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Assessment of fracture resistance of teeth instrumented by different file system

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Abstract

Vertical root fractures often result in tooth extraction. There are many factors which contribute for this incidence & root canal preparation is one of the important cause in that.

Objective: The aim of this study was to compare the effects of three different instrumentation techniques on vertical root fracture resistance of endodontically treated teeth.

Materials and Methods: 45 freshly extracted mandibular premolar teeth of similar dimensions were randomly divided into hand K-file (HF, n = 15), Wave One reciprocating single-file (WO, n =15) & rotary file (RF, n = 15) groups. After cleaning and shaping the root canals, obturation was completed & root canals were embedded in standardized auto polymerizing acrylic resin blocks, subjected to a vertical load to cause vertical root fracture. The forces required to induce fractures were measured using a universal testing machine. ANOVA and Tukey's post-hoc test were used to analyze the data.

Results: All experimental groups showed statistically significant reductions in fracture resistance as compared with the Hand files. The fracture resistance was more in HF followed by WO & RF group respectively.

Conclusion: Hand files were more resistance to fracture compared to others. But, all three instrumentation techniques caused weakening of the structure of the roots and rendered them susceptible to fracture.

Keywords: Vertical root fracture (VRF), Endodontically treated tooth, hand K file, wave one reciprocating file, rotary file

Introduction

Extraction of endodontically treated teeth is more common because of vertical root fractures (VRF). It is defined as a longitudinally oriented fracture, extending from the root canal to periodontium [1]. The prevalence of VRFs in endodontically treated tooth is 11% [2]. The prognosis of root-filled tooth with VRF is very poor because of its potential to weaken the tooth structure [3]. The initiation of the crack was related to canal preparation, while filling techniques were associated with the propagation of this. Advances in rotary instruments (Nickel - Titanium) have led to the introduction of canal instrumentation systems with different file designs, metallurgical alloys, and rotational motions [4]. But, these files were associated with high stress generation within the root canals despite having several advantages compared with the traditional hand instruments [4-8]. These cracks can gradually degenerate into VRFs.

The single-file reciprocating Wave One (Dentsply-Maillefer; Ballaigues, Switzerland), was an improvement in gradual shaping with multiple instruments [9]. Due to the reduced number of files used compared with the multi-instrument rotary canal preparation techniques, it is claimed to be cost-effective and less time-consuming [10].

Hence, this study aimed to compare the differences in fracture resistance of the roots prepared with hand K-file (HF, Dentsply-Maillefer; Ballaigues, Switzerland), rotary file (BR, FKG Dentaire; La- Chaux-de-Fonds, Switzerland), and large Wave One reciprocating single-file (WO, Dentsply-Maillefer).

Methodology

Prior to conducting the study, the research protocol was approved by the Institutional Ethical Committee.

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Teeth with curved roots, open apices, resorption or previous root canal treatment were excluded from the study.

Forty five human mandibular premolars with single root were collected and stored in saline. Using a diamond disc at low speed the crown of each tooth was sectioned to 2.5 mm coronal to cementoenamel junction. No 8 K file was used to determine the working length and apical patency was maintained by No 10 file. All teeth were hand instrumented by using No 15 K file. Then the teeth were randomly allocated to 3 groups of different file systems with 15 teeth in each group.

Group 1 (HF) - Instrumentation with 0.02 tapered stainless steel K-files (Mani Inc).

Group 2 (WO) - Instrumentation with Wave One files (Dentsply).

Group 3 (RF) - Instrumentation with rotary NiTiProTaper (Dentsply).

Step back technique was used for hand K-files. No 15 K file in the sequence of 20, 25, 30, 35 and size 40 was used, 60 size file being the last one. During instrumentation canals, 1% sodium hypochlorite solution used as root canal irrigant. One set of files were used to prepare four teeth.

Single-file reciprocating technique was used for Wave One file. Wave one dedicated motor (Dentsply, Maillefer) was set according to the manufacturer. Roots were instrumented through a progressive up and down motion with little force. The files were removed after every three to four pecks, wiped clean, and canals were irrigated with 1% sodium hypochlorite solution. Four canals were prepared with each instrument.

For Rotary NiTi files (RF), crown-down technique using an X-Smart was used for Pro taper files canals.

Root canals in all groups were dried with paper points and obturated using an Element Obturation Unit (Sybron-Endo; Sybron Dental Specialties Inc., Glendora, CA, USA) with a master gutta-percha cone size of 40, and a continuous wave of warm gutta-percha. AH26 (Dentsply De Trey; Germany) was used as root canal sealer & it was confirmed by Post-operative radiographs. To prevent root dehydration, it was covered with double layer of nail polish and stored in normal saline for 2 weeks.

All the roots were mounted vertically in standardized cylindrical auto polymerizing acrylic with diameter of 13mm and length of 14mm. To retain 12mm of the root inside the mount, it was positioned at the centre of the acrylic resin and covered with a very thin layer of wax (0.2–0.3 mm). After setting, the roots were removed and remaining wax was washed out. To simulate a periodontal ligament, a thin layer of polyvinyl siloxane was applied to the cavity of the root inside the acrylic resin, and the roots were returned to the same position.

A continuous perpendicular external static force was applied with a stainless steel parallel rod (0.7-mm diameter flat end) on the root canal filling material. Obturation material acted as a medium to distribute the force. A universal testing machine (Instron Corp.; Canton, MA, USA) was used, operating at a cross-head speed of 1.0 mm/min. To distribute the load on canal walls, the rod was inserted into the root canal to contact gutta-percha. In control group, the load was directed to the canal lumen. After detecting fracture or by sudden reduction in load, the machine was stopped immediately. The load at fracture time was recorded in Newton. The maximum load during each test was defined as the fracture load. To confirm the fracture and determine the pattern of the fracture lines to be buccolingually, mesiodistal or compound after each test, the roots were dyed with 2% methylene blue dye solution and viewed under magnification & recorded.

The data obtained were subjected to statistical analysis to compare the fracture resistance among three groups.

Results

Table 1 & Graph 1 shows the descriptive data for fracture resistance in all the three groups in terms of mean & standard deviation with minimum & maximum values. Hand files showed more resistance to fracture with 246.8 N compared to other two groups.

Table 2 depicts tukeys posthoc analysis which shows the significant difference between hand file when compared with Wave One& rotary files. And Wave one also showed significant difference compared with rotary files in resisting the fractures.

Table 1: The mean force in Newton required for fracture resistance of all the test groups.

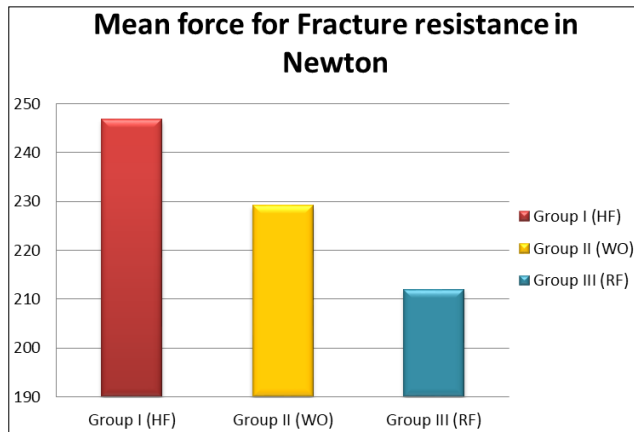
Groups	n	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Group I (HF)	15	246.8000	13.73317	239.1948	254.4052	228.00	270.00
Group II (WO)	15	229.2000	12.80736	222.1075	236.2925	200.00	250.00
Group III (RF)	15	212.0000	14.04584	204.2217	219.7783	189.00	240.00

F= 24.776, p<0.001 Highly Significant

Table 2: Tukeys Posthoc test for intergroup comparisons.

Multiple Comparisons Tukey HSD					
Group	Compared with	Mean Difference (I-J)	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Group I	Group II	17.60*	0.003	5.5892	29.6108
	Group III	34.80*	0.000	22.7892	46.8108
Group II	Group III	17.20*	0.003	5.1892	29.2108

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



Graph 1: Mean force in Newton

Discussion

The catastrophic event of VRF leads to tooth extraction or root resection. Instrumentation may contribute to VRF by inducing stress or by excessive dentinal removal. Different instrumentation techniques featuring different cross-sectional geometry, taper and flute form, type of manufactured alloy, number of instruments used and rotational motion which can influence tooth resistance to VRF, NiTi K-file, BioRaCe, and Wave One were chosen for the study. In this study, fracture resistance was evident between roots prepared with hand NiTi K files when compared with others ($p < 0.05$). Bier *et al.* [14] & Yoldas *et al.* [15] who observed no influence of HF on development of cracks. However, it was observed by Liu *et al.* [11] Hin *et al.* [12] Zandbiglari *et al.* [13] & SAH Sheikh *et al.* [14] showed lesser number of cracks by HF compared to rotary files which was similar to the present study results.

File design can result in dentinal defects and reduce the fracture resistance of roots as stiffer files generate higher stress concentration [7]. Stiffness is related to many factors like size, taper, cross-section, method of manufacturing, and the material out of which the instrument is made [15]. The designs of the files used in this study were, a modified convex triangled - Wave One file, reverse-acting cutting edges with a simple triangular cross sectioned - BioRaCe. Evidently studies have stated that more even stress distributions along their length, and lower stress concentrations were noted with instruments with a triangular cross-section, than the instruments with rectangular cross-sectional designs [15].

The constant torque applied by NiTi rotary instruments on the root canal wall can cause significant micro-crack formation. These stresses can create defects and damage the dentinal walls which can progress to VRFs [5, 16]. On the other hand, Sathorn *et al.* (2005) studied the effects of intrinsic factors of roots on fracture susceptibility and pattern, and found that dentinal removal is not the only factor associated with reduced fracture resistance, and does not always result in increased fracture susceptibility [17]. Rather, root fracture results from interaction between multiple factors with intrinsic aspects of the canal playing an important role.

While fracture resistance of a root is significantly affect the canal morphology and the external shape of roots [17], clinicians can limit VRF occurrence through identifying susceptible teeth by their intrinsic factors, and adopting conservative and valid clinical principles when treating these teeth.

Conclusion

Root canal treatment weakens roots, and in this study, instrumentation with handfile was associated with resistance

to fracture comparable with the roots prepared with wave one or rotary instruments.

This study gives an indication of root susceptibility to VRF when subjected to forces encountered in clinical situation such as obturation, post placement, and subsequent clinical function. Considering root fracture in a multi-factorial context, further research should evaluate their shaping abilities in comparison with different instrument systems.

Limitations

In a clinical situation, roots should withstand different forces during and after root canal treatment but in the present study the roots were subjected to static vertical force. It was assumed that gutta-percha distributes the vertical load equally and uniformly around the canal wall. Usually in practice, this may not be achieved. Lateral condensation techniques by spreaders may also lead to a point load. Root dentine sclerosis in relation to the age and race of the patients, which affect the strength of root were not recognized in this study.

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