MDJ

The effect of Hand Stainless-Steel and NiTi Rotary file… Vol.:8 No.:2 2011

The effect of Hand Stainless-Steel and NiTi Rotary file on vertical root fracture.

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Abstract

The aim of this study was to compare the fracture resistance of roots following root canal therapy using stainless-steel hand instrumentation (SS), Rotary Profile (PF) instrumentation, Rotary ProTaper instrumentation (PT). Forty-five mandibular premolars teeth were divided into three groups of 15 teeth each, according to the type of instrumentation. All root obturated with gutta-percha and AH26 sealer. The roots were vertically loaded using a universal testing machine. Fracture loads were analysed by ANOVA and LSD test, and fracture patterns were analyzed with Chi-Square. Profile & ProTaper groups have significantly lower fracture load than hand instruments group ($P < 0.05$). Chi-Square showed a significant differences between groups ($P < 0.05$) .

Keywords: Root fracture, Instrumentation, Fracture pattern.

Introduction

Vertical root fractures (VRFs) in endodontically treated teeth are a most serious complication. VRFs have a poor prognosis and usually result in tooth extraction. Clinical diagnosis of VRFs is difficult because in only a few cases can the presence of a fracture line be detected correctly with radiographic or oral examinations [(1)]. VRFs might initiate in the crown or at the root apex, but can occur at any point [(1)]. Definitive diagnosis can often be made when the affected tooth is explored surgically and the fracture line is detected [(2)], and as a result, endodontic procedures have been blamed as a frequent cause of VRF. Numerous experimental studies have challenged this conclusion. Dentin of endodontically treated teeth does not exhibit mechanical properties that are significantly different from those of vital teeth; that is, dentin does not appear to become more brittle [(3, 4)]. It has been shown that access cavity preparation has non-significant effects on tooth stiffness [(5)].

Lateral compaction of gutta-percha is widely used to fill the root canal system and was reported previously to be associated with an increased risk of VRF [(6)]. Spreader design and applied forces were suggested as contributing factors to the appearance of VRF during lateral compaction [(7)]. However, laboratory stress distribution studies consistently conclude that the pressure applied during lateral compaction is insufficient to cause VRF [(8)].

Canal preparation involves dentin removal and may compromise the fracture strength of the roots; it is, therefore, another area that has been studied as a potential cause of VRF [9]. The resistance to fracture of the root filled tooth is directly related to the amount of remaining tooth structure [6]. When comparing the force required to fracture enlarged but unfilled roots and intact roots, Zandbiglari et al.[10] reported that the instrumented groups were significantly weaker than the intact group.

Traditionally, root canal preparation was carried out using stainless steel endodontic files manipulated by hand. In recent years, advances in rotary nickel– titanium (NiTi) instruments have led to new designs and techniques of root canal preparation [11]. Various studies have concluded that these instruments exhibit superior performance over hand preparation. Rotary NiTi instruments are believed to allow preparations of root canals with fewer procedural errors than conventional stainless steel instruments [12]. Indeed, canals prepared with NiTi rotary instruments show increased cleanliness, better shaping ability and less canal straightening, apical transportation and perforations [13, 14]. With rotary NiTi preparation, canal shapes are more likely to be rounder and smoother [13, 14]; canal irregularities are likely to be incorporated into the preparation and eliminated. Theoretically, smoothly tapering canals prepared using rotary NiTi should result in higher fracture strength. Patterns of VRF might also be different with this new canal preparation technique. The purpose of this study was to compare the fracture load and the incidence of fracture pattern in the roots prepared either with hand instrumentation or different types of rotary NiTi instrumentation.

Materials and Method

Forty five extracted mandibular premolar teeth that were approximately of similar dimension were selected and stored in purified filtered water. Proximal radiographs were taken to verify the presence of a single canal. Teeth with curved roots, apical resorption or previous root canal treatment were discarded. The tooth crown was removed with a diamond disc mounted in a low-speed handpiece with water coolant, and the root length was adjusted to 12 mm. All roots were observed under 8x magnifications in a stereomicroscope to exclude cracks. All roots were kept moist in purified filtered water throughout the experimental procedures in order to prevent dehydration.

Teeth were randomly distributed into three experimental groups, each with a sample of 15:

- **(group I):** Hand preparation using stainless steel K-files (SS) (Maillefer, Dentsply).
- **(group II):** Rotary NiTi canal preparation using ProFile (PF) (Maillefer, Dentsply,Tulsa Dental, Tulsa, OK).
- **(group III):** Rotary NiTi canal preparation using ProTaper (PT) (Maillefer, Dentsply,Tulsa Dental, Tulsa, OK).

Cleaning and Shaping

Group (I):Hand Instrumentation (SS)

The teeth in this group were prepared with stainless steel K-files with a non-cutting tip using a step-back technique. To enlarge the canal, a balanced force technique was used with successive files placed into the canal, with a clockwise movement of 60–90^{o} and slight inward pressure. Then, a counterclockwise movement of 120–180^{o}, under apically directed pressure, was made to cut the dentine. The apical enlargement was performed with the sequential use of files size 15, 20, 25, 30, 35, and finally size 40 with coronal flaring up to size 60 . All canals were irrigated with 1% sodium hypochlorite solution and EDTA followed by recapitulation with a size 15 file after each file change. Instrumented teeth were then kept moist in water until the obturation phase.

Group(II):Rotary NiTi Profile Instrumentation (PF)

A crown-down technique was utilized. The torque-control motor (NSK, Japan) was set at the recommended rotational speed and torque according to the manufacturer's recommendation for each instrument. The teeth were irrigated with 1% sodium hypochlorite solution and EDTA after each file change, and all canals were enlarged to size 40, 0.04 taper. Instrumented teeth were then kept moist in water until the obturation phase.

Group(III):Rotary NiTi ProTaper Instrumentation (PT)

A crown-down technique was utilized. The torque-control motor (NSK, Japan) was set at the recommended rotational speed and torque according to the manufacturer's recommendation for each instrument. The teeth were irrigated with 1% sodium hypochlorite solution and EDTA after each file change, and all canals were enlarged to size F4. Instrumented teeth were then kept moist in water until the obturation phase.

Obturation

Canals in all groups were thoroughly dried with paper points before insertion of gutta-percha. Lateral condensation was employed using nickel-titanium spreader with master cone size 0.40 taper 0.04 gutta-percha (Dentsply, Tulsa Dental) for all groups. AH 26(Dentsply, De Trey, Konstanz, Germany) root canal sealer was used for all canals. A polyether impression material was used around the tooth during the filling procedures in order to mimic the mechanisms of stress distribution. The coronal gutta-percha was removed with a flame-heated plugger, and the impression material was removed. Roots were stored for 1 week at 37^0C and 100% humidity to allow the sealers to set.

Fracture test

The roots were directly embedded into an acrylic tube (20 mm height &10 mm diameter) with an autopolymerisable resin. The root was positioned at the centre of the acrylic tube [(15)]. The centre of the coronal surface of the RCF material was continuously loaded by a cobalt-chromium rod with a 0.9-mm diameter flat end. A universal testing machine (Instron, USA) was operated at a cross-head speed of 1.0 mm/min until the cobalt-chromium rod was inserted to a depth of 2 mm, or until load reduction could be confirmed [(15)]. The maximum load during the test was defined as the fracture load.

Fracture patterns

After the fracture test, the acrylic tube was carefully removed, and the root surface was dyed with methylene blue dye solution. The root surface was then viewed through a stereomicroscope using a cold light source (KL 2500 LCD; Carl Zeiss). Pictures were taken with a camera (Axio cam; Carl Zeiss) at a magnification of X12. Fracture patterns were classified into four categories according to the previous research by Okitsu et al [(16)]:

(NF): No fracture.

(PF): Partial fracture not involving the root apex.

(AF): Partial fracture involving the root apex.
(CF): Complete fracture.

Statistical analysis

Fracture loads were statistically analyzed using ANOVA and LSD test. The fracture patterns were statistically analyzed using Chi-Square. With statistical significance set at ($P < 0.05$).

Results

Fracture loads and fracture patterns are summarized in table (1)&(2). ANOVA test revealed a significance difference between groups $P<0.01$. The mean of the fracture load of hand instrumentation (419.1N) was significantly higher than both Profile group(371.2 N), and ProTaper group(353.5 N) table (3), Fig (1). Chi-Square of fracture patterns showed a significant differences between groups ($P < 0.05$), table (4), Fig.(2).

Discussion

This study was conducted to evaluate the effect of rotary and hand instrumentation on the vertical root fracture. In this study all teeth were subject to the same handling procedures and were soon returned to their storage environment. The storage medium used to keep the teeth was purified filtered water. This medium was previously recommended for investigations of human dentine[17] as it causes the smallest changes in dentine over time.

In this experiment, the gutta-percha in the canal was continuously loaded in an apical direction and expansion of the gutta-percha pushed the root canal wall horizontally. Regarding the initiation of VRFs, it could be hypothesized that, clinically, a crack formed in the root canal wall during root canal preparation could progress apically or coronally in a vertical direction. When load reduction could not be confirmed by the fracture test, a cobalt-chromium rod was inserted to a depth of 2 mm to prevent contact with the root canal wall. The observed load, without load reduction, would underestimate the fracture load; however, the NF loads were assigned to the fracture load, as shown by Okitsu et al.[16].

According to the result of this study a significant difference in the fracture load of hand and rotary NiTi canal preparations was observed. This may be attributed; that the thickness of the surrounding root dentin hardly affects the distribution of forces and the resistance of the root to cracks and fracture [18]. The progressive tapering of newly design NiTi instrument results in excessive removal of dentinal wall, which in turn result in weakening of instrumented root. Moreover, the torque and friction developed during root canal preparation with rotary instruments were located at or near the file tip [19]. The pattern of stress distribution in the apical area might influence crack development and fracture propagation. In a recent study, Soros et al.[20] concluded that complete vertical root fracture should not be considered as an instant phenomenon, but as a result of gradual diminution of root structure. This result coincide with a study conducted by Satborn et al.[21], who showed that fracture occurred more often in the rotary NiTi groups than hand group.

Adorn et al.[22] in 2010, found that when preparation go beyond the working length and reached the apical foramen more teeth exhibited cracks. With rotary instrumentation working length is less control than hand instrumentation, and this may be explained why the incidence of fracture involvement the apex occurred more in ProFile & ProTaper groups than hand group, (7), (5), (3) respectively with a significant difference.

The highest number of the root with fracture involving the apex occurred in the ProFile group, and even more than ProTaper group. In a study conducted by Shemesh et al. in 2009[23] a significant larger number of apical defect was observes in ProFile prepared group, the ProFile instruments have lands, a U shaped cross section. The lands makes the instruments passive and prevent canal transportation, this design increases the contact area with the canal wall as compared to ProTaper instruments devoid such lands, and might increase friction and torque and thereby fracture risk.

Attempts to reduce fracture susceptibility of the roots clinically are limited because many factors interact in influencing fracture susceptibility, and most of them are beyond the control of clinicians e.g. root shape, proximal concavity. The clinician can, however, reduce fracture susceptibility by maintaining the root structure as much as possible, and by striving for a smooth canal without irregularities. In addition, clinicians can identify susceptible teeth before commencement of endodontic treatment, based on root size and taper.

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Table (1): Examined conditions, results of loading

Groups	No.	Mean	SD
SS	15	419.6	67.467
PF	15	371.2	57.083
PT	15	353.5	63.29

Table (2): Fracture pattern

	Group SS		Group PF		Group PT	
	No.	**%**	**No.**	**%**	**No.**	**%**
NF	5	33.4	1	6.7	2	13.3
PF	7	46.6	5	33.4	6	40.0
AF	3	20.0	7	46.6	5	33.4
CF	0	0.00	2	13.3	2	13.3
Total	15	100	15	100	15	100

*Chi-square=7.183 P=0.0304 P < 0.05 Significant

Table (3): LSD test

Groups	P-value	Sig.
SS&PF	0.043	S
SS&PT	0.010	S
PF&PT	0.80	NS

S: Significant NS: Non significant

Table (4): Chi-Square between groups

	Chi-Square	P-value
NF	3.54	0.043 S
PF	1.76	0.143 NS
AF	3.46	0.039 S
CF	0.00	1.00 NS

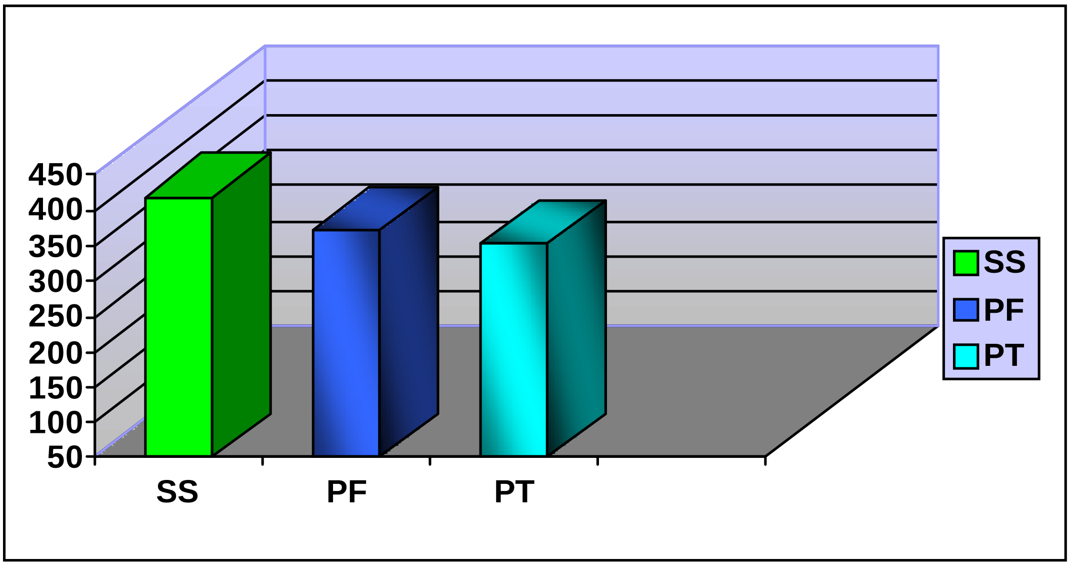

Fig.1: Bar chart graph to compare the Mean of fracture load

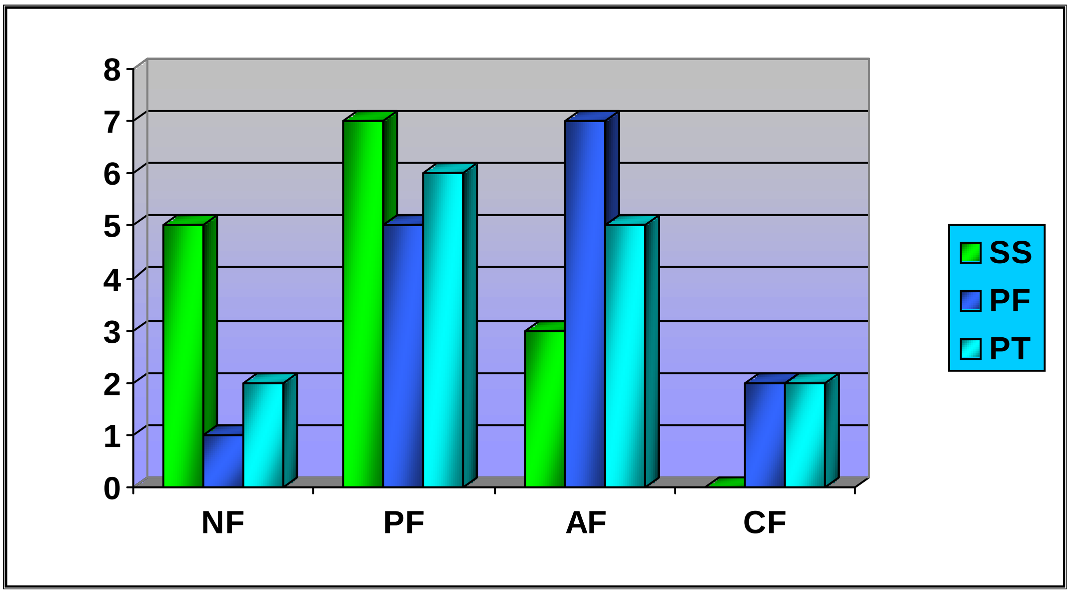

Fig.2: Bar chart graph to compare the incidence of fracture pattern