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Root fracture resistance of endodontically treated teeth using three different instrumentation systems (An in vitro study)

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ABSTRACT

Vertical root fractures are result largely from procedures performed in the root canal in the endodontic treatment of roots. In this study three groups of thirty premolars roots have been instrumented with three different systems, hand step back instrumentation with K-files, rotary K3 file system and rotary Protaper file system. The roots then obturated with gutta percha and sealer using lateral condensation technique and then subjected to a vertical load via universal testing machine until fracture. The results showed a statistically significant difference among all groups and a statistically significant difference between group 1 and group 2,3 respectively and no difference between group 2and 3.The hand instrumentation provides more fracture resistance to roots that receive endodontic treatment than the rotary instrumentation techniques.

Introduction

There is a clinical impression that endodontically treated teeth are more friable and fracture easily thus may have to be removed[1].Vertical root fractures are severe complications that are seen in root filled teeth which often lead to extraction[2,3,4,5,6].

A vertical root fracture is a longitudinally oriented fracture of the root extending through the entire thickness of the dentin from the root canal to the periodontium.it may be initiated in the crown or in the root apex or in some cases along theroot between these two points[7].Vertical root fractures are result largely from procedures performed in the root canal in the endodontic treatment of roots for example excessive canal shaping excessive pressure during compaction of gutta percha ....etc.[8]

Lertchirakarnetal 1999 reported fractures resulted from excessive lateral compaction forces during root filling[9], however lateral condensation alone should not be a direct cause of root fracture as loads generated during lateral condensation were significantly lower than the forces required to fracture of roots[10,11].

The instrumentation is un avoidable step in the endodontic therapy thus advancement in the rotary nickel titanium (Ni-Ti) instruments over the last decade have led to a new design concepts and techniques of canal preparation which made the endodontic easier and faster than hand instruments resulting in consistent and predictable root canalshaping[12] in order to create a continuously tapered conical flared preparation advanced instruments designs with non-cutting tips, radial lands , different cross sections, superior resistance to torsional fracture and varying tapers have been developed[13].

Most of the recent systems incorporate instruments with a taper greater than the standard 2%(0.02) and the Ni-Ti instruments available with tapers ranging from 0.04 up to 0.012 and this large taper of these systems may influence the resistance of the endodontically treated teeth roots to fracture.

AIM OF THE STUDY

To compare the fracture resistance of endodontically treated roots using hand standardized instruments technique and other two different rotary Ni-Ti systems the rotary K3 file system and the rotary Protaper system.

Materials and Method:

30 single rooted mandibular premolars will be used.All teeth stored in distilled water until they were tested. teeth will be cleaned with ultrasonic scaler and each tooth will be decoronated at the cement enamel junction with a diamond disc leaving 14mm of each root which will be examined for cracks and defects with magnifying lens and the patency of the canal will be checked by passing no. 10 k-file in the canal until its appear from the apex of the root.

All teeth will be kept moisten in the distilled water throughout the experimental procedure to prevent the dehydration of the roots.

The roots will be divided into three groups:-

1-**Group 1** instrumented by hand step back technique with stainless steel hand k-files.

2-**Group 2** instrumented by crown down technique with Ni-Ti rotary K3-file system.

3-**Group 3** instrumented by crown down technique with Ni-Ti rotary Protaper file system.

Group 1: step back technique with standardized stainless steel hand k- files

The canals will be prepared with hand filling to the master apical file size 30 and then step back with 1mm shorter for the three successive file sizes with recapitulation by the master apical file to the full working length will be performed after each file size of the step back procedure.

Using irrigation solution 2.5% NaOCI after each size preparation by inserting 27-gauge needle. The roots will be stored in distilled water to prevent dehydration.

Group 2: crown down technique with Ni-Ti rotary k3-file system.

The canals will be prepared with k3-files. The Ni-Ti k3-files compromised of 6 Ni-Ti files (two orifice shapers and four shaping files) the instrumentwill be advanced apically with peeking motion until the first sign of resistance detected with a rotation speed between 200-300 rpm.

These instruments are available in different treatment sequences each including six files with size 15-60 with three different tapers(2%,4% and 6%) in addition there are two orifice openers (8% and 10%) for coronal pre flaring. The cross section of the k3-files is asymmetrical(14). Canal preparation will be completed to size 30 with crown down steps using sodium hypochlorite 2.5 % for irrigation.

Group 3: crown down technique with Ni-Ti rotary protaper-file system.

The canals will be prepared with rotary Ni-Ti protaper files at speed 16:1 gear and at 1.4 torques between 250-350 rpm starting with shaper S using multiple passive pressure passes to the working length and later using S2.

Apical part of the canal finished using finishing files F1 and later F2 to the working length. This system have tapers range from (2%,3%,4%,7%,8%,11%,11.5% and 19%) of three shaping files and three finishing files[15].

1-Sx (auxiliary shaper): (iso size 19) taper 3%-19%
2-Sl:(iso size 17) taper 2%-11%
3-S2:(iso size 20) taper 4%-11.5%
4-Fl:(iso size 20) taper 7%-5.5%
5-F2:(iso size 25) taper 8%-5.5%
6-F3:(iso size 30) taper 9%-5%

Canal preparation completed to size 30 using sodium hypochlorite 2.5 % for irrigation.
Recapitulation with size 10 k-file after every instrument used and will be stored in distilled water to prevent dehydration.

Obturation:

After the canals have been dried with absorbent paper points all specimens will be obturated with gutta-percha and zinc oxide based eugenol sealer using lateral condensation technique.

All specimens will be mounted individually in a cold cure acrylic base up to 8mm of the root. The roots will be kept moist using damp towel to prevent dehydration.

Each specimen placed individually on the platform of the Instron testing machine with a round tip that have a 4mm in diameter, this round tip will contact the coronal surface of the specimen and will subject a slowly increase in vertical force of 1mm per minute until fracture occurred when there is a drop in the value of stress applied to the specimen and values will be recorded in Newton then the results will be compared statistically between the different groups.

Results:

The results have been shown a significant difference among the three groups as shown in ANOVA test table.

ANOVA Groups

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9944.018	2	4972.009	6.201	.006
Within Groups	21649.302	27	801.826		
Total	31593.320	29			

The mean value of fracture point for group 1 was 244 Newton which is higher than the mean value of fracture point for group 2(215).the mean value of fracture point for group3 was 200 Newton which is less than the other two groups as shown in case summaries table.

There is a significant difference between group 1 and group 2as there is a significant difference between group 1 and group 3.

There is no significant difference between group 2 and group 3 as shown in Post Hoc Tests (multiple comparisons) table below

Post Hoc Tests
Multiple Comparisons

Groups LSD

(I) Types	(J) Types	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Stepback	ProTaper	43.9400*	12.6635	.002	17.957	69.923
	K3	28.5700*	12.6635	.032	2.587	54.553
ProTaper	Stepback	-43.9400*	12.6635	.002	-69.923	-17.957
	K3	-15.3700	12.6635	.235	-41.353	10.613
K3	Stepback	-28.5700*	12.6635	.032	-54.553	-2.587
	ProTaper	15.3700	12.6635	.235	-10.613	41.353

*. The mean difference is significant at the 0.05 level.

Discussion:

Root canal instrumentation is an essential stage in endodontic treatment.But it is generally accepted that several endodontic procedures such as access preparation, instrumentation and even irrigation with sodium hypochlorite lead to reduction in fracture resistance of instrumented teeth.

The risk of fractureduring root canal space obturation in both lateral and vertical condensation techniques is high if too much forces exerted during compaction. Studies showed that instrumentation alone has been found to significantly weaken roots. Inasmuch as it is difficult to ascer¬tain the amount of dentine that can be removed before this weakening effect takes place, it seems logical to remove as little dentine as possible during instrumentation without jeopardizing long term success The load required to fracture the root provides an indication of fracture susceptibility of the root when subjected to forces encountered during obturation, post placement, or subsequentclinical function.

When an apical pressure is applied with a round instrument inserted into an elliptical canal, it will bind at its narrowest width, which is typically from mesial to distal. The initial forces will be directed towards the mesiodistal direction leading to a strain on the buccolingual surface. Hence the resulting fracture lines will orient in the buccolingual direction.

Treatment options, destruction of the supporting tissues, opposite to the fracture as a result of the constant release of irritants including bacterial elements to the area, precludes any treatment other than extraction.

The use of CO2 and Nd–YAG laser to fuse fractured roots was tested in an in vitro study, but proved ineffective [16].

The results of this study showed that roots prepared by the hand instruments have higher resistance to fracture than the roots prepared by the rotary systems statistically and this obviously due to the fact that less dentine removal from the inside of the canal when using hand instruments which is due to the design of the instrument itself (taper, cross section) and this agree with the results of ***Shwailiya*** also this finding is agree to the study by ***Wilcox etal***[17],and ***Zandbiglari etal***[18], which concluded that the more root dentin was removed, the more likely a root was to fracture.

Disagree with ***Mirtha etal***[19].which stated that there is more fracture load needed to fracture root prepared with rotary instruments than that prepared with hand instruments this may be a result of the effect of therounder canal shapes preparations leading to reduced areas of stress concentration which may offset the effect of increased dentin removed.

There is no significant statistical difference between fracture loads needed for group 2(K3 file system) and group 3(protaper file system) and this agree with ***Mirthaetal***[19].

There was no variability in the fracture load of the roots, compared to a three-fold range in the ***Lertchirakarnetal***[9]. studyand a four -fold range in the work of ***Pitts etal***[7]. This is presumably because of the variation in root morphology, dentin thickness, calcification, and canal preparation techniques.

Singlaetal.stated that Profile 6% taper instruments offer the advantage of maximum debridement without significant reduction in root fracture resistance compared to step back technique and other tapers of the system**(20)**.

Conclusion:

The hand instrumentation provides more fracture resistance to roots that receive endodontic treatment than the rotary instrumentation techniques. This aspect of endodontic treatment should be considered

in relation with other aspects like ability of cleaning, ability of shaping and ability of fatigue resistance of the instruments.

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