ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 3, June - 2023, Page No. : 98 – 104

Comparative evaluation of instrument taper on the fracture resistance of root canal treated teeth: An in vitro study

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Citation of this Article: Dr. Dipin Tom Jose, Dr.Pradeep P.R., Dr.Ananthakrishna. S, Dr.Vijayshankar L.V., Dr. Shirin Sunil Darure, Dr. Vinayak Jagdish Rao, "Comparative evaluation of instrument taper on the fracture resistance of root canal treated teeth: An in vitro study", IJDSIR- June - 2023, Volume – 6, Issue - 3, P. No. 64 - 78.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim- To study the effect of taper of shaping files on the fracture resistance of endodontically treated teeth.

Materials and methods- Eighty single rooted teeth that were indicated for extraction due to orthodontic reasons and periodontal problems were collected. All the teeth were decoronated apical to the cementoenamel junction to standardize the canal length to 13 mm with a diamond disc under water coolant. Samples were randomly divided into four groups (one control and three experimental) based on the instruments used for the canal preparation (n= 20 in each group).

Group 1: Instrumentation with Dentsply K- files up to file 25/.02 (Control group)

Group 2: Instrumentation with Hyflex CM (Coltene) rotary files up to file 25/.04

Group 3: Instrumentation with Hyflex CM (Coltene) rotary files up to file 25/.06

Group 4: Instrumentation with R25 (VDW) reciproc files 25/.08

Root canal shaping procedure was done with size 25mm k file and 3 different rotary files of three different taper (4%,6% and 8%).During the procedure 3% sodium hypochlorite was used as irrigant, EDTA gel as lubricant, Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration. zinc oxide eugenol wase used as sealer and 2%,4%,6%,8% gutta percha were used as obturating material with single cone obturation technique. After the completion of root canal therapy samples were mounted on acrylic blocks and a vertical load was applied to each specimen using a universal testing machine until the root fractures.

Inferential statistics- The results obtained from the Universal Testing Machine (UTM) and were subjected to ANOVA test followed by Tukey's post hoc analysis.

Results- The test result showed the mean Fracture resistance for Group 1 was 365.104 ± 29.092, Group 2 was 332.453 ± 37.856, Group 3 was 319.057 ± 22.712 and Group 4 was 275.019 ± 17.538 The difference in the mean fracture resistance between 4 groups was statistically significant at P

Conclusion- Within the limitations of this study, it could be concluded that endodontically treated teeth prepared with larger taper files shows least fracture resistance when compared with canals prepared with lesser taper files. Further in vitro and in vivo studies are required to know more about the overall performance of these files and its effects on fracture resistance.

Keywords: UTM, EDTA, VWA, ANOVA

Introduction

During biomechanical preparation of root canals, contact between the instrument and canal wall applies stress to dentin and may cause microcracks and craze lines. Cracks may propagate in the long term and cause root fracture. [1]

In performing endodontic treatment, dental practitioners use stainless-steel hand or rotary files to widen the root canal, removing the infected pulp tissue and dentin from within in the process. Root canal preparation should preserve the canal path while eliminating microorganisms from the whole system. While larger files remove more dentin and make canal debridement and irrigation easier, they can produce increased friction and stresses on the canal wall that may damage the root structure. [2]

Taper is a factor that determines final root canal dimensions and, consequently, the dimensions of the space for the cleaning action of irrigants. [3]

A higher taper of mechanical preparation offers sufficient enlargement of the root canal entailing better removal of debris and smear layer, improvement of irrigant flow, and better distribution of stresses during both lateral and vertical gutta-percha compaction. However, possible excessive removal of dentin raised concerns regarding the susceptibility of roots to fractures. Vertical root fracture (VRF) is a complication in both endodontically and nonendodontically treated teeth, usually leading to extraction. [4]

Materials And Methods

Procedure: Eighty single rooted teeth that were indicated for extraction due to orthodontic reasons and periodontal problems were collected. The procedure for preparation was standardized for all groups and performed by a single operator to minimize experimental variables.

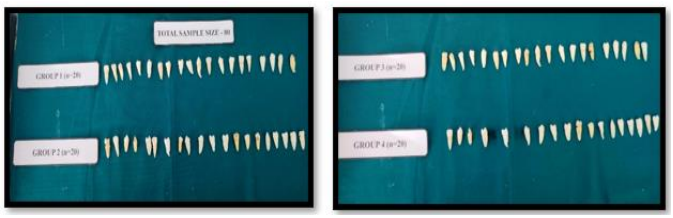


Figure 1

All the teeth were decoronated apical to the cementoenamel junction to standardize the canal length to 13 mm with a diamond disc under water coolant. The root samples were then viewed under stereomicroscope to access any pre-existing external defects or cracks.

Figure 2

Samples were randomly divided into four groups (one control and three experimental) based on the instruments used for the canal preparation (n= 20 in each group)

Group 1: - Instrumentation with Dentsply K- files up to file 25/.02 (Control group)

Group 2: - Instrumentation with Hyflex CM (Coltene) rotary files up to file 25/.04

Group 3: - Instrumentation with Hyflex CM (Coltene) rotary files up to file 25/.06

Group 4: - Instrumentation with R25 (VDW) reciproc files 25/.08

Working length of all samples were established by subtracting 1mm from the length of a size 10 K-file inserted into the canal until the tip of the file become visible at the apical foramen.

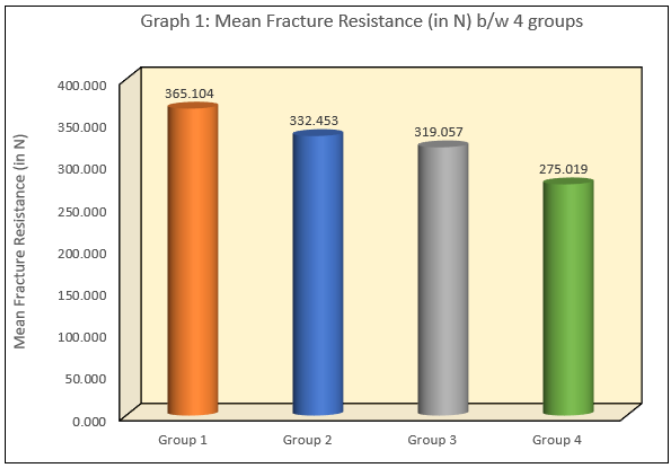
Figure 3

After each instrumentation technique, the specimens were irrigated with 3% sodium hypochlorite using a syringe and 30 G endo irrigation needle with side vent, placing it 1mm from the working length. Canal were rinsed with distilled water after the completion of the procedure to avoid dehydration. Zinc oxide eugenol was used as sealer and 2%,4%,6%,8% gutta percha were used as obturating material with single cone obturation technique After the completion of root canal therapy samples were mounted on acrylic blocks and a vertical load is applied to each specimen using a universal testing machine until the root fractures. The results obtained from the Universal Testing Machine (UTM) were subjected to ANOVA test followed by Tukey's post hoc analysis.

Figure 4

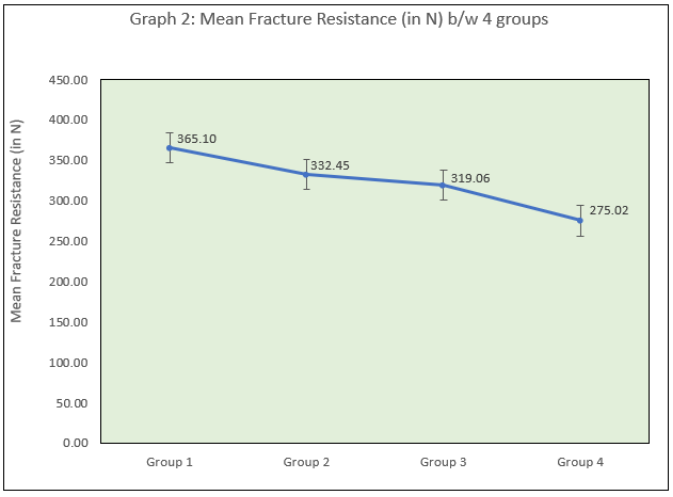
Comparison of mean Fracture Resistance (in N) b/w 4 groups using One-way ANOVA Test						
Groups	N	Mean	SD	Min	Max	P-Value
Group 1	20	365.104	29.092	318.03	429.47	<0.001*
Group 2	20	332.453	37.856	260.10	385.83	
Group 3	20	319.057	22.712	291.84	372.93	
Group 4	20	275.019	17.538	246.87	306.98	

Table 1



Multiple comparison of mean difference in the Fracture Resistance b/w groups using Tukey's Post hoc Test					
		Mean Diff.	95% CI for the Diff.		
(I) Groups	(J) Groups	(I-J)	Lower	Upper	P-Value
Group 1	Group 2	32.651	9.516	55.786	0.002*
	Group 3	46.047	22.912	69.182	<0.001*
	Group 4	90.084	66.949	113.220	<0.001*
Group 2	Group 3	13.396	-9.739	36.531	0.43
	Group 4	57.433	34.298	80.569	<0.001*
Group 3	Group 4	44.037	20.902	67.173	<0.001*

Table 2



Statistical Analysis

The results obtained from the Universal Testing Machine (UTM) and were subjected to ANOVA test followed by Tukey's post hoc analysis.

Results

Group 1 – Dentsply K Files 25 / .02 Group; Group 2 – Hyflex CM 25 / .04 Taper Group, Group 3 – Hyflex CM 25/.06 Taper Group, Group 4 – Reciproc R25 25/08 Group

The test result showed the mean Fracture resistance for Group 1 was 365.104 ± 29.092, Group 2 was 332.453 ± 37.856, Group 3 was 319.057 ± 22.712 and Group 4 was 275.019 ± 17.538 The difference in the mean fracture resistance between 4 groups was statistically significant at P<0.001. According to the results obtained shows that the fracture resistance of endodontically treated teeth decreases when the file taper increases.

Discussion

In endodontic treatment, canal shaping is performed to provide sufficient space for efficient dentine disinfection by the irrigating solution and to get three dimensional obturation with hermetic seal. However, this step generates stresses that can also weaken the root and consequently lead to crack formation (especially in the apical portion of the root). [5]

Quantity of dentinal damages can be due to various factors like physical properties of teeth, preparation technique or various endodontic instruments that are used, etc., Thus, each preparation technique can weaken root dentin. [6]

A higher taper of mechanical preparation offers sufficient enlargement of the root canal entailing better removal of debris and smear layer, improvement of irrigant flow, and better distribution of stresses during both lateral and vertical gutta-percha compaction. However, possible excessive removal of dentin raised

concerns regarding the susceptibility of roots to fractures. Vertical root fracture (VRF) is a complication in both endodontically and nonendodontically treated teeth, usually leading to extraction.[3] Mechanical preparation affects both the geometry and volume of root canals, leading to stresses on the root dentin and, consequently, dentinal defects. When NiTi rotary instruments are used, a rotational force is applied to root canal walls. Thus, they can create microcracks or craze lines in root dentin. The extent of such a defect formation may be related to the tip design, cross-section geometry, constant or progressive taper type, constant or variable pitch, and flute form.[7]

In this present study teeth were instrumented with following files:

25/.02 hand K file (SS K files)

25/.04 rotary file (Hyflex CM, Coltene)

25/.06 rotary file (Hyflex CM, Coltene)

25/.08 rotary file (R25, reciproc, VDW)

K files are square in cross section and has moderate cutting force. They are divided in to stain less steel and nickel titanium files according to the material. In the present study we have used stainless steel k files. Stainless steel files have more cutting force but less breaking resistance than nickel titanium files.

Hyflex CM files are nitinol files machined from control memory wires. These CM wires are subjected to a proprietary, novel, thermomechanical processing procedure. Clinical and experimental studies have indicated that these new Hyflex® CM rotary instruments have outstanding clinical fatigue resistance. The Controlled memory effect helps the file to retain the shape of the canal even when it is out of the canal. This property is responsible for avoiding procedural errors such as ledge formation, transportation, perforations etc. The extreme flexibility and lesser taper of these files make them very advantageous in curved canal cases.[8]

The use of mechanical instruments in reciprocation with unequal forward and reverse rotation was introduced in 2008. Reciproc series of instruments (VDW GmbH, Munich, Germany) were designed specifically for this type of motion. The Reciproc system includes 3 instruments Reciproc 25, Reciproc 40 and Reciproc 50, matching paper points, matching gutta-percha cones, and matching gutta-percha obturators (GuttaFusion). The Reciproc instruments have an S-shaped cross section. The three instruments have a regressive taper starting at 3 mm from the tip. The Reciproc R25 has a diameter of 0.25 mm at the tip and an 8% (0.08 mm/ mm) taper over the first 3 mm from the tip. In the majority of the canals, only one Reciproc instrument is used in reciprocation to complete the canal preparation without the need for hand filing or creating a glide path.[9]

Advances in nickel-titanium (NiTi) rotary instruments have led to the introduction of canal instrumentation systems with different file designs, metallurgical alloys, and rotational motions. Despite having several advantages compared with the traditional hand instruments, these files are associated with high stress generation within the root canals. Different NiTi instrument designs are associated with different levels of stress and resistance of roots to fractures.

A study by Burklein et al. (2013) compared root canal preparation performed with single-file reciprocating systems with that performed with sequential full rotational files. They showed that defects occurred independently of the instrumentation technique, but reciprocating instruments created more cracks in the apical third of canals. Complete canal preparation with a single-file instrument might be assumed to generate more stresses, since only a single file performs the entire

enlargement of the canal, which can increase the incidence of dentinal defects, and reduce resistance to VRF.[10]

The purpose of this study was to compare the fracture resistance of teeth instrumented with differently tapered NiTi files and hand files. It is generally accepted that the fracture resistance of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure.

Result of the present study showed significant increase in fracture resistance in group 1, when compared to other groups. This result was in accordance with study done by Nisha Acharya et al. who evaluated the Effect of Hand and Rotary Instruments on the Fracture Resistance of Teeth and demonstrated that hand files and rotary files with less taper will better preserve the strength of teeth than rotary files with increased tapers.

In group 2 and group 3, root canal preparation was done by using Hyflex CM rotary files up to file 25/.04 and 25/.06 respectively. The result showed significantly higher mean fracture resistance as compared to Group 4 and lower fracture resistance when compared to group 1. This result was in accordance with study done by Sameer Ahmed Khan et al[11] who evaluated the fracture resistance of endodontically treated teeth after instrumentation with different nickel titanium systems and demonstrated that Hyflex CM files treated tooth shows higher fracture resistance when compared to higher taper files.

In group 4, canal preparation was done with Reciproc R25 files, and the result showed least fracture resistance when compared to group 1 group 2 and group 3. This result was in accordance with study done by Sakshi Tyagi et al[12] who evaluated the fracture resistance of endodontically treated teeth after instrumentation with different nickel titanium systems and demonstrated that Reciproc files system treated teeth shows least fracture resistance.

Reciprocating files are characterized by a triangular or modified triangular cross-section, resulting in a low cutting efficiency and less chip space. An increased cutting ability is usually associated with an improved cleaning efficacy, and the reciprocal motion seems to enhance debris transportation toward the apex and may result in increased torsional forces.[12]

So, in our present study multiple comparison of mean differences between groups showed that Group 1 showed significantly higher mean fracture resistance as compared to Group 2 at P=0.002 & between Group 3 & Group 4 at P<0.001. This was then followed next with Group 2 & Group 3 showing significantly higher mean fracture resistance as compared to Group 4 groups at P<0.001. However, no significant difference was demonstrated in the mean fracture resistance between Group 2 & Group 3 [P=0.43]. This infers that the Group 1 demonstrated significantly higher mean fracture resistance, followed by Group 2 and Group 3 with Group 4 showing significantly the lowest fracture resistance.

Conclusion

Under the limitations of this in-vitro study, it can be concluded that:

• All the file system used for the study reduced the fracture resistance of endodontically treated teeth, except the first group which was prepared using Hand K files.

• Among the rotary files used reciproc R25 with 8% taper showed less fracture resistance compared to Hyflex CM files with 4% and 6%.

• Among Hyflex CM files teeth instrumented with 4% taper group showed better fracture resistance compared to teeth instrumented with 6% taper group.

• Root canal prepared with Hand K-files with 2% taper showed best fracture resistance among all experimental groups

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