lock, and torque on root canal dentin [8]. it is also manufactured from heat treated alloy M-Wire which have higher flexibility and better mechanical properties than conventional NiTi alloy [9].

Recently, TruNatomy (TRN; Dentsply Maillefer, Ballaigues, Switzerland) was introduced with an off-centered parallelogram cross-section design and distinctive slip shaping, allowing for a larger debridement area. The manufacturer declared that TRN instruments have increased flexibility and cyclic fatigue strength by virtue of the characteristic heat procedure [10]. It has been stated that TRN instruments conserve tooth structure due to its unique design [11].

Race Evo (RE; FKG Dentaire SA, La Chaux-de- Fonds, Switzerland) is the ultimate evolution of popular and proven Race rotary system which has original Race features; alternate cutting edges with triangular cross-section design and fixed taper, combined with proprietary heat treatment resulted in safer and more efficient than ever before [12].

To date no studies in literature have evaluated incidence of dentinal microcracks after root canal preparation with Race Evo file system, and only one study evaluated incidence of apical crack formation associated with TruNatomy file system [13], so the current study's objective was to assess incidence of dentinal crack after root canal instrumentation by TruNatomy and Race Evo compared with Protaper Next rotary files.

MATERIALS AND METHODS

The proposal for this in-vitro study was granted permission by the Ethics committee, Faculty of Dentistry, Cairo University. (REC reference: 28/2/23).

Sample size calculation:

Sample size calculation was performed based on data extracted from Çırakoglu and Özbay 2022 [13]. The percentages of cracks due to different filling system were (40 and 7%). The anticipated sample size using z-test for the difference between two proportions was a total of 50 specimens, based on an alpha (α) level of (5%) and a power of 80%. Sample size was increased to a total of 60 specimens to compensate in case of any losses during the experiment and to obtain more precise results.

Samples selection and preparation

60 Freshly extracted human permanent maxillary single rooted premolar teeth with intact mature apices that were extracted for purposes unrelated to this study were selected. Teeth were radiographed, and only teeth with single canal and curvature less than 10° were included in the study. Any debris or tissue remnants were removed by curette, then samples were kept in distilled water until further use.

For the sake of samples homogeneity, decoronation of the teeth using a low-speed saw (Buehler Ltd., Lake Bluff, IL, USA) in the presence of water coolant was performed, to obtain root length of 14 mm. Also, the canal diameter near the apex in all selected roots was fitting for a size 10 K-file (Mani, Inc., Utsunomiya, Japan).

Then the roots were examined under a stereomicroscope at 25X magnification (Leica microsystems Ltd, Germany), roots with any preexisting external defects or cracks were excluded from the study and replaced by another intact samples.

The working length was detected by introducing size 10 k-file into the root canal until the file's tip became visible from the apical foramen then subtracting 1 mm from that length.

Afterwards, a monolayer of aluminum foil was employed to encircle each root before being immersed in a cold-cure acrylic resin to set in a resin tube. After setting, the root was removed and the aluminum foil layer was replaced by light-body impression material (Coltene/ Whaledent AG, Switzerland) for periodontal ligament simulation, then the root was relocated [14].

Root canal preparation

Roots were randomly allocated into 3 experimental groups and one control group according to the nickel titanium (NiTi) root canal preparation system that were used as follows:

Control group (n=15): Not prepared root-canals.

Group I (n=15): prepared using Protaper next (PTN) rotary system.

Group II (n=15): prepared using Race Evo (RE) rotary system.

Group III (n=15): prepared using Trunatomy (TRN) rotary system.

One endodontist, performed all root canal preparation. Each file was used only in 5 root canals and operated by an electric cordless torque control endodontic handpiece (Rooter S, FKG Dentaire, Switzerland).

A glide path was secured by a manual stainless steel #10 K-file (Mani, Inc., Utsunomiya, Japan). Each canal was prepared in a crown-down manner till the working length, to obtain final apical preparation with size 25 in each group. Each NiTi rotary file system was used in accordance with the following guidelines from the manufacturer;

Group I (PTN); At 300 rpm and 2 Ncm torque, the canals were prepared by first utilising PathFile (16/.02), then PTN X1 (17/.04), and finally PTN X2 (25/.06).

Group II (Trunatomy); shaping root canals started with orifice modifier followed by the glider then Prime (26/.04) till the full working length at 500 rpm speed and 1.5 Ncm torque.

Group III (Race Evo); root canal preparation started with using RE1 (15/.04) to perform glide path followed by shaping with RE2 (25/.04) and then RE3 (25/,06) till working length for final apical preparation at1000 rpm speed and 1.5 Ncm torque.

Root canals were irrigated between files with 3 ml of 2.5% NaOCl using 30-gauge side vented needle (Cerkamed, Poland). Following preparation root canals were rinsed with distilled water, then 5 ml of 17% EDTA (Cerkamed, Poland) and finally flushed with distilled water

Microscopic Examination

Samples were then sectioned horizontally at 3, 6, and 9 mm from the apex with a low-speed saw under water coolant (Buehler Ltd., Lake Bluff, IL, USA) to be observed under a stereomicroscope (Leica Microsystems Ltd., Germany) at 25 X magnification and digital images of each section were taken (Figure 1).

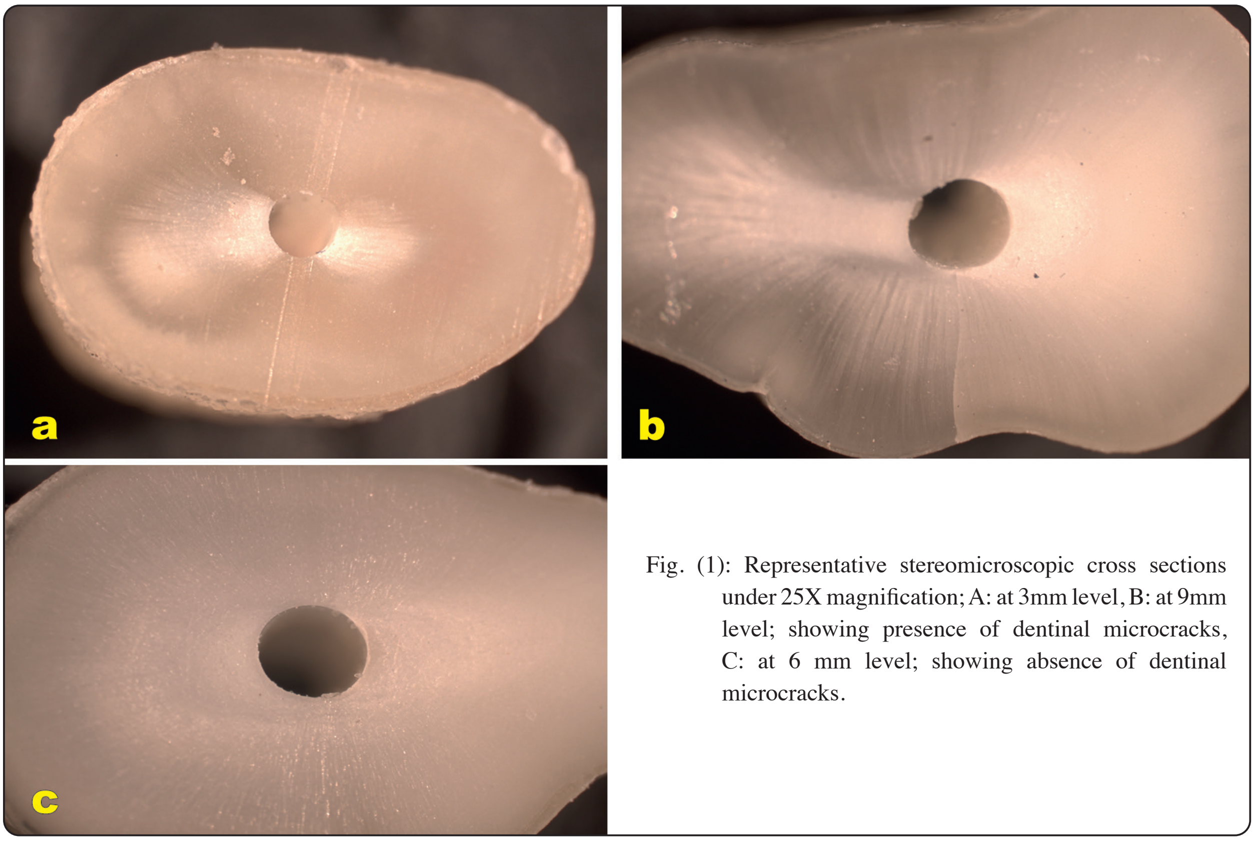


Fig. (1): Representative stereomicroscopic cross sections under 25X magnification; A: at 3mm level, B: at 9mm level; showing presence of dentinal microcracks, C: at 6 mm level; showing absence of dentinal microcracks.

Sections were investigated for the presence of dentinal microcracks by an operator that was blinded to the rotary file system that had been used in the root canal preparation.

Roots were considered cracked if they have any microcrack originated from the inner wall of root canal at any section [15] (Figure 1; A, B)

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. Micro-crack data presence (Yes/No) was shown as frequencies and percentages. The Fisher's Exact test was employed to compare different systems. The Friedman's test was applied to compare various root levels. The level of significance was established at $P \leq 0.05$.

RESULTS

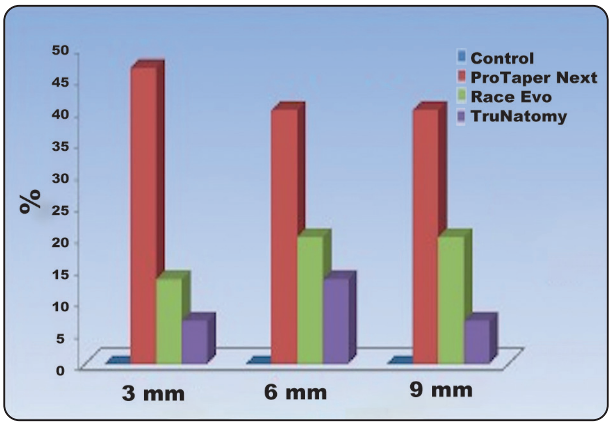
The occurrence of microcracks in each group and root level as well as their proportions per group are shown in (Table 1 and Figure 2). Control group showed no micro-cracks at the three levels. At 3 mm root level, 6 as well as 9 mm root levels there was a statistically significant difference between systems in which ProTaper Next showed the highest prevalence of micro-cracks followed by Race Evo then TruNatomy.

As regards comparison between root levels within each group, there was no statistically significant difference between prevalence of micro-cracks at different root levels with ProTaper Next, Race Evo as well as TruNatomy systems (p-value= 0.368, effect size=0.067) for each system, respectively.

TABLE (1) Frequencies, percentages (%) of micro-cracks, results of Fisher's Exact test for comparison between systems and Friedman's test for comparison between different root levels

	Micro-Cracks [n(%)]				p-value	Effect size (v)
	Control group (n=15)	Group I ProTaper Next (n=15)	Group II Race Evo (n=15)	Group III TruNatomy (n=15)		
3 mm	0(0%)	7(46.7%)	2(13.3%)	1(6.7%)	0.006*	0.482
6 mm	0(0%)	6(40%)	3(20%)	2(13.3%)	0.042*	0.373
9 mm	0(0%)	6(40%)	3(20%)	1(6.7%)	0.018*	0.410
p-value	Not computed	0.368	0.368	0.368		
Effect size (w)		0.067	0.067	0.067		

: Significant at p≤ 0.05



Fig/ (2): Bar chart representing prevalence of micro-cracks in different groups

DISCUSSION

Several aspects of NiTi rotary systems, including design, cross section, and metallurgy, may influence the occurrence of dentinal crack formation [16,17].

Maxillary premolars were chosen because they are thought to be one of the most vulnerable teeth to vertical root fracture [18].

To ensure standardization in the groups, only teeth with an apical canal diameter fitted with a size 10 K-file were included and all the roots were 14 mm long [19].

Periodontal ligament simulation has been performed using acrylic blocks and a light body impression material since it serves as a significant stress absorber and may affect the results of such studies [20].

In the present study, the incidence of dentinal crack formation after root canal preparation with TruNatomy, Race Evo and Protaper Next NiTi rotary systems was assessed. Since, Protaper Next had been widely used and had been extensively studied in literature, it was used in the current study as benchmark [19,21].

Absence of microcracks in the control group assured that the sectioning procedure didn't contribute to crack initiation.

The results of the present study showed that ProTaper Next produced more dentinal microcracks when compared to TruNatomy and Race Evo rotary systems.

TruNatomy and Race Evo are more flexible than ProTaper Next owing to improved metallurgy, it has been reported that heat treatment's increased flexibility had a greater impact on microcrack occurrence than other parameters [15].

Despite the fact that both ProTaper Next and TruNatomy have off-centered cross section which generates a swaggering motion that reduces the contact between the file and dentin wall [8], TruNatomy has many advantages due to its new post-manufacturing heat treatment as well as its regressive taper which makes it more flexible [10].

Race Evo is identical to Race in terms of design, but it is made of a new heat-treated NiTi alloy that is up to 1.4 more flexible [12].

Additionally, both systems have higher rotational speed which has been linked to improved cutting efficiency [22] leading to lower incidence of dentinal microcracks [21]

Thus, the greater flexibility and greater cutting efficiency could be considered the reason of the fewer dentinal microcracks in TruNatomy and Race Evo groups.

TruNatomy showed lower incidence of dentinal microcracks than Race Evo group which might be attributed to regressive taper design of TruNatomy [10]

One of the present study's limitations was the use of nearly straight canals which didn't always represent clinical situations; therefore, further evaluation in severely curved root canals is recommended.

CONCLUSION

Within confines of this in vitro study, it could be concluded that TruNatomy and Race Evo rotary systems showed lower incidence of dentinal microcracks in comparison to ProTaper Next rotary system.

Conflict of Interest

The study's authors rule out any potential conflicts of interest.

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