

## Original Research

# Comparative evaluation of influence of instrument taper on the fracture resistance of endodontically treated teeth, an in-vitro study

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## ARTICLE INFO



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## ABSTRACT

**Aim** - The aim of this study was to examine the influence of instrument taper, on the fracture resistance of endodontically treated roots.

**Method** - In total, 24 maxillary central incisors complying with the inclusion criteria were sectioned at approximately 13 mm from the apex. The roots were standardized with respect to the buccolingual-mesiodistal diameter before being randomly distributed into 3 experimental Groups (n = 6) and 1 control group (n = 6). The roots in group 1 were instrumented with hand files up to file 25/.02 and groups 2 and 3 with DXL – PRO rotary file up to files 25/.04 and 25/.06, respectively. After mechanical preparation, the roots were obturated with gutta-percha and sealer. Roots in group 4 acted as uninstrumented controls. A vertical load was applied to each specimen using a universal testing machine until the roots fractured. Data were statistically analysed by one way ANOVA test.

**Results:** The mean fracture load was **326.283333** N for the control group, **297.21667** N for group 1, **276.31666** N for group 2, and **236.016667** N for group 3.

**Conclusion:** After instrumentation using hand files up to file 25/.02 and rotary files up to files 25/.04 and 25/.06 changes the fracture resistance of endodontically treated roots.

## INTRODUCTION

Proper cleaning and shaping of the root canal space is considered to be essential for success in endodontic therapy. With the objective of total removal of vital tissue, necrotic debris, and microorganisms from within a root canal system.<sup>1</sup> Technological innovations in rotary nickel titanium (NiTi) files have led to new concepts of root canal instrumentation including an increased taper of preparation.<sup>2</sup> Most of the new systems incorporate instruments with a taper greater than the ISO standard 0.02 design; indeed rotary nickel-titanium instruments are available with tapers ranging from 0.04 to 0.12<sup>3</sup>

Vertical root fractures occur in teeth during or after endodontic therapy. These fractures count among of the most serious complications of root canal treatment and often result in tooth extraction, because the prognosis of a vertical root fracture in an endodontically treated tooth is very poor<sup>4</sup> The cause of vertical root fractures mainly is iatrogenic, resulting from dental treatment excesses, for example, excessive canal shaping, excessive pressure during compaction of gutta-percha, excessive width and length of a post space in relation to the tooth's anatomy and morphology, or excessive pressure during placement of the dowel<sup>5</sup>

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Previous studies have attempted to compare the susceptibility to fractures of endodontically treated teeth instrumented with hand and rotary instruments of different tapers<sup>(6, 7)</sup>.

The objective of this study was to examine the influence of instrument taper on the fracture resistance of endodontically treated roots alone, minimizing the impact of all other possible factors under in vitro experimental conditions.

## **MATERIALS AND METHOD**

Ethical clearance was taken before starting the study.

### **Sample Selection**

Initially, 24 human maxillary central incisors extracted for periodontal reasons were selected for the study with the inclusion criteria: single-rooted teeth with fully formed apices without calcifications and previous endodontic treatment as confirmed radiographically and a similar diameter (buccolingual [BL], mesiodistal [MD]) as measured 6 mm from the anatomic apex using a calliper. Each tooth was stored in normal saline solution until the performance of the compressive test. All teeth were sectioned at 13 mm from the anatomic apex using a diamond-coated bur under water cooling. After sectioning, all roots were examined with a stereomicroscope under 20x magnification to detect pre-existing craze lines or cracks and weighed using a sensitive precision balance.

### **Preparation of the Specimen and Fracture Measurement**

A single layer of aluminium foil (Super wrap, Hindalco, India) was used to wrap the root portion of the teeth. And then embedded into auto-polymerizing resin set in an aluminium hollow block. Later, the aluminium foil was peeled off and the root was coated with a thin layer of

hydrophilic vinyl polysiloxane impression material to simulate periodontal ligament. The teeth were then repositioned immediately into the acrylic block.

### **The roots were assigned to the following groups**

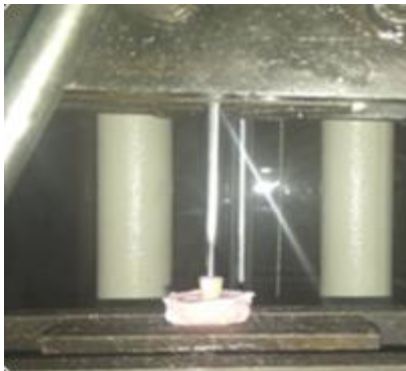
**Group 1:** Samples were instrumented with hand k files (Sybron endo) 25/.02 (n = 6); the root canals were shaped with stainless steel hand K-files up to file # 25, which served as the master apical file, and then flared using a step-back technique in 2-mm increments up to size # 60. During instrumentation, the root canal was irrigated with 3 % sodium hypochlorite (NaOCl) solution. After instrumentation, a final irrigation procedure was applied using saline, and the roots were obturated using the lateral condensation technique with gutta-percha 25/.02 and AH Plus (DENTSPLY, sirona) as the canal sealer.

**Group 2:** instrumentation with DXL – pro (Kraft marketing, India) rotary files up to file 25/.04 in crown down fashion following the manufacturer's protocol. During instrumentation, the root canal was irrigated with 3 % NaOCl solution. After instrumentation, a final irrigation procedure was applied using normal saline, and roots were obturated using the single-cone technique with gutta-percha 25/.04 and AH Plus as the canal sealer.

**Group 3:** instrumentation with DXL – pro (Kraft marketing, India) rotary files up to file 25/.06 in crown down fashion following the manufacturer's protocol. During instrumentation, the root canal was irrigated with 3 % NaOCl solution. After instrumentation, a final irrigation procedure was applied using normal saline, and roots were obturated using the single-cone technique with gutta-percha 25/.06 and AH Plus as the canal sealer.

**Group 4:** root canals were not instrumented which acts as a control group.

All roots were prepared by one operator following the continuously tapering concept of preparation. All specimens were kept in saline throughout the experiment. The roots were tested with a universal testing machine. A steel conical tip was aligned with the centre of the canal orifice of each specimen. Force was applied with a 1-mm/min crosshead speed until root fracture occurred. The load necessary to cause fracture was recorded in newtons.



### Statistical Analysis

The data recorded was entered in Microsoft excel and statistical analysis was performed using statistical package of social sciences (V.19.O) One way ANOVA test; was used to evaluate fracture resistance. Pair wise comparison was done by using Post hoc tukey test.

The statistical analysis of the mesiodistal diameter ( $P = 0.335$ ) buccolingual diameter ( $P = 0.681$ ) and the weight ( $P = 0.264$ ) of the roots revealed no significant differences between the groups.

### RESULTS

The descriptive statistics of the fracture loads of the roots and all other variables in the 4 groups are shown in Table

1. All of the roots were fractured in the BL direction, and the control group showed the highest fracture resistance (326.283333), whereas group 3 showed the least fracture resistance (236.016667). Pairwise comparison in Table 2 showed significant difference in FR in between 2% & 4% taper ( $p=0.014$ ), in between 2% and 6% taper ( $p=0.001$ ), 4% and control group ( $p=0.016$ ) and 6% and control group ( $p=0.001$ ).

### Comparison of buccolingual diameter (in mm)

Groups	N	Mean	Std. Deviation	F value	p value
2% Taper	6	6.283	.2483	0.508	0.681 (NS)
4% Taper	6	6.333	.2160		
6% Taper	6	6.483	.2858		
Uninstrumented group	6	6.400	.4050		

One way ANOVA test; NS – Non significant

Buccolingual diameter was maximum in 6% taper whereas least in 2% taper group. Difference in BL diameter among all the groups was not significant ( $p=0.681$ ).

### Comparison of mesiodistal diameter (in mm)

Groups	N	Mean	Std. Deviation	F value	p value
2% Taper	6	4.233333	.2065591	1.201	0.335 (NS)
4% Taper	6	4.150000	.2664583		
6% Taper	6	4.383333	.1471960		
Uninstrumented group	6	4.316667	.2639444		

One way ANOVA test; NS – Non significant

Mesiodistal diameter was maximum in 6% taper whereas least in 4% taper group. Difference in MD diameter among all the groups was not significant ( $p=0.335$ ).

#### Comparison of weight

Groups	N	Mean	Std. Deviation	F value	p value
2% Taper	6	0.4500	.02828	1.429	0.264 (NS)
4% Taper	6	0.4750	.03209		
6% Taper	6	0.4350	.04037		
Uninstrumented group	6	0.4483	.03488		

One way ANOVA test; NS – Non significant

Weight was maximum in 4% taper whereas least in 6% taper group. Difference in weight among all the groups was not significant ( $p=0.264$ ).

**Table 1:** Comparison of Fracture resistance (in Newton)

Groups	N	Mean force	Std. Deviation	F value	p value
2% Taper	6	326.883333	22.7440029	17.233	0.001*
4% Taper	6	276.316667	13.4648307		
6% Taper	6	236.016667	28.4935373		
Control group	6	326.283333	34.1836462		

One way ANOVA test; \* indicates significant at  $p<0.05$

FR was maximum in 2% taper whereas least in 6% taper group. Difference in FR among all the groups was significant ( $p=0.001$ ).

**Table 2:** Pairwise comparison of fracture resistance

Groups	Mean difference	p value
2% vs 4%	50.56	0.014*
2% vs 6%	90.86	0.001*
2% vs Uninstrumented	0.60	1.000 (NS)
4% vs 6%	40.30	0.061 (NS)
4% vs Uninstrumented	49.96	0.016*
6% vs Uninstrumented	90.26	0.001*

Post hoc tukey test; \* indicates significant at  $p<0.05$ ; NS

– non significant

Pairwise comparison showed significant difference in FR in between 2% & 4% taper ( $p=0.014$ ), in between 2% and 6% taper ( $p=0.001$ ), 4% and uninstrumented gr ( $p=0.016$ ) and 6% and uninstrumented gr ( $p=0.001$ ).

#### DISCUSSION

The purpose of this study was to compare the fracture resistance of teeth instrumented with differently tapered NiTi files and hand files. In the present study the force required to fracture the treated teeth was maximum in 2% taper whereas least in 6% taper group. Difference in fracture resistance among all the groups was significant ( $p=0.001$ ).

Pairwise comparison showed significant difference in FR in between 2% & 4% taper ( $p=0.014$ ), in between 2% and 6% taper ( $p=0.001$ ), 4% and uninstrumented gr ( $p=0.016$ ) and 6% and uninstrumented gr ( $p=0.001$ ).

The standardization of the sample is an important parameter in fracture resistance studies using natural teeth. It is generally accepted that the fracture resistance of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure<sup>(8, 9)</sup>. Variations in root dimensions may affect the residual dentin thickness after instrumentation with different tapers. In the present study, approximately similar teeth were selected, and a step-by-step process was followed

for unbiased standardized groups and analysis to be achieved.

In this study, saline - stored teeth were used. Moreover the crowns of all teeth were removed prior to strength testing. This created a situation that is certainly not clinically relevant in most cases and might have weakened the teeth. Thus the actual forces required to create vertical fractures may be much higher in vivo. Also the use of EDTA may have some weakening effect on the dentin. In addition, simulation of the periodontal ligament was performed with silicone impression material, and after specimen preparation, examination of the dental structure for craze lines and cracks was repeated

According to the literature, vertical root fracture is the third most common reason for extraction of an endodontically treated tooth.<sup>10</sup> Gher et al. have reported a low incidence of 2.3%. And highest incidence has been observed in endodontically treated teeth<sup>11</sup> an overall prevalence of 3% to 5% has been reported in retrospective studies<sup>(12, 13)</sup>

Zandbiglari et al<sup>14</sup> evaluated Influence of instrument taper on the resistance to fracture of endodontically treated roots and they have concluded that the roots were significantly weakened by the preparation with greater taper instruments. In the present study, rotary files of same design, settings and kinematics were used and were compared to minimally invasive hand instrumentation. Many studies on fracture resistance compare roots instrumented with different rotary systems under in vitro experimental conditions.<sup>(15, 16, 17, 18)</sup> During cleaning and shaping various contacts between the files and the dentinal walls leads to formation of variable root canal geometry. These contacts induce stresses on the canal walls which produces dentinal defects that can increase the susceptibility of the tooth to fracture<sup>(19, 20)</sup>. While

mechanical behaviour of the files which is determined by their cross-sectional and longitudinal design, torque settings, number of rotations, and kinematics have influence on the level of these contact stresses<sup>(20,21,22,23)</sup>

Eleni Krikeli et al<sup>2</sup> examined the influence of instrument taper on the fracture resistance of endodontically treated roots under in vitro experimental conditions and it has been observed that after instrumentation using hand files up to file 40/.02 and rotary files up to files 40/.04 and 40/.06, only the last appeared to change the fracture resistance of endodontically treated roots.

## CONCLUSION

Under the conditions of this in vitro study it can be concluded that instrumented maxillary central incisors have a higher risk to fracture than uninstrumented counterparts and roots were significantly weakened by the preparation with instruments having greater tapers.

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**Conflicts of interest** - There are no conflicts of interest.

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