FRACTURE RESISTANCE EVALUATION AFTER MINIMAL INVASIVE PREPARATION USING TRUNATOMY VERSUS PROTAPER NEXT (A COMPARATIVE IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: Minimally invasive endodontics (MIE) is the latest innovation in endodontics that focuses on minimal mechanical preparation; as it leads to preserving the fracture strength of teeth.
AIM OF THE STUDY: To compare the fracture resistance of mandibular molars following preparation by TruNatomy versus ProTaper Next rotary instruments.
MATERIALS AND METHODS: Thirty permanent mandibular molars were selected in this study. Teeth were randomly distributed into two equal groups. Decoronation of the crown was done and the distal root was sectioned from the mesial root and acted as a control group. Study Group I: Fifteen mesial roots (MB and ML canals) were prepared using TruNatomy (TRN) rotary files up to the prime file (26/.04). Study Group II: Fifteen mesial roots were prepared using ProTaper Next (PTN) rotary files to size X3(30/.07). Control Group: The distal root of each tooth. Roots were placed in acrylic resin blocks and fracture loading was applied. Data were statistically analyzed.
RESULTS: Roots prepared with TRN were significantly more fracture resistant than roots prepared with PTN. In addition, a significant difference was noted between the mesial and distal roots within each group.
CONCLUSIONS: Mandibular molar mesial roots prepared with TRN rotary files (26/.04) are significantly more fracture resistant than those prepared with PTN rotary files (30/.07). In addition, intact mandibular molar distal roots were significantly less prone to fracture than the mesial roots prepared with both systems.
KEYWORDS: Endodontically treated teeth, Fracture resistance, Mandibular molars, ProTaper Next, TruNatomy.
RUNNING TITLE: Fracture resistance evaluation after minimal invasive preparation.

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INTRODUCTION

Tooth fracture is considered to be one of the most undesirable outcomes of endodontically treated teeth (ETT) (1). The strength, integrity, and pattern of force distribution during mastication have been reported as they have a great impact on ETT (2, 3).
ETT being susceptible to fracture is related to the loss of tooth structure due to caries or during different endodontic procedures; such as access cavity and canal preparations (4). Therefore; maintaining the tooth structure not only increases the fracture resistance but also preserves its structural integrity (3).
Minimally invasive endodontics (MIE) is a concept that focuses on minimal mechanical shaping and preparation as this leads to better maintaining the original canal anatomy (5). However, preparing root canals with small taper instruments caused problems during debridement. Thus, clinicians didn't know whether it was essential to maintain the tooth structure at the expense of treatment failure or not (6).
Recently, TruNatomy (TRN) (Dentsply Maillefer, Ballaigues, Switzerland) rotary files were launched. These new files are heat-treated and can shape the root canal systems to a continuously tapered preparation with maximum preservation of tooth structure. They are claimed to offer more simplicity, safety, better cutting efficiency, and mechanical properties compared to previous rotary files (7).
This system is made of an orifice modifier, a glider, and three shaping files. In addition, they are more

flexible and resistant to fatigue and are claimed to be safely used for approximately five canals with curvature 90° (7).

ProTaper Next (PTN) (Dentsply Maillefer, Ballaigues, Switzerland) rotary files, have made a great impact on the mechanical preparation of root canal systems (8). However, the progressive taper of these files can remove a greater amount of dentin, affecting the strength of teeth (3).

It was stated in literature that hard tissue removal from the canal walls might predispose to root fracture (9). However, some authors claimed that increasing canal preparation taper allowed forces to be better distributed; this might increase the fracture resistance of teeth (4).

Therefore, the research question was whether there would be a difference between the performance of TRN rotary files and PTN rotary files regarding the fracture resistance of mandibular molar roots. The null hypothesis of this study was that no significant difference between the two studied file systems would be found.

MATERIALS AND METHODS

The study was accepted by the ethical committee at the Faculty of Dentistry, Alexandria University. The sample size was estimated to be 13 per group, increased to 15 to make up for laboratory errors. The total sample size= number of groups × number per group= 2 X 15= 30. Using permuted block randomization technique, the allocation sequence was done using a random allocation software (https://www.sealedenvelope.com/simple-randomiser/v1/[Accessed 15 Sep 2021].) where samples were allotted in blocks of 4 (10).

The study was conducted on 30 extracted human permanent mandibular molars with non-fused roots and separate mesial canals with canal curvature ranging from (20°-40°) according to Schneider's technique (11). All teeth were decoronated and the length of the remaining roots was standardized to be 14 mm. Teeth were then sectioned through the furcation using a diamond disc to separate the mesial and distal roots. After that, the external root surfaces were evaluated under a stereomicroscope to exclude the possibility of any preexisting defects (12). Teeth were then disinfected and stored in saline.

They were randomly allocated into two equal groups (n=15). **Study Group I:** Fifteen mesial roots were prepared using TRN files till the prime file (26/.04). **Study Group II:** Fifteen mesial roots were prepared using PTN files till the X3 file (30/.07). **Control Group:** The Distal root of each tooth (un-instrumented). **(Figure 1)**

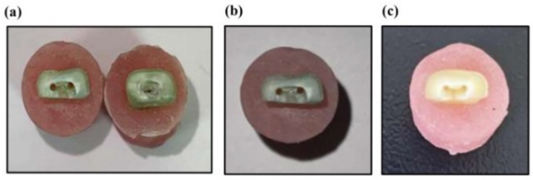

Figure (1): (a) Representative image showing the mesial and distal roots embedded in acrylic resin blocks, **(b)** The mesial root prepared by the PTN rotary files, **(c)** The mesial root prepared by the TRN rotary files.

For the TRN (group I), a glide path was reached using size 10 and 15 k-files in both MB and ML canals. An orifice modifier (20/.08 apical taper) was used in the coronal part. Followed by a glider (17/.02 apical taper) to the full working length. Finally, the Prime file (26/.04 apical taper) was used as the final file in the canal preparation. The speed and torque for all TRN files were adjusted at 500 rpm and 2.5 Ncm. **(Figure 2)**

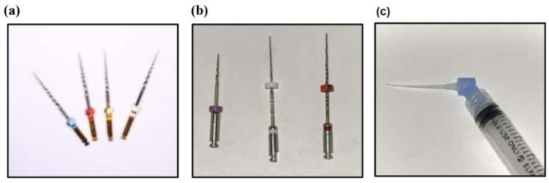

Figure (2): (a) ProTaper Next and Proglider files, **(b)** TruNatomy files **(c)** The specially designed irrigating needle of TruNatomy files.

For the PTN (group II), a manual glide path was reached using size 10, 15 k-files together with the Proglider (16/.02 apical taper) in both mesial canals. Canal preparation was done using X1, X2 and X3 (30/.07apical taper) as the final file in the canal preparation. The speed and torque for all PTN files were set at 300 rpm and 2 Ncm. **(Figure 2)**

For both groups, X-Smart plus motor (Dentsply Maillefer, Ballaigues, Switzerland) was used. EDTA gel (MD chelcream-Meta) was used as a chelating agent during the instrumentation along with 2ml of 2.5% (NaOCL) (Chlorox, Egyptian industry, ARE) irrigating solution after each instrument change. A 30-gauge side vented needle was used for the PTN and a special two side vented irrigating needle was used for the TRN. For the smear layer removal, 5 ml of 17% EDTA for one minute followed by a final flush of 5 ml of 2.5% sodium hypochlorite was used. All specimens were kept moist throughout the instrumentation procedure and were stored in saline after completing the instrumentation procedure.

Fracture Resistance Testing

Roots were placed into an acrylic resin mold (Acrostone; Dent Product, Egypt). Before testing, all roots were stored in distilled water. A vertical compressive loading at the center of the canal orifices using a universal testing machine by a round-end ball at a crosshead speed of 1 mm/ min was applied (13). **(Figure 3)**

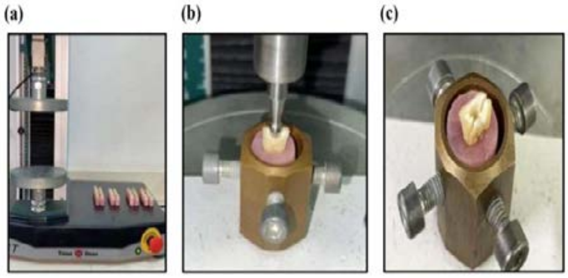

Figure (3): (a) The universal testing machine, **(b)** Load application at the center of the root between the two orifices, **(c)** Specimen after fracture

Statistical analysis of data

Data were assessed using IBM SPSS for Windows (Version 23.0). Normality was checked using descriptive statistics, plots (histogram and boxplot), and normality tests. Variables showed normal distribution, so means and standard deviation (SD) were calculated. Comparison of fracture resistance between the two study groups was performed using independent samples t-test, while comparison of the mesial and distal roots within each group was done using paired t-test. Significance was set at p-value <0.05.

RESULTS

The mean fracture resistance values of the mesial roots were (279.40 ± 47.52) and (206.53 ± 35.57) for the TRN and the PTN groups, respectively with a statistically significant difference between the two groups (P<0.001). The mean fracture resistance values of the distal roots were (327.07 ± 52.35) and (301.93 ± 30.89) for the TRN and the PTN groups, respectively with no statistical significant difference. Moreover, within each study group, a statistical significant difference was noted on comparing the mean fracture resistance values of the mesial and the distal roots (P=0.009 and P <0.001 respectively). **(Table 1 and Figure 4)**

Table (1): Fracture resistance values (N) of the two study groups

	TruNatomy (n= 15)	ProTaper Next(n= 15)	T-test P value
	Mean ± SD		
Mesial	279.40 ± 47.52	206.53 ± 35.57	T= 4.75 **P <0.001***
Distal	327.07 ± 52.35	301.93 ± 30.89	T= 1.60 P= 0.12
Paired t-test Mesial vs. Distal	T= 3.04 **P= 0.009***	T= 9.06 **P <0.001***	

*Statistically significant at p value <0.05

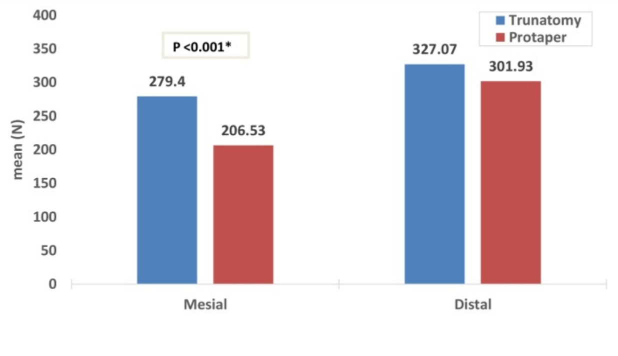

Figure (4): The mean fracture resistance values in the two study groups. (P value <0.05)

DISCUSSION

Root canal treatment needs effective cleaning and shaping to allow better disinfection of the canals. Given that rotary instrumentation is greatly accepted as a method for debriding and shaping the canals, it is essential to investigate different tapers used by rotary systems as they may eventually lead to VRF.

Root canal shaping should be performed mainly in such a conservative manner that the structural integrity of the tooth is preserved**.** Choosing a smaller taper might reduce the errors during shaping but it might compromise the cleanliness of the canal space. However, too large tapers might improve the cleanliness but may also lead to strip perforations and predispose to VRF. This is the debate which this study mainly focuses on.

The present study compared the effect of two rotary systems; newly heat-treated TruNnatomy files and ProTaper Next files on the fracture resistance of the mesial roots of extracted human permanent mandibular molars using the Universal testing machine.

In the current study, mandibular molar teeth were chosen as they are the first to erupt and the most prevalent for root canal treatment. In addition, they have the least survival rates as they are more susceptible to fracture and bear a lot of stresses during mastication(14). In addition, mesial root canals (study group) were instrumented as they have narrow diameter and they are the most susceptible roots to VRF (15). Although the distal root of lower molar teeth may have different canal/s configuration, dentin thickness and curvature than the mesial root, the distal root of each tooth was chosen to act as the control group in the present study to ensure that it has similar microstructure and chemical composition of the instrumented mesial root. Choosing intact mesial roots of different teeth to serve as control would not allow this feature which may influence the fracture resistance values.

The sample standardization is very important in fracture resistance testing studies using natural teeth as the fracture resistance of ETT is related directly to the amount of remaining sound tooth structure

(16). Decoronation and standardization of the root length were done to provide standardized experimental conditions. This was in accordance with previous studies (17,18). On the contrary, others left the crown intact to act as a reservoir for the irrigant (19).

In the present study, irrigation was another factor that was controlled. Two ml of 2.5% NaOCL was used as the main irrigant after each file change during instrumentation. The effect of NaOCl as an irrigant on the mechanical properties of root dentin offered a strong evidence that NaOCl alters negatively these properties, and the lowest possible concentrations is recommended as described by Dotto et al (2020) (20). The irrigation regimen in this study was done in accordance with previous studies (19, 21).

Regarding the smear layer removal in this study, 5 ml of 17% EDTA was used for one minute then 5ml of 2.5% NaOCL as a final flush was used. Regarding strength properties, teeth tend to fracture when they come in contact with solutions of higher concentrations or for a longer exposure time because of greater organic or inorganic tissue removal that leads to a reduction in these properties. Moreover, 17 % EDTA was used for one minute as the fracture resistance of ETT was significantly affected by the different concentrations of EDTA at different exposure times as mentioned by Uzunoglu et al (2012) (22).

Roots were embedded in acrylic blocks without periodontal simulation in agreement with Nawafleh et al (2020) (23), Capar et al (2014) (17) and Marchionatti et al (2014) (24) who claimed that the fracture load between groups with and without PDL simulation did not differ significantly. In addition, roots were vertically positioned in acrylic blocks to closely simulate the stresses that occur during mastication as described by Singla et al (2010) (25). Moreover, an Instron universal testing machine was used in the current study to evaluate tooth fracture resistance because it is the simplest and the most frequently used method to investigate tooth strength (26).

The concept of MIE instrumentation is one of the most important clinical debates nowadays where new files are being launched for this purpose. TRN files are recently introduced rotary files, designed to shape root canals to a continuously tapering preparation. They could maintain the canal geometry, especially in severely curved canal because of its regressive taper, less shape memory and special heat treatment of the NiTi alloy (27, 28). The cyclic fatigue and torsional resistance of the TRN files have been previously tested (27, 29), however, no data was available in literature on the effect of these files on the root fracture resistance.

The results of the present study showed that the mandibular molar mesial roots instrumented with TRN files are significantly more fracture resistant than roots instrumented with PTN rotary files. This finding may be due to several reasons. First of all, these systems have different sequences and alloy designs where the TRN is heat-treated while the PTN is made of M-wire alloy. Abou El Nasr et al (2014) (13) claimed that heat treatment has a critical effect on decreasing the dentinal defects development regardless of the kinematics, sequences and configuration of every instrument. Moreover, the higher flexibility owing to heat treatment might be related to the reduced incidence of dentinal cracks as mentioned by Capar et al (2014) (17).

A second reason for this finding could be due to the different tapers of these rotary files. In the TRN group roots were instrumented till the prime file which has 4% taper, while in the PTN group, roots were instrumented till file X3 which has a 7% apical taper. This difference in taper might be a reason for reduced fracture resistance in the PTN group in comparison with the TRN group. This was in line with Smoljan et al (2021) (30), who found that narrow progressive taper preparations lead to more fracture resistance than wider progressive taper preparations, and with Van der vyver et al (2019) (31) who reported that using the PTN files removed more dentin and the larger apical tip diameter of these files could lead to reducing the fracture resistance of roots. On the contrary, Sabeti et al (2018) (4) showed no significant difference in the fracture resistance of the roots by .06 taper instrumentation when compared with .04 but both differed significantly from the .08 taper.

The main purpose of our study was to evaluate the effect of different root canal preparation tapers on the root fracture resistance. However, the difference between the apical preparation sizes although kept minimal (0.26 in the TRN and 0.3 in the PTN), this might have influenced the results as more dentin was removed from the apical part of the root canals in the PTN group. This could be considered as a limitation.

The results of the current study showed that the control group (the distal root) had significantly higher fracture resistance values than those of the TRN and the PTN groups. These findings are in line with previous studies (32, 33) who suggested that the dentin wall thickness was directly related to the susceptibility of roots to fracture. This can be explained by the fact that instrumentation even with minimal taper (4%) removes from the dentinal walls causing weakening of the tooth structure.

Given our findings, the null hypothesis of the current study has been rejected as the increase in taper from .04 to .07 affected tooth fracture resistance significantly. The results of the present study did not support the use of the .07 taper and encourage the idea of a minimally invasive tapered canal preparation as has been previously reported (4, 34). Thus, when clinicians evaluate the root canal preparation taper the potential weakening effect of large instrument taper must be considered.

CONCLUSION

Mandibular molar mesial roots prepared with TRN rotary files (26/.04) are significantly more fracture resistant than those prepared with PTN rotary files (30/.07). In addition, intact mandibular molar distal roots were significantly less prone to fracture than the mandibular molar mesial roots prepared with both rotary systems.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

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