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A COMPARISON STUDY TO EVALUATE THE RESISTANCE TO VERTICAL ROOT FRACTURE AFTER REMOVING SEPARATED INSTRUMENTS UTILIZING THREE INSTRUMENT RETRIEVAL SYSTEMS: AN IN VITRO STUDY

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ABSTRACT

Introduction: Various instrument systems have been used to retrieve distinct instruments from root canals. Nonetheless, it has long been noted that using the existing retrieval techniques may weaken tooth roots, increasing their vulnerability to fracture and ultimately the treatment's overall failure. Therefore, using Ultrasonic U Files, Ultrasonic Tip (Acteon Endo Success ET25 Retreatment Tip), or the Endo Rescue System under the magnifying power of a dental operating microscope, the following study was carried out to assess and compare the resistance to vertical root fracture following the retrieval of separated instruments from the root canal.

Materials and Methods:Fourty-two moderately curved mesiobuccal roots from extracted decoronated mandibular first molar teeth were hemisectioned to a length of 15 mm. In the middle part of the mesiobuccal root canal, 4 mm long ProTaper gold rotary finishing files F2 were purposefully separated after biomechanical preparation, and this was confirmed radiographically. Following a random division of the samples into three groups, the Ultrasonic U files, Ultrasonic ET25 Retreatment tip, or Endo Rescue System were used, respectively, to retrieve the separated instrument. Following the recovery of the separated instruments, a universal testing equipment with an accuracy of ± 1% was used to test the samples for vertical root fracture resistance. Following data collection from each sample, statistical analysis was performed.

Result: Ultrasonic U files (Group A) showed the highest vertical root fracture resistance, with a statistically significant difference from the samples treated with ET 25 Ultrasonic retreatment tips(Group B). No significant differences were observed between Group A and C or Group B and Endo Rescue System (Group C) ($P > 0.05$).

Summary and Conclusion: Following the removal of separated instruments, the Endo Rescue system, and finally the ultrasonic ET25 retreatment tips, it was found that Ultrasonic U files provide the least reduction in the vertical root fracture resistance. Clinicians should carefully consider the tooth's future prognosis when determining the treatment protocol, even though no single instrument retrieval system is universally suitable for all situations due to a variety of factors like root anatomy, instrument type, location, size, pulpal status, and operator skill.

Keywords: Instrument separation; retrieval; vertical root fracture

INTRODUCTION

Instrument type, root canal anatomy, and operator skill all play a role in the difficult problem of instrument separation during endodontic treatment.[1,2] Although there are several ways to recover broken tools, such as using ultrasonics or microtube systems, there is increasing worry about how these approaches will impact the tooth's remaining structure, especially its ability to withstand vertical root fractures.[3, 4]

The success rate of extracting detached instruments has frequently been the main focus of research, with little attention paid to how these techniques weaken the remaining tooth. By comparing vertical root fracture resistance following the application of three widely used retrieval systems—Ultrasonic U Files, ET25 Retreatment Ultrasonic Tip, and Endo Rescue system—the study seeks to allay this worry.By investigating the impact of these retrieval techniques on the vertical root fracture resistance, the study seeks to provide clinicians with valuable insights into how different methods affect the structural integrity of the tooth. This information will help in making more informed decisions, balancing the effectiveness of instrument retrieval with the preservation of tooth strength.

MATERIALS AND METHODS

This study was conducted in the department of conservative dentistry and endodontics at the institution. It was approved by the ethical committee of this institution.

Sample size determination

The sample size was determined as 42 extracted mandibular first molar teeth with a total of 14 samples per group using the estimates of mean and standard deviation values from literature keeping the power of the study at 80%, with a 5% type I error and 20% type II error.

Sample selection

Freshly extracted sample teeth were placed in a 2.5% sodium hypochlorite solution for 15 min for the dissolution of soft tissue remnants. Later, the teeth were stored in 10% formalin solution.

Inclusion criteria

1. Mandibular first molar teeth with sound crown and root
2. The mesial root is moderately curved (Schneider’s classification)
3. Mature apex.

Exclusion criteria

1. Endodontically treated teeth
2. External or internal resorption
3. Teeth with developmental anomalies
4. Teeth with preexisting root fractures, cracks, or root caries.

Sample preparation

Forty-two moderately curved mesiobuccal roots of extracted decoronated mandibular first molar teeth were hemisection to standardize them to a length of 15 mm each. These root surfaces were assessed under the dental operating microscope to exclude any teeth with preexisting root fractures or cracks following which each root was embedded into silicone impression material that was allowed to be set within a custom-made metal ring which was held firmly on a laboratory bench top. The root canal was cleaned and shaped using the ProTaper Gold Rotary File System (Dentsply Sirona) till the finishing file F1.

Intracanal fracture of instruments

ProTaper Gold F2 rotary finishing files were notched 4 mm from the tip using a round bur to facilitate controlled breakage. The notched files were inserted into the canal until resistance was encountered and then rotated with pressure to fracture the instrument. Radiographs were taken to confirm that the fracture occurred in the middle third of the mesiobuccal root canal. The fractured instruments were examined under a dental operating microscope

Grouping

The samples were randomly divided into three groups (n = 14):

- Group A – Separated instruments were retrieved using Ultrasonic U Files attached to an ultrasonic unit with an Endo Chuck. An endosonic file was inserted into the fragment's coronal end and activated to create a trough. A precurved #10 K-file was then used to bypass the fragment. Once bypassed, the fragment was dislodged through irrigation and agitation with the endosonic file at low power. Confirmation of removal was done with a radiograph.
- Group B – Separated instruments were retrieved using an Acteon EndoSuccess ET25 ultrasonic tip. The canal was instrumented up to the fragment, and a staging platform was created with a modified Gates Glidden bur under magnification.[5] The coronal segment of the fragment was exposed by dry ultrasonic troughing with the tip at low power, which was then used to trephine dentin around the fragment in a counterclockwise motion until it was freed. A radiograph confirmed the successful retrieval.
- Group C – Separated instruments were retrieved using the Komet Endo Rescue System Kit 4601. A straight line access to the fragment was created with a cylindroconical bur with a non cutting tip. The canal entrance was relocated using a Gates Glidden bur #4, and direct access to the fragment was established with a Gates Glidden bur #3. The excavation was performed with a centering drill, and the fragment was removed using a trepan bur rotated counterclockwise. The fragment was held in the trepan bur by dentin residues.

The samples were pulled out from their molds, and after adequate irrigation, root surfaces were assessed under a dental operating microscope to detect cracks, fractures, and perforations.

Preparation for mechanical testing

The samples were mounted in a custom box filled with self-cure acrylic resin and tested with a universal testing machine accurate to ±1%. The samples were fixed so that a 5-mm diameter flat plugger applied axial force to the root at a crosshead speed of 1 mm/min [Figure 1]. The force at which each root fractured, indicated by a sharp drop in force and an audible cracking sound, was recorded in Newtons.

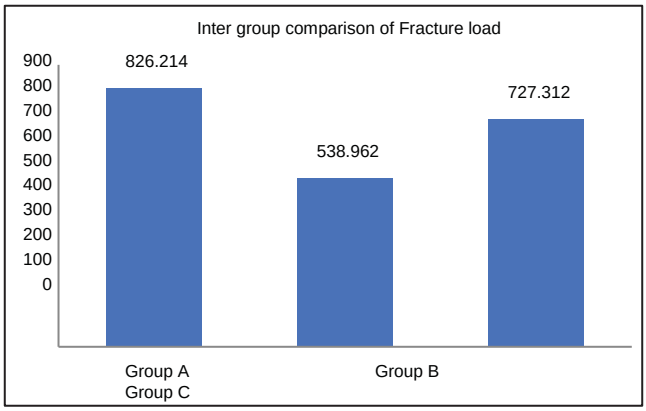
The data collected from all the samples were then subjected to statistical analysis using Statistical Package for Social Sciences (SPSS v 26.0, IBM) (IBM, India Private Limited, Bengaluru, Karnataka,India) [Table 1 and Graph 1].

Figure 1: Sample mounted in self-cure acrylic resin subjected to universal testing machine

Table 1: Intergroup comparison of fracture load

	N	Mean	SD	SE	Median	$\chi 2$	P value of Kruskal–Wallis test
A	14	826.314	296.2712	79.1674	730	10.133	0.006**
B	14	538.962	133.9031	35.7871	546.75		
C	14	727.312	332.0972	88.7567	745.50		
Total	42	697.500	288.1305	44.4595			

**Statistically highly significant difference seen for the values between the groups (P<0.01) with higher values in group A SD: Standard deviation, SE: Standard error



Graph 1: Intergroup comparison between Ultrasonic U Files (Group A), Ultrasonic ET25 Retreatment Tip (Group B), and Endo Rescue System (Group C)

RESULTS

The force required to fracture the roots was the greatest in the Ultrasonic U files (Group A), and it was the least for the Ultrasonic ET25 Retreatment tip (Group B). Hence, the roots from which separated instruments were retrieved using the Ultrasonic U files (Group A) were the most resistant to vertical root fracture and were statistically highly significant when compared with those roots wherein the separated instruments were retrieved using the ET 25 Ultrasonic retreatment tips (Group B) [Table 2 and Graph 2].

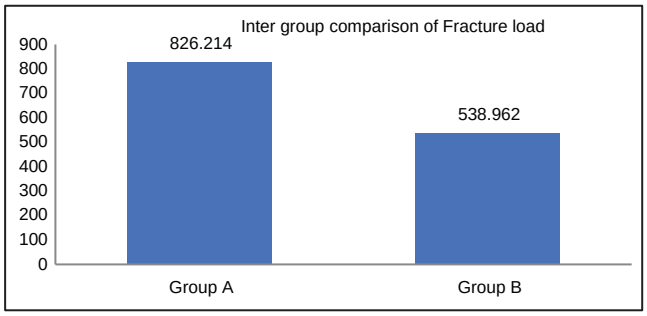
Table 2: Intergroup pairwise comparison using Mann– Whitney *U*-test

Group	Versus Group	Mann- Whitney U	Z	P value of Mann–Whitney U-test
A	B	16.000	-3.767	0.000**

A	C	85.000	-0.595	0.550#
B	C	70.000	-1.285	0.198#

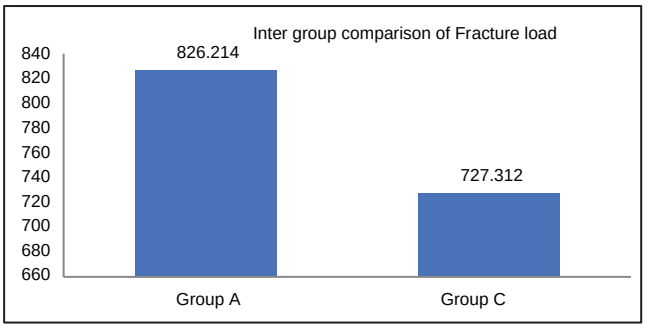
**statistically highly significant difference seen (P<0.01) between group A vsB. #Statistically non-significant difference seen (P>0.05) for the values between groups A vs C. #Statistically non-significant difference seen (P>0.05) for the values between groups B vs C

Graph 2: Intergroup comparison between Ultrasonic U Files (Group A) and Ultrasonic ET25 Retreatment Tip (Group B)

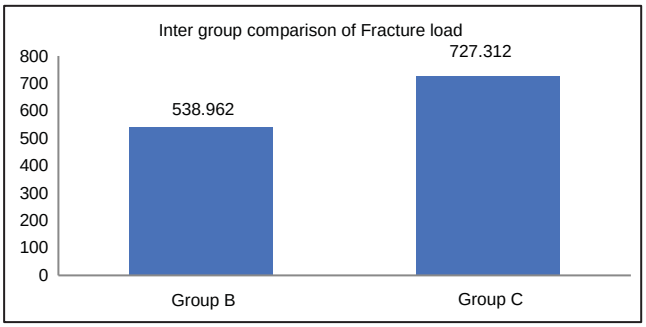


There was a statistically nonsignificant difference seen (P > 0.05) for the values between Groups A versus C [Table 2 and Graph 3].

Graph 3: Intergroup comparison between Ultrasonic U Files (Group A) and Endo Rescue System (Group C)



Graph 4: Intergroup comparison between Ultrasonic ET25 Retreatment Tip. (Group B) and Endo Rescue System (Group C)



There was a statistically non-significant difference seen (P > 0.05) for the values between Groups B versus C [Table 2 and Graph 4].

DISCUSSION

Endodontic therapy uses efficient root canal system cleansing, shape, and obturation to treat pulpal and periradicular disorders. These procedures have been greatly enhanced by advances in instrumentation, such as rotating nickel-titanium (NiTi) files and barbed broaches.[6–8] Nevertheless, despite their advantages, NiTi rotary files continue to have problems with cycle fatigue and torsional stress, which results in a clinical fracture rate of 2.27%.[9,10]

Separated instrument management needs to be a methodical but flexible procedure, with the physician continuously evaluating patient progress and, if required, taking into account alternate treatment choices. Every instrument retrieval scenario is different, and these differences will determine the management strategy used. This study was carried out to assess the impact of Ultrasonic U files, ET25 Retreatment ultrasonic tips, and the Endo Rescue system on the vertical root fracture resistance of the tooth after the separated instrument was removed. This was done because ultrasonics and holding techniques are the most widely used systems for instrument retrieval.

The samples were hemisectioned and decoronated at 15 mm from the root apex to establish standardization and to offer ideal conditions for the removal of broken tools avoiding coronal influences, which is why mandibular first molars were selected for this investigation.

After removing the separated instruments, samples were tested for vertical root fracture resistance directly as obturation could lead to dentinal defects, as noted by Blum *et al*.,[16] Shemesh *et al*.,[17] and Kumaran *et al*.[18] wherein it was concluded that teeth subjected to both lateral compaction and warm vertical condensation resulted in defects. Testing was conducted by applying force vertically along the long axis of the sample to ensure uniform force distribution, as recommended by Cobankara*et al*.,[19] Teixeira *et al*.,[20] and Sagsen*etal*.[21]

In the current study, Group A (Ultrasonic U files) showed the highest vertical root fracture resistance with a mean of 826.214 N, followed by Group C (Endo Rescue System) with a mean of 727.321 N. Group B (Ultrasonic ET25 Retreatment tip) had the lowest fracture resistance with a mean of 538.964N. The superior performance of Group A is attributed to the small tip diameter (0.2 mm) and the absence of a need for a staging platform, which minimizes radicular dentin loss.

The Endo Rescue System (Group C) exhibited moderate fracture resistance, with no statistically significant difference ($P > 0.05$) compared to the other groups. This is in accordance with a study conducted by Gerek *et al*.[22] (2012) where the reduction in vertical root fracture resistance proved to be statistically nonsignificant following a comparison in the removal of separated instruments with Masserann kit (holding technique) and ultrasonics. However, previous studies have stated holding techniques to be more aggressive while removing separated instruments from the root canal as compared to ultrasonics.[23]

The group that used the Ultrasonic ET 25 retreatment tip (Group B) showed the least resistance to vertical root fracture after the separated instruments were removed. This is consistent with a study by Fu et al. [24] that found that the main cause of decreased vertical root fracture resistance was the use of this ultrasonic tip, which clearly increases the root canal volume because it necessitates the construction of a staging platform in order to access the separated instrument, which results in the formation of microcracks.

Given that this study is *in vitro*, the results may not directly translate to clinical scenarios, highlighting the need for additional research.

CONCLUSION

Following the removal of dissociated instruments, Ultrasonic U files showed the least reduction in vertical root fracture resistance, followed by Ultrasonic ET25 retreatment tips and the Endo Rescue System. No single retrieval strategy is universally optimal because of the wide variations in root structure, instrument type, position, size, pulpal state, and operator skill. Clinicians ought to base their treatment plans on a careful evaluation of the tooth's prospects for the future.

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Conflicts of interest

There are no conflicts of interest.

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