EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 70, 809:814, JANUARY, 2024
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
CONSERVATIVE DENTISTRY AND ENDODONTICS
Submit Date : 21-10-2023 • Accept Date : 15-11-2023 • Available online: 10-01-2024 • DOI : 10.21608/EDJ.2023.243906.2752

ASSESSMENT OF FRACTURE RESISTANCE OF MESIAL ROOTS OF MANDIBULAR MOLARS PREPARED BY NITI ROTARY FILES OF DIFFERENT TAPERS AND ALLOYS (A COMPARATIVE IN-VITRO STUDY)

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ABSTRACT

Objective: the objective of the current study was to compare fracture resistance of mesial roots of mandibular first molars prepared by ProTaper Next (PTN; Dentsply Sirona, Ballaigues, Switzerland) and Race Evo (RE; FKG Dentaire SA, La Chaux-de- Fonds, Switzerland) at different tapers.

Materials and methods: 44 freshly extracted mature intact human mandibular molars that were free of cracks or fractures were selected. After decoronation and distal root separation samples were randomly allocated into one control group unprepared and three experimental groups according to the system used for mesiobuccal root canal preparation as follows; Group (I) was prepared using the ProTaper Next up to X3 (30/07), and Group (II) was prepared using RaCe EVO up to 30/04. Group (III) was prepared using RaCe EVO up to 30/06. Then samples were mounted into acrylic blocks with periodontal ligament simulation and subjected to fracture resistance test utilizing the universal testing machine.

Results: The control group showed statistically highest resistance to fracture (*P*-value <0.001, Effect size = 0.839). Comparison between experimental groups showed that RaCe EVO 4% group had the highest resistance to fracture followed by RaCe EVO 6% group and the ProTaper Next group showed the lowest resistance to fracture.

Conclusion: It could be concluded that decreasing root canal preparation taper increased root resistance to fracture also fixed taper preparation had higher root resistance to fracture than progressive taper preparation.

KEYWORDS: Protaper Next; Race EVO; Fracture resistance.

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INTRODUCTION

Mechanical instrumentation of root canals is a critical step in root canal treatment to promote disinfection of root canals [1]. Root canal preparation size should achieve proper debridement, allow deep penetration of irrigants, and facilitate obturation without compromising tooth structure [2,3]

Small taper preparation may decrease the incidence of procedural errors but may affect the cleanliness of the root canal while large taper preparation may be associated with better canal cleanliness but at the same time may be associated with procedural errors [4,5].

Removal of much tooth structure during root canal preparation may weaken the root making it susceptible to vertical root fracture [6,7]. Vertical root fracture is one of the worst complications of root canal therapy, which frequently ends in tooth loss [8].

Various NiTi systems with different designs, alloys, and tapers have evolved in the market [9].

ProTaper Next (PTN; Dentsply Sirona, Ballaigues, Switzerland) instruments are made from special heat-treated alloy (M-Wire) and have an off-centered rectangular cross-section with progressive taper design, they are available in different sizes; X1 (17/04), X2 (25/06), X3 (30/07), X4 (40/06), and X5 (50/06) [10].

Race Evo (RE; FKG Dentaire SA, La Chaux-de- Fonds, Switzerland) instruments have the same design features as the RaCe rotary system of alternate cutting edges with triangular cross-section design and fixed taper but are manufactured with special unique heat-treated alloy that increased flexibility, they are available in different sizes and tapers (15/04, 25/04, 25/06, 30/04, 30/06, 35/06, 40/04, 50/4) [11].

There are still conflicts in the literature regarding ideal root canal preparation size and taper that achieve disinfection without scarifying tooth structure [12].

According to the literature, there was no study comparing the fracture resistance of roots prepared by ProTaper Next and RACE EVO rotary instruments with different tapers. Therefore, the objective of this study was to compare fracture resistance of the mesial roots of the mandibular first molars prepared by ProTaper Next and Race Evo at different tapers.

MATERIALS AND METHODS

The Minia University Faculty of Dentistry's Research Ethics Committee gave the study its approval; (Committee No 89, Decision No 634).

Sample size calculation

Sample size calculation was performed based on the results of Kiliç Y et al. (2021) [13] in which the resulting effect size (f) was 0.543. Using Alpha (α) level of (5%), power = 80%, the anticipated sample size was not less than a total of 44 specimens (11 specimens per group). G*Power Version 3.1.9.2 was used to calculate the sample size.

Samples selection:

44 freshly extracted mature human mandibular first molars that were free from root caries and extracted for periodontal or orthodontic reasons were collected from the outpatient clinic, Faculty of Dentistry, Minia University. All debris and hard tissue remnants were removed using a scaler. Teeth were examined under a stereomicroscope at 16 X magnification (Zeiss Technival 2, Germany) to exclude the presence of any cracks or fractures. Then teeth were radiographed to exclude those with internal resorption or calcification. Teeth were accessed and only those with two separate patent mesial canals with apical size compatible with K file size 15# were selected.

Samples preparation and grouping:

Distal roots and coronal portions were separated using a diamond bur to obtain a mesial root with a

standardized length of 16mm. teeth were rechecked under a stereomicroscope at 16X magnification (Zeiss technical 2, Germany) to exclude and replace any sample that showed any fractures or cracks following the separation process

Samples were randomly allocated into three experimental groups and one control group (n=11) according to the instrument used for MB canal preparation as follows:

Control group: Not instrumented

Group I: MB canal was enlarged using the ProTaper Next up to X3 (30/07)

Group II: MB canal was enlarged using RaCe EVO up to 30/04.

Group III: MB canal was enlarged using RaCe EVO up to 30/06.

The working length was established as 1 mm shorter than the apical foramen and a glide path was secured by hand K file size 15# (Mani, Inc., Utsunomiya, Japan).

Root canals in each group were prepared to working length according to the manufacturer's recommendations using torque control handpiece as follows;

In group I; PTN was used in sequence of X1 (17/04), X2 (25/06), and X3 (30/07) till working length at 300 rpm speed and 2 Ncm torque.

In group II; RE files were used in the sequence (15/04, 25/04, and finally 30/0.04) at 800 rpm and 1.5 Ncm torque.

In group III; RE files were used in the sequence (15/04, 25/04, 25/06, and finally 30/0.06) at 800 rpm and 1.5 Ncm torque.

During preparation, root canals were irrigated with 3 ml 2.5% NaOCl between files followed by distilled water and 5 ml 17% EDTA then final flush with 5 ml 2.5% NaOCl. Irrigation was performed using a 30-gauge side vented needle (Cerkamed, Poland) mounted on the plastic syringe.

Then root canals were dried using sterile paper points (Meta Biomed, Korea) and obturated with a single cone technique using matched gutta percha points (Meta Biomed, Korea) and ceraseal bioceramic sealer (Meta Biomed, Korea), then samples were incubated for 2 weeks.

The apical 5mm of each root was covered with aluminum foil and immersed into chemical-cured acrylic resin blocks, after setting the root with aluminum foil was removed and the space occupied by aluminum foil was filled by light body silicone impression material (3M ESPE, Seefeld, Germany) to simulate periodontal ligament [14] after that root was repositioned in acrylic blocks.

Fracture resistance test

A universal testing machine performed a fracture-resistant test (Instron model 3345 England). Each root sample was subjected to continuous axial static load parallel to the long axis of the root using a stainless-steel ball 2 mm at a speed of 1.0 mm/min until fracture occurred (Figure 1). Forces required for fracture were recorded as newtons by machine software (BlueHill universal Instron England).

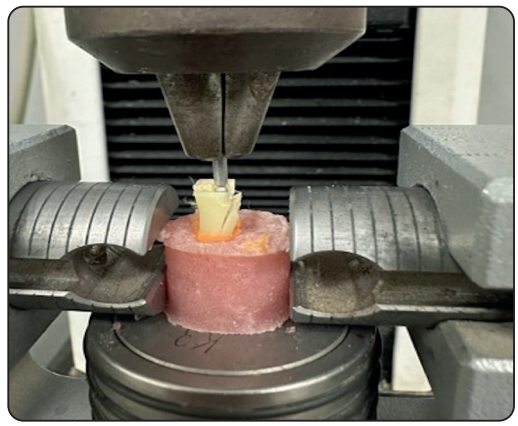

Fig. (1) Sample mounted on universal testing machine subjected to load until fracture.

Statistical Analysis

By examining the data distribution and applying tests for normality (Kolmogorov-Smirnov and Shapiro-Wilk tests), numerical data were examined for normality. Compressive strength data showed normal (parametric) distribution. The mean and standard deviation (SD) values of the data were presented. The one-way ANOVA test was employed to evaluate variations across groups. Pair-wise comparisons were made using Bonferroni's post-hoc test when the ANOVA test was significant. The cutoff for significance was chosen at $P \leq 0.05$. With IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp, Statistical analysis was carried out.

RESULTS

Results are presented in table (1) and figure (2). There was a statistically significant difference between the mean compressive strength values of different groups (*P*-value <0.001, Effect size = 0.839). Pair-wise comparisons between groups showed that the control group had the statistically significantly highest mean compressive strength. Race Evo Taper 4% showed statistically significantly higher mean compressive strength followed by Race Evo Taper 6% with a statistically significant difference between the two groups. ProTaper Next group showed the statistically significantly lowest mean compressive strength.

TABLE (1): Mean, standard deviation (SD) values and results of one-way ANOVA test for comparison between compressive strength (N) with different groups

Group (n = 7)	Mean	SD	*P*-value	*Effect size (Eta squared)*
ProTaper Next	231.2 ^{D}	30.1	<0.001*	0.839
Race Evo Taper 4 %	359 ^{B}	25.5		
Race Evo Taper 6 %	298.4 ^{C}	32.4		
Control	421.9 ^{A}	43.4		

: Significant at P ≤ 0.05, Different superscripts indicate statistically significant difference between groups

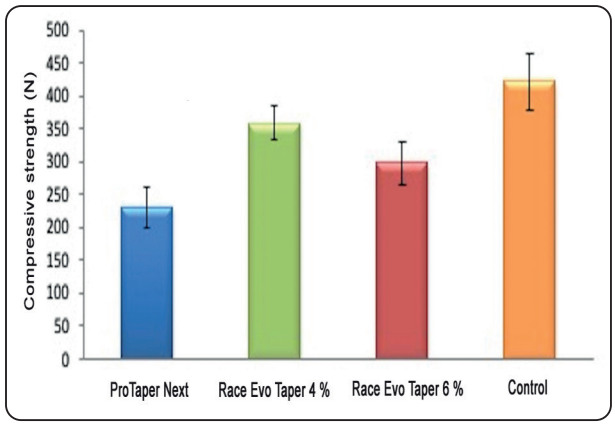

Fig. (2): Bar chart representing mean and standard deviation values for compressive strength of different groups

DISCUSSION

Root canal preparation size is one of the potential factors that may predispose to vertical root fracture [7]. The present study aimed to evaluate the effect of root canal preparation with different tapers on fracture resistance of mesial roots of mandibular molars.

Mesial roots of mandibular molars were selected as these roots have narrow mesiodistal dimensions and are susceptible to vertical root fracture [15].

Root canals were apically prepared to size # 30 as it has been shown that apical preparation to a size that is three times larger than the initial file is adequate for root canal cleanliness [16].

In the present study, all NiTi systems were used in rotary motion to ensure that all samples were prepared in the same way [17].

All samples were obturated using a single cone technique to avoid other confounding factors such as stresses generated during the lateral compaction technique [18] or during the warm vertical compaction technique [19].

Simulating the periodontal ligament was performed using light body impression material in the tooth model to accommodate some of the vertically applied forces [20].

The result of the present study showed that the fracture resistance of each experimental group was lower than that of the control group which was in agreement with previous studies [5,20,21].

Race Evo taper 4 % group showed the highest resistance to fracture in comparison to other experimental groups, this could be explained by decreased loss of root structure in comparison to files with greater taper that tend to remove more pericervical dentin and so decreasing root resistance to fracture [21,22].

Protaper next group showed the lowest resistance to fracture in comparison to both Race Evo groups which might be attributed to greater root stresses produced by progressive taper design than that produced by constant taper design in accordance to previous studies [23,24].

Also, Protaper next is operated at a higher torque value than that of Race Evo which might cause more root stresses during instrumentation and so lowering root resistance to fracture [25].

CONCLUSION

Within the limitations of this in vitro study, it could be concluded that decreasing root canal preparation taper would increase root resistance to fracture, and fixed taper preparation had higher root resistance to fracture than progressive taper preparation.

Conflict of interest

The authors rule out any conflict of interest

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