



## **Effect of Using Race Evo, EdgeFile X7, and Protaper Gold Rotary File Systems on the Fracture Resistance of Obturated Root Canal (A comparative study)**

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### **Abstract**

**Aim:** The purpose of this research was to compare the fracture resistance of obturated roots prepared by using the Race Evo, Edge File X7, and Protaper Gold file systems.

**Materials and methods:** 60 extracted maxillary first molars were selected, their coronal portions were removed and their working length was calculated. The samples were separated into three experimental groups according to the used NiTi rotary systems and one control group; each group contains 15 samples. Group one remained uninstrumented (control), Groups 2-4 were instrumented by the Race Evo (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), Edge File X7(Edge Endo; Albuquerque, New Mexico, United States), and Protaper Gold file systems (Dentsply, Maillefer, Switzerland) respectively. After instrumentation, the experimental groups were filled using a single-cone technique. The sealer was mixed according to manufacturing instructions with master Gutta-Percha cones of size 40 (0.04 taper, (Diadent Group International, Korea) for Race Evo and Edge file X7, and size 40 taper 0.06 for the Protaper Gold file system (Dentsply, Maillefer, Switzerland). To set the sealer, the specimens were kept at 37 °C and 100% humidity for two weeks. The root fracture stress was measured in Newtons using Instron universal testing equipment.

**Results:** One Way ANOVA test showed there was a significant difference in the mean value of the fracture resistance between the four groups ( $P < 0.05$ ). The LSD test was used for the comparison of the multiple groups so the control group showed the highest fracture resistance among groups ( $p < 0.05$ ). among the experimental groups, the roots prepared by Race Evo showed the highest fracture resistance ( $p < 0.05$ ), while roots prepared by Protaper Gold and Edge file x7 showed the lowest fracture resistance with a statistically significant difference ( $p > 0.05$ )

**Conclusion:** Root canal instrumentation with NiTi rotary files damages roots and promotes root fractures. NiTi file-cutting efficiency may reduce root canal dentinal wall fractures.

**Keywords:** fracture resistance, rotary instruments, Race Evo, Protaper Gold, and Edge File X7.

## Introduction

Mechanical root preparation is one of the most important factors affecting the outcome of root canal treatment and creating sufficient space for chemical irrigation and obturation materials (Hülsmann et al., 2005).

Because of their flexibility and shape memory, rotary Ni-Ti instruments simplify root canal treatment; however, dentinal cracks may develop as a result, weakening the tooth structure and leading to fractures (Liu et al., 2013; Pawar et al., 2018)

Tooth structure loss from cavities or trauma, dentin dehydration, access cavity preparation, instrumentation with rotary files, the negative effects of irrigation solutions, and too much pressure during filling procedures are all factors that can weaken the integrity of an endodontically treated tooth and lower its chances of survival (Karapinar et al., 2009; Tang et al., 2010)

When the frequency of microcracks increases, so does the danger of vertical root

fractures (VRF) in teeth (Bier et al, 2009). VRF associated with endodontically treated teeth is one of the most problematic clinical problems that might occur as a result of instrument design, kinematics, and mechanical behavior after root canal therapy operations (Testori et al., 1993; Capar et al., 2014).

ProTaper Gold (PTG) has advanced metallurgy but the same geometrical characteristics similar to ProTaper Universal (PTU; Dentsply Maillefer): triangular convex cross-section, modified non-cutting tip, and varied tapers across each file's cutting blades (Shi et al., 2022).

The EdgeEndo X7 rotary system: An annealed heat-treated (AHT) nickel-titanium alloy is used in the construction of the EdgeEndo X7 rotary system, and FireWire technology is used (EdgeEndo; Albuquerque, New Mexico, USA). The files in its system are all constantly tapered with varying pitches. The manufacturer claims that the technology is reliable and adaptable (Gambarini et al., 2019)

Race Evo file systems (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) have a non-cutting tip, a triangular cross-section, a constant taper, and a patented alternative cutting edge that reduces the screwing effect. They are heat-treated to improve the shape memory of the NiTi alloy and reduce its sensitivity to cyclic fatigue and fracture, and their blue hue indicates the existence of a titanium oxide layer that improves their resistance (FKG Dentaire, 2020).

Several studies have been done to find out how different NiTi rotary files, either full rotation or reciprocating files, have an impact on the fracture resistance of teeth that have had endodontic treatment. The Race Evo and Edge file X7 file systems were utilized in this investigation since there was no evidence available in the literature concerning their impact on the fracture resistance of obturated roots.

The goal of this study was to compare the performance of the Race Evo, the EdgeEndo X7, and the Protaper Gold endodontic rotary systems in terms of reducing root fractures.

## Materials and methods

The local ethics committee of Mustansiriyah University's School of Dentistry authorized the present study (code: 9412257396). The research used 60 extracted maxillary first molars. The teeth exhibited no cavities, open apices, or cracks. A digital caliper was used to measure buccolingual and mesiodistal widths at 3 mm, 6 mm, and 9 mm to standardize root measurements. Palatal roots were cut 11 mm from the apex. Subtracting

1 mm from root length gives working length. The samples were divided into four groups according to the instrument used.

Group 1: control group ( $n = 15$ )

Group 2: Race Evo endodontic files ( $n = 15$ )

Group 3: Edge file x 7 endodontic files ( $n = 15$ )

Group 4: Protaper Gold endodontic file ( $n = 15$ )

## Root canal preparation

Each instrument was utilized in no more than three canals per tooth while using a torque-controlled endodontic motor (X-Smart; Dentsply Maillefer) with all NiTi rotary files, as recommended by the manufacturer. All files are used in a rotation motion.

The patency of the canal was confirmed by size #10 k file and the initial size file of the canal was #20 K file.

Group 1: The roots were left uninstrumented, and just the pulp was extirpated. Irrigants included 2% NaOCl and distilled water.

Group 2 (Race Evo): fifteen samples were instrumented with the Race Evo system. This was done by first using an ISO No 10 stainless steel hand file to create a smooth glide path then using a size 15 glide path RE1 (15.04), then start the preparation with a RE2 (25.04) initial shaping file, then a RE3 (30.04), and finally RE4 40 with a taper

of 0.04 that was used in a rotation motion using an electric speed and torque-controlled endodontic micromotor X Smart Plus, which has a pre-programmed setting with speeds of (800–1000 rpm) and (1–1.5 Ncm) as recommended by manufacturing instruction.

Group 3 (EdgeEndo X7 system): the fifteen samples were prepared by using a 15K file to the working length that was operated at 300 rpm (3 Ncm) in the following order: file (17/04), file (20/04), file (25/04), file (30/04), file (35/04), and file (40/04) until the entire working length was attained (AbdelWahed, 2021).

Group 4 (Protaper Gold System): the fifteen samples were prepared with a rotational file in this sequence SX: 0.19/.04, S1: 0.18/.02, S2: 0.20/.04, F1: 0.20/.07, F2: 0.25/.08, F3: 0.30/.09, and F4: 0.40/.06 according to the manufacturing instructions (Protaper Gold Brochure, 2014.)

Every time a new file size was introduced, the canals were irrigated with 5 mL of a 2.5% NaOCl solution and after instrumentation, we flushed the root canals with 5 milliliters of a solution containing 17% EDTA for one minute, Finally, 10 mL of normal saline was used to flush the canals before being dried with paper points (Mohammed & Al-Zaka, 2020)

### **root canal obturation**

The samples in groups 2, 3, and 4 were obturated using a single cone obturation method utilizing Guttaflow 2 Rokeo sealer (COLTENE, Switzerland) that was mixed

according to the manufacturing instructions, a master gutta-percha cone of Diadent taper 0.04 for race Evo, and edge file, and a gutta-percha cone of Protaper Gold taper 0.06 for protaper gold file were used. The specimens were maintained at 37°C and 100% humidity for two weeks. (Omran & Alhashimi, 2019; Mohammed & Al-Zaka, 2020)

### **Fracture test**

The roots were marked at the 9 mm point of the root length and the root surfaces were dipped into molten wax (dipping wax) (Shanghai New Century Material Co. Shanghai) to get a wax layer of 0.2 to 0.3 mm thickness, then self-cure acrylic (Shanghai New Century Material Co., Shanghai) mixed and placed into a mold and the samples were placed vertically with the aid of surveyor (Hassan & Gholam, 2020; Omran & Alhashimi, 2019). A universal testing device was used to evaluate the resistance to root fracture (Instron). The upper plate of the testing apparatus consisted of a tapered metal rod with a tip diameter of 0.8 mm and a 6% taper. After positioning the tip of the instrument above the canal opening, a gradually increasing vertical force was applied. (0.5 mm/min) until fracture occurred. (AbdelWahed, 2021)

### **statistical analysis**

The Statistical Package for the Social Sciences (SPSS) version 20 program was used to analyze the data (SPSS Inc., Chicago, IL, USA). Data normality was tested using the Shapiro-Wilk test (P value >

0.05), and the degree of significance was tested using the "One Way ANOVA test" (for multiple comparisons). To examine the differences in force values between groups LSD tests were used at a  $P < 0.05$ .

## Results

The result of the Shapiro-Wilk test showed that the samples were normally distributed,  $P > 0.05$ . The One Way ANOVA test showed a statistically significant difference among groups (Tables 1 and 2). The fracture resistance of roots prepared by Race evo, Edge File X7, and Protaper Gold was significantly lower than the control (unprepared root) ( $p < 0.05$ ). Race Evo had significantly higher fracture resistance compared to Edge File and Protaper Gold file systems ( $p < 0.05$ ), while Protaper Gold and Edge File X7 were not statistically significant differences ( $p > 0.05$ ).

## Discussion

Dentin microcracks from root canal preparation are still controversial. Numerous investigations have found that root dentin prepared using rotational NiTi tools develops structural defects such as microcracks and craze lines. Nevertheless, multiple micro-computed tomography investigations found no dentinal microcracks after root canal instrumentation (De-Deus et al., 2015; Pradeep Kumar et al., 2019).

Effective chemo-mechanical root canal preparation is thought to have an impact on successful endodontic results. Because of the constant contact that is maintained

between the endodontic cutting tool and the dentin walls during preparation, there is a potential increase in the risk of root fractures. (Rundquist et al, 2006; Adorno et al, 2009). When the root canal system is mechanically instrumented using a NiTi instrument, tiny cracks in the canal dentinal walls are possible (Bürklein et al., 2013).

The cross-section, taper, flute form, alloy type, and rotational motion of NiTi instruments used for root canal preparation might impact VRF resistance (Mohan et al., 2018).

Mechanical testing requires specimen uniformity to determine fracture resistance [Nur et al., 2015]. After decoronation, similar roots were selected and root lengths equalized. This research used upper permanent first molar palatal roots because they had more circular channels, distributing stress more evenly (Khdairah and Al-Gharrawi, 2020)

The results of this investigation demonstrated that Group 1 (the control) has the greatest statistically significant fracture resistance value, which clearly explains and validates the deleterious influence of NiTi file instrumentation on root canal fracture resistance as compared to, unprepared roots. There was a significant difference between the experimental groups as well.

Comparatively, Group RaceEvo has high fracture resistance. The triangular cross section's smaller area may explain this. Compared to smaller cross-sectional areas, the stress buildup during bending increased

as the cross-sectional area increased. The contact between the instrument and root canal walls generates internal stresses in the instrument and on the root canal wall. The convex triangular cross-section design in this study displayed the highest von Mises stress during bending and torsion; this is because the cross-section's surface area and perimeter were increased in addition to the three points of contact with the canal walls, which increased torsional fatigue. Conversely, a decrease in cross-sectional area may be related to the file's increased flexibility (Kim et al., 2009a; Galal and Hamdy, 2020).

Adjusting the transition temperature and alloy microstructure during the thermal treatment of NiTi alloys improves their mechanical performance. The heat-treated NiTi alloy is mostly R-phase and martensite, which is more flexible than austenite (Pereira et al., 2015; Zupanc et al., 2018). Heat treatment makes all of the rotational systems employed in this study more flexible.

We employ four files sequentially in Race Evo, six files in Edge File X7, and seven files in Protaper Gold Systems during instrumentation. So this agrees with Liu et al. (2013), who conducted research comparing the fracture resistance of the three single-file systems (Reciproc, OneShape, SAF), and ProTaper systems (multiple files) and discovered that the Reciproc, OneShape, and SAF—caused less damage than the ProTaper system. This is consistent with other studies that have suggested that additional canal

modifications may result in the accumulation of harm (Shemesh et al., 2011; Liu et al., 2013).

the fracture resistance of the root canal by using Protaper Gold which has a greater taperness of 6% while other groups have 4% (according to the manufacturer). this decrease in fracture resistance was attributed to that greater taper weakening the treated tooth and lowering the fracture resistance (Aidasani et al, 2020; Nassar et al., 2022)

Taking into account the limitations of this in vitro study, when the ProTaper Universal instrument was used to clean out root canals with high torque settings, more cracks appeared in the root canal dentin than when the instrument was used with low torque settings. The high-torque settings may have more cracks because the dentinal surface was under more stress (Dane et al., 2016). This may support the results of this study as The torque values used in Race Evo, Edge File X7, and Pro Taper Gold were 1.5, 3, and 4 Ncm, respectively.

According to Peter et al.,2014 and Capar et al.,2015, the increased rotational speed is related to increased cutting efficiency and lesser crack formation so this may indirectly affect the result of the current study in that group Race Evo had the greatest fracture resistance as it was used at high speed (800) rpm according to the manufacturing instruction.

The ProTaper Next and HyFlex instruments cause fewer dentinal cracks than the ProTaper Universal instrument, which may

be related to the fact that the ProTaper Next and HyFlex systems require fewer instruments to shape than the ProTaper Universal system and that the HyFlex instrument's suggested speed (500 rpm) is greater than the other devices examined in this study. The low incidence of cracks in root dentin after root preparation is due to their superior cutting effectiveness, the HyFlex, and ProTaper Next groups had fewer fractures than the ProTaper Universal group (Peters et al., 2014; Capar et al., 2014).

An in-and-out motion of NiTi rotary instrumentation, commonly known as the pecking motion, has been proposed to lessen the risk of fracture by distributing the instrument's flexural stress. The pecking action is supposed to be a regulated movement against the rotating instruments' screw-in forces. This may coincide with the current study result in that the Race Evo group had the highest fracture resistance compared to the other experimental groups as the pecking motion used with Race Evo files (Li et al., 2002; Ha et al., 2017).

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The results of this research reject the null hypothesis that there is no difference in the fracture resistance of root canals prepared using different rotary file systems (Race Evo, Edge File X7, and Protaper GOLD file systems).

### Conclusion:

Root canal instrumentation with NiTi rotary files has a negative impact on roots and increases the risk of root fractures in comparison to intact, unprepared roots. Roots prepared by the Race Evo file system have better fracture resistance than other experimental groups.

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**Table 1:** One way Anova test for comparison of root fracture resistance prepared by different file systems

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	372094.067	3	124031.356	15.914	.000
Within Groups	436445.867	56	7793.676		
Total	808539.933	59			

**Table 2:** LSD test for comparison across the group

Groups		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	Race Evo	97.6000(*)	32.23596	.004	33.0236	162.1764
	Edge filex7	183.4667(*)	32.23596	.000	118.8903	248.0430
	Protaper Gold	196.6667(*)	32.23596	.000	132.0903	261.2430
Race Evo	Edge filex7	85.8667(*)	32.23596	.010	21.2903	150.4430
	protaper	99.0667(*)	32.23596	.003	34.4903	163.6430
Edge filex7	Protaper Gold	13.2000	32.23596	.684	-51.3764	77.7764

\* The mean difference is significant at the .05 level.