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Comparative study of the influence of instrument taper on the fracture resistance of endodontically treated teeth-An *In-vitro*

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Abstract
Objective: The Objective of this study was to examine the influence of Instrument Taper on the Fracture Resistance of Endodontically treated roots under in-vitro experimental conditions.
Methods: In total, 40 mandibular first Premolar were sectioned at approximately 15 mm from the apex. The roots were will be randomly distributed into 3 experimental groups (*n* = 10) and 1 control group (*n* = 10). The roots in group 1 will be instrumented with hand files up to file (40/.02), groups 2 with Hyflex EDM Rotary File (40/.06), Group 3 with Neoendo Neohybrid rotary File (40/.04) and Group 4 acted as un-instrumented control. After mechanical preparation, the roots were obturated with gutta-percha and sealer. A vertical load will be applied to each specimen using a universal testing machine until the roots fractured. **Statistical analysis:** Data will be collected and statistically analyzed.
Results: The mean fracture load was 357.47 ± 110.54 N for the control group, 338.86 ± 105.23 N for group 1, 297.74 ±77.31 N for group 2, and 280.10 ± 68.51 N for group 3. However, only the difference between group 3 and the control group was statistically significant (P <.05).
Conclusions: 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
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Keywords: influence of instrument taper, fracture resistance, endodontically

Introduction

Technological innovations in rotary nickel titanium (NiTi) files have led to the new concepts of root canal instrumentation including an increased taper of preparation. A higher taper of mechanical preparation offers a sufficient enlargement of the root canal entailing better removal of debris and smear layer [1], improvement of irrigant flow [2], and better distribution of the stresses during both lateral and vertical gutta-percha compaction [3, 4].

However, possible excessive removal of the dentin raised concerns regarding the susceptibility of the roots to fractures [5]. Vertical root fracture (VRF) is a complication in both endodontically and non-endodontically treated teeth, usually leading to the extraction [6]. Predisposing factors for root fractures have been discussed thoroughly in the literature, and various classifications have been proposed [7, 8]. Mechanical preparation affects both the geometry and volume of the root canals, leading to the stresses of the root dentin and, consequently, dentinal defects [5, 9].

The root canal preparation instruments and the methods used combined with the apical diameter might all be involved in the increased risk for root fracture during and subsequent to root canal treatment [8]. Many factors can contribute to VRFs, thus making the assessment of their individual contributions challenging, especially when measured under in the vitro experimental conditions. Previous studies have attempted to compare the susceptibility to fractures of endodontically treated teeth instrumented with the hand and rotary instruments of different tapers [10-13]. Methodologic limitations concerning both the standardization and randomization of the sample combined with the instrumentation and experimental techniques used have produced a variety of results.

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. Technological innovations in rotary nickel titanium (NiTi) files have led to new concepts of root canal instrumentation including an increased taper of preparation. A higher taper of mechanical preparation offers sufficient enlargement of the root canal entailing better removal of debris and smear layer [1], improvement of irrigant flow [2], and better distribution of stresses during both lateral and vertical gutta-percha compaction [3, 4]. However, possible excessive removal of dentin raised concerns regarding the susceptibility of roots to fractures [5].

Many factors can contribute to VRFs, thus making the assessment of their individual contributions challenging, especially when measured under *in vitro* experimental conditions [6]. Previous studies have attempted to compare the susceptibility to fractures of endodontically treated teeth instrumented with hand and rotary instruments of different tapers [7, 8]. Methodologic limitations concerning both the standardization and randomization of the sample combined with the instrumentation and experimental techniques used have produced a variety of results [9]. 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 [10, 11].

Aim of the Study

Aim of this *study* was to examine the influence of instrument taper on the fracture resistance of endodontically treated roots under *in vitro* experimental conditions.

Armamenterium and Materials

- 48 Mandibular 1st premolar
- Hand files (0.2%)
- Neoendo neohybrid file system (0.4%)
- Hyflex EDM 90.6%)
- saline solution
- diamond-coated bur
- Curing light
- Universal testing machine

Methodology

Each tooth was stored in 0.1% thymol solution for 5 days after extraction and then in saline solution until the performance of the compressive test. All teeth were sectioned at 15 mm from the anatomic apex using a diamond-coated bur under water cooling. Acrylic resin blocks were prepared according to the method used in earlier studies [14, 15]. Each root was wrapped in a single layer of lead foil and invested vertically in a plastic mold with self-curing acrylic resin (Kemdent, Swindom, UK), leaving approximately 1 mm of its coronal portion exposed. Subsequently, the lead foil was removed, and each root was radiographed in the MD and BL directions while mounted on its artificial socket to ensure vertical positioning. If roots diverted from the vertical position, mounting was repeated.
Roots were allocated to 4 groups as follows:

1. **Group 1:** instrumentation with hand files up to file 40/.02 (n = 10): the root canals were shaped with stainless steel hand K-files (VDW, Munich, Germany) up to file #40, which served as the master apical file, and then flared using a step-back technique in 2-mm increments up to size #80. During instrumentation, the root canal was irrigated with approximately 13 mL 2.5% sodium hypochlorite (NaOCl) solution. After instrumentation, a final irrigation procedure was applied using 5 mL distilled water, and the roots were obturated using the single-cone technique with gutta-percha 40/.02 and AH Plus (Dentsply DeTrey, Konstanz, Germany) as the canal sealer.
2. **Group 2:** instrumentation with Neoendo neohybrid rotary files up to file 40/.04 (n= 0): the root canals were shaped with Neoendo neohybrid rotary files up to file 40/.04 following the manufacturer's protocol (ie, 10/.04, 15/.05, 20/.06, 25/.06, 30/.05, 35/.04, and 40/.04).

During instrumentation, the root canal was irrigated with approximately 13 mL 2.5% NaOCl solution. After instrumentation, a final irrigation procedure was applied using 5 mL distilled water, and roots were obturated using the single-cone technique with gutta-percha 40/.04 and AH Plus as the canal sealer.

3. **Group 3:** instrumentation with Hyflex EDM rotary files up to file 40/.06 (n=10): the root canals were shaped with Hyflex EDM rotary files up to file 40/.06 following the manufacturer's protocol (ie, 10/.04, 15/.05, 20/.06, 25/.07, 30/.06, 35/.06, and 40/.06). During instrumentation, the root canal was irrigated with approximately 13 mL 2.5% NaOCl solution. After instrumentation, a final irrigation procedure was applied using 5 mL distilled water, and the roots were obturated using the single-cone technique with gutta-percha 40/.06 and AH Plus as the canal sealer.
4. **Group 4:** control group (n=10): the root canals were not instrumented or filled. All roots were prepared.

Fig 1

The roots were tested with a universal testing machine (Testometric M350-10 KN: Lincoln Close, Rochdale, UK).

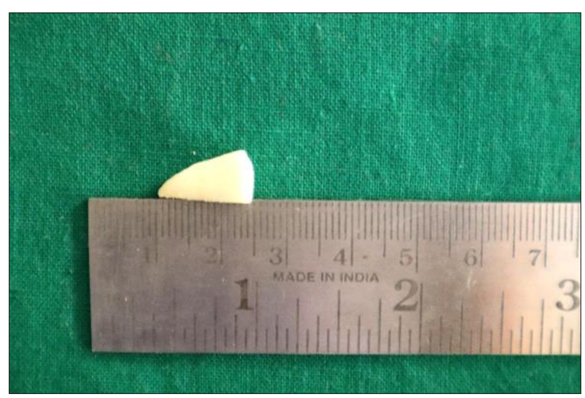

Fig 2

Force was applied with a 1-mm/min crosshead speed until root fracture occurred the load necessary to cause fracture was recorded in newtons.

Investigation design

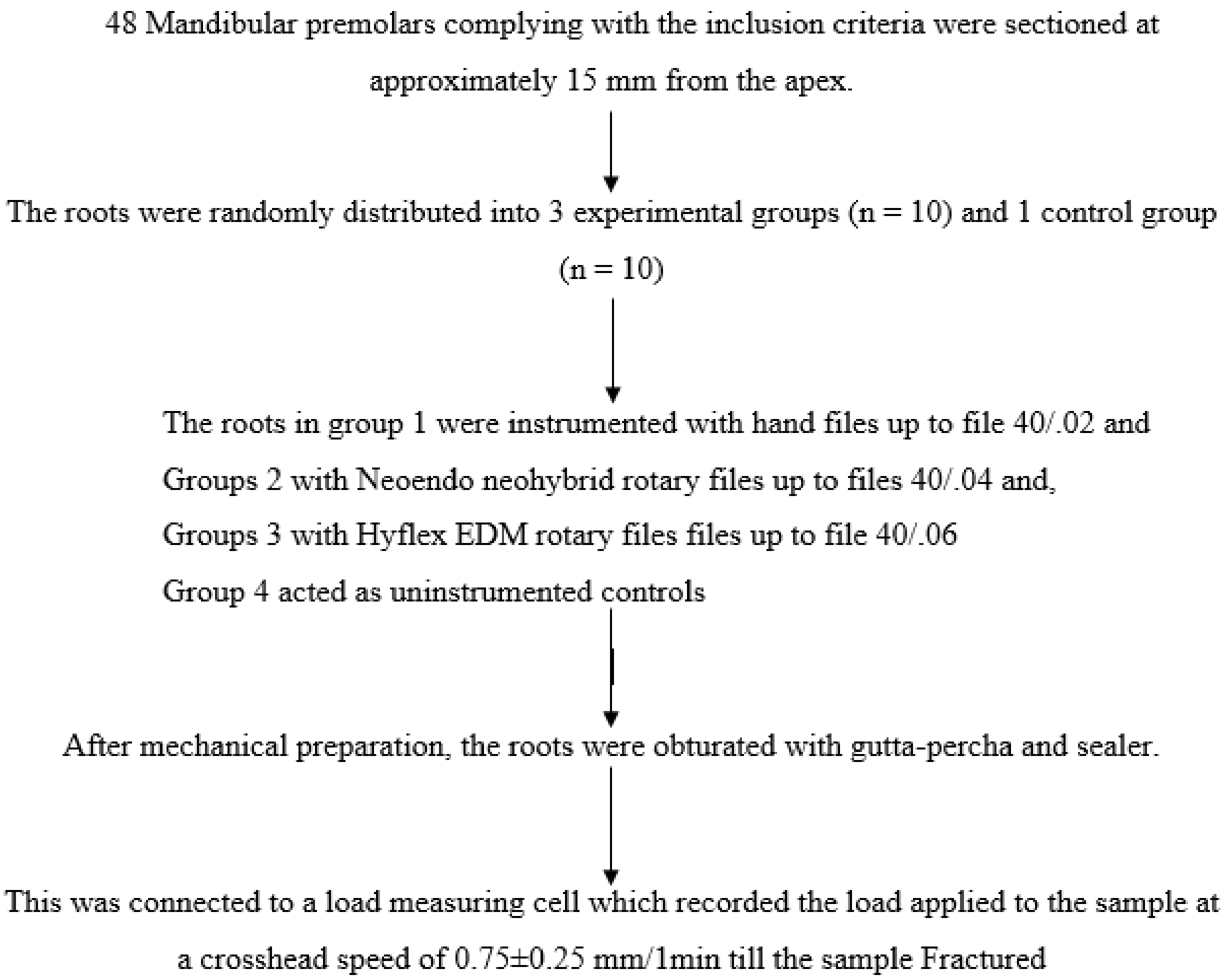

Fig 3

Results

Table 1

Primary data	Control group 4	Group 1	Group 2	Group 3	Anova (P values)
BL	3.40 ±0.69	3.39 ± 0.45	3.62 ± 0.44	3.47 ± 0.37	0.408
MD	5.06 ± 0.41	5.17 ± 0.57	5.28 ± 0.41	5.11 ± 0.56	0.619
After fracture test data Fracture load	357.47 ± 110.54	338.86 ± 105.23	297.74 ± 77.31	280.10 ± 68.51	0.493

Discussion

The purpose of this study was to compare the fracture resistance of the teeth instrumented with differently tapered NiTi files and hand files. Despite the accordance of current results with the previous studies [11, 13], these are not directly correlated because of methodologic differences considering sample standardization, statistical analyses applied, specimen preparation, and the instrumentation performed [15, 16]. The standardization of the sample is an important parameter in the fracture resistance studies using natural teeth [16].

It is generally accepted that the fracture resistance of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure [17, 18]. Variations in root dimensions may affect the residual dentin thickness after the instrumentation with different tapers. Also, the most susceptible roots to fracture are those with the narrow MD diameter compared with the BL dimension [19]. In the previous studies, the dimensions of the roots were omitted or poorly examined [10, 12, 13]. Only Zandbiglari *et al* [11] used roots with a standardized length and BL diameter. However, the MD diameter and weight of these roots were not examined.

After the fracture test, the use of correlation analysis to ensure standardization found in the previous studies [21, 22] could potentially introduce bias because interactions between several variables [23]. Hence, regression analysis was used instead to estimate the impact of the instrument taper and the latent variable on fracture resistance [23, 24]. The purpose of introducing the latent variable in the regression equation was to evaluate whether other conditions (eg, inadequate standardization) could affect the results or not. Thus, having controlled the analysis through the latent variable [22].

There seems to be a lack of 3 basic parameters in the experimental methodology of these types of studies in the current literature: the vertical placement of the teeth in molds, simulation of the periodontal ligament, and observation of the tooth structure after specimen preparation have not been documented. Zandbiglari *et al* [11] reported the use of a protractor for the root orientation in the casts, whereas Singla *et al* [13] referred to a soft silicon liner used to aid better handling of the specimens. In the present study, the vertical orientation of the roots was confirmed radio graphically in order to align the tip of the crosshead with the long axis of the roots. In addition, simulation of the periodontal ligament was performed with silicone impression material.

During instrumentation, root canal geometry is formed by the various momentary contacts between the files and the dentinal walls. These contacts induce stresses on the canal walls, producing dentinal defects that can increase the susceptibility of the tooth to fracture [24, 25]. The level of these contact stresses depends on the mechanical behavior of the files, something mainly determined by their cross-sectional and longitudinal design, torque settings, number of rotations, and kinematics [9, 24, 26, 27].

In the present study, rotary files of the 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 the *in vitro* experimental conditions [21, 22, 28, 29]. Only Singla *et al* [13] compared files of the same design but with the different taper (Profile 0.04 and Profile 0.06: Dentsply Maillefer, Ballaigues, Switzerland), and their results were similar to those of our study despite other methodologic differences. Nonetheless, under clinical conditions, both tooth pathology and the root canal anatomy should be taken into consideration when the apical size and taper of preparation are chosen.

The cleaning efficacy of the root canal instrumentation and the resultant vertical fracture strength of the roots are 2 parameters contributing to the success of root canal treatment [13]. Moreover, specimen preparation and the direction of the force applied in this study are different from the clinical conditions. therefore, any direct correlation between fracture load values and clinical reality should be interpreted with caution. Under the given conditions, the present results can only serve as a reasonable predictor of clinical performance.

The current study showed no significant reduction of the fracture resistance of the root by. 06 taper instrumentation compared with 0.04. In agreement with the results, a previous study has shown that during instrumentation, maintaining the natural geometry of the root canals is a paramount stabilizing factor for the tooth, and, therefore, if the root canal outline is not substantially altered, tooth fracture resistance is relatively unaffected[3]. In this study, the decrease in the fracture resistance that followed. 06 taper instrumentation might have been the result of geometric alterations of the root canals because. 06 taper files are more rigid and less adaptable. Another factor could be the typically small diameter of distobuccal roots because root preparation with a thicker file leads to a further weakening of it [25]. Root fracture occurs as a result of propagation of microcracks created in the root canal shaping process with occlusal forces [26]. Thus, the increased risk of fracture with the. 06 taper in this study might be associated with the greater number of the craze lines and the greater degree of imposed stress in root dentin. Moreover, the findings corroborated with the results of a previous study that reported that preparation with larger taper instruments significantly weakened the roots. Also, Zandbiglari *et al* [28] suggested that this result was probably caused by the greater amount of dentin removed with larger tapering instruments compared with common taper hand files.

Conclusions

Within the limitations of this study, it can be concluded that the fracture resistance of the roots instrumented with rotary files up to 40/.06 was lower than that of intact roots under *in vitro* experimental conditions. Methodology standardization is of great importance concerning *in vitro* studies for interpretation of the results.

Does the study require any investigations or interventions to be conducted in patients or other humans

No. The study will be done under the supervision of our guide.

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