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COMPARATIVE EVALUATION OF DENTINAL CRACK FORMATION DURING ROOT CANAL PREPARATION USING PROTAPER GOLD, HYFLEX EDM FILES

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Abstract:
Aim: To evaluate and compare in vitro the dentinal crack formation after instrumentation of root canals with Protaper Gold, Hyflex EDM instruments.
Materials and methods: Fourty five single rooted teeth were used for this study. Fifteen teeth were unprepared as the negative control group, and the remaining 30 teeth were assigned to two root canal shaping groups. The root canal shaping procedure was performed to the full working length with: Protaper Gold (Group 1), Hyflex EDM (Group 2). All the specimens were sectioned perpendicular to the long axis at 3, 6, and 9 mm and were observed under a digital stereomicroscope at X25 magnification. The absence/presence of cracks was recorded, and the data were analysed with a chi-square test. The significance level was set at 5%.
Result: Protaper Gold was having more number of cracks than Hyflex EDM. Between groups, Protaper Gold and Hyflex EDM group showed statistically significant difference ($P<0.05$).
Conclusion: Hyflex EDM tend to produce less number of cracks as compared to Protaper Gold.
Key words: Dentinal crack, Hyflex EDM, Protaper gold, Root canal preparation, Tooth fracture

Introduction

Biomechanical preparation of root canal is one of the main steps in achieving endodontic success as it enables bacterial elimination, removal of debris, and facilitates obturation. Perforations, canal transportation, ledge and zip formation, and separation of instruments are some of the complications encountered during root canal preparation and retreatment cases. Vertical root fracture and crack formation can also be seen in root dentin during and after endodontic procedures.[1]

During biomechanical preparation, a canal is shaped by the contact between instruments and dentinal walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may induce dentinal defects and micro cracks or craze lines. These in turn, were associated with increased susceptibility to Vertical root fracture (VRF) because of applied stresses caused by root canal obturation, retreatment, repeated occlusal forces and can be exponentially amplified at the tip of those defects and can initiate or propagate into cracks[2] .

In the last decade, advances in nickel-titanium (NiTi) instruments have added a new dimension to root canal treatment. Recently, single-file systems in rotary and reciprocating motion were introduced.[3] Various file systems differing in their design features such as the NiTi core diameter, cross-sectional shape, rake angle and flute depth may affect the behavior of the file and, therefore, may influence the generation of cracks[4].

ProTaper rotary files are popular instruments that are characterized by an increasing taper design, convex triangular cross-section throughout their active portion, and a negative rake angle[5] . Their design facilitates active cutting motion and removes relatively more dentin coronally compared with other systems. ProTaper rotary files were reported to create more dentin damage than other rotary instruments[6]. To overcome their disadvantage, recent

advancements have been made in ProTaper rotary files. Now the ProTaper legacy continues with ProTaper Gold.

ProTaper Gold features the same simplicity, smoothly tapered shapes and predictable performance you know and trust from ProTaper Universal. ProTaper Gold provides more than twice the resistance to cyclic fatigue as ProTaper Universal. And that's an important advantage, because cyclic fatigue is the leading cause of file separation[7].

Another innovation has been introduced into HyFlex file series i.e. HyFlex EDM. HyFlex EDM files are produced using an innovative manufacturing process called Electrical Discharge Machining. The EDM process results in a file that is extremely flexible and fracture resistant. In fact, HyFlex EDM files are up to 700% more resistant to cyclic fatigue compared to traditional NiTi files. HyFlex EDM files follow the anatomy of the canal, which can significantly reduce the risk of ledging, transportation and perforation.

Therefore, this study is to evaluate the dentinal microcrack formation during root canal preparation using two latest NiTi rotary file systems namely, ProTaper Gold, HyFlex EDM.

Materials and Methods

Fourty five single rooted teeth that had been extracted for reasons unrelated to this study were collected and kept in distilled water. Root fractures, cracks, open apices, curved canals, multiple roots, caries or restorations, severe anatomic variations, calcified canal will be excluded. Fifteen teeth were left unprepared as the negative control group, and the remaining 30 teeth were assign to root canal shaping groups.The external root surfaces were inspected under a stereomicroscope (Olympus BX43; Olympus Co, Tokyo, Japan) to exclude the possibility of any external defects or cracks. To ensure standardization, the teeth were section under water cooling with a diamond disc 16 mm from the apex. The roots were covered with a single layer of aluminium foil. The root inserted in acrylic resin set in an acrylic tube. The roots were then removed from the acrylic tube, and the aluminium foil suspended from the root surface. A light body silicon-based material was used to fill the space created by the foil and to simulate the periodontal ligament, and the root was replaced to the impression.

The working length of the canals were determined by inserting a size 10 K-type file into the root canal terminus and subtracting 1 mm from this measurement.

A glide path was perform via a size 15 K file. The apical preparation is completed with a size 20 instrument. The root canal was irrigated with sodium hypochlorite solution after each instrument change. After preparation, the specimens from the prepared groups were rinsed with distilled water. The root canal shaping procedures were performed to the full working length in three groups with:

Negative Control: Fifteen teeth were left unprepared as the negative control group.

Protaper Gold [Group 1]: Using the torque-controlled endodontic motor (X-Smart; Dentsply Maillefer), the root preparation of the specimens in this group was performed by using a Protaper Gold (PG) NiTi rotary file system's SX (19/.04), S1 (18/.02), S2 (20/.04), F1 (20/.07) and F2 (25/.08) files according to the manufacturer's instructions.

Hyflex EDM [Group 2]: Using the torque-controlled endodontic motor (X-Smart; Dentsply Maillefer), the root preparation of the specimens in this group was performed by using 25/.12, 25/.~ NiTi file system according to the manufacturer's instructions at 500 rpm and 2.5 Ncm torque.

All of the roots were sectioned perpendicular to the long axis at 3, 6 and 9mm from the apex using a low-speed diamond disc under water cooling. Digital images of each section were captured at 25X magnification using a digital camera attached to a stereomicroscope. In order to avoid confusing descriptions of root fractures, two distinct categories were made: "no defect" and "defect".

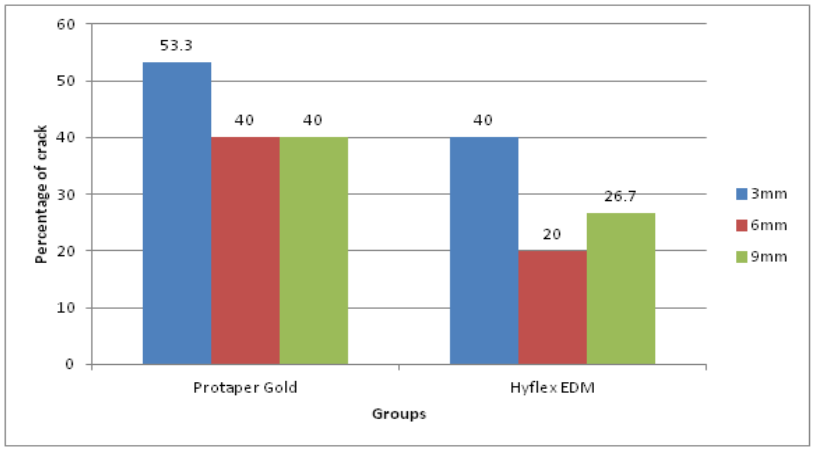
''No defect'' was defined as root dentin devoid of any craze lines or microcracks either at the external surface of the root or at the internal surface of the root canal wall. ''Defect'' was defined if any lines, microcracks, or fractures were present in root dentin.

STATISTICAL ANALYSIS

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 19.0 Version (Table 2). The descriptive statistics included mean, standard deviation. The intergroup comparison was done using One Way ANOVA and Chi Square to find the difference between the different groups. The level of the significance for the present study was fixed at 5%.

RESULT

Vertical root fractures were not observed in any group. Maximum number of cracks observed at apical section for all groups. Protaper Gold is having more number of cracks than Hyflex EDM(Table 1). Between Protaper Gold and Hyflex EDM groups difference shows statistical significant (P<0.05)(Table 3).



Graph 1: Percentage of Dentinal crack at different level

Table 1: Dentin cracks at different instrumentation

Experiment	Protaper gold	Hyflex EDM
3mm	8	6
6mm	6	3
9mm	6	4

Table 2: Data analysis in SPSS software

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Group I (Protaper Gold)	6.66	1.154	0.661	3.798	9.535	6.00	8.00
Group II (Hyflex EDM)	4.33	1.52	0.882	0.538	8.128	3.00	6.00

Table 3: Post hoc test for pairwise comparison

(I) GP	(J) GP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Group I	Group II	2.33333*	1.00000	0.048	.0273	4.6393

DISCUSION

The nickel titanium instruments with new design features in relation to tip size, taper, helix angle, cross section and pitch are continually produced in an attempt to overcome the canal preparation errors.[8] The technological advancement in metallurgy has led to the introduction of new alloys with superior mechanical properties. The mechanical performance of NiTi alloy is extremely sensitive to their microstructure and associated thermomechanical treatment.

However there is no consensus and limited data available to compare the dentinal crack formation

with these newly introduced files and thus is the need for study.

The samples included in the study were examined under stereomicroscope before the start of experiment to determine the presence of crack or fractures. The periodontal ligament with its viscoelastic property plays a major role in dissipating stress generated by load application. Therefor roots surfaces were coated with a layer of polyvinyl siloxane material before placing within the acrylic block to simulate periodontal ligament, as described by Milani et al.[9]

Capar I.D et al reported that use of larger files in shaping the root canals increase the incidence of dentinal defect formation.[10] For this reason, in the present study, the apical diameter of files was determined to be 0.25 mm, and no larger file was used.

The sectioning method used in the present study allowed the evaluation of effect of root canal preparation procedures on root dentin by direct inspection and is in agreement with the methodology described in previous study. The sectioning procedure had no influence on crack formation because the controlled teeth did not show any defect.

The major number of microcracks was observed in the apical section (3 mm) for all tested instruments, which is in agreement with previous studies by Kim et al. This may be due to maximum stress in the apical third of the root canals during cleaning and shaping by rotary files.[11]

According to our study, incidence of crack observed in root dentin was greater after instrumentation with Protaper Gold as compared to Hyflex EDM files. Similar results were found by Ozyurek T, reported cracks in 70% of roots instrumented with Protaper Gold comparing with Hyflex EDM and WaveOne Gold.[12]

In the present study maximum no of fractures were observed in the Protaper Gold group because of uncontrolled pressure which leads to excessive dentin removal. According to Kim et al and Bier et al increasing the taper of files also increased the stress on root canals during shaping procedure.[13,11] In case of rotary ProTaper F2 file has a large apical taper of 0.08 which could explain the higher incidence of damage observed in this group. The progressive tapering of Protaper Gold instrument results in excessive removal of dentinal wall, which in turn result in weakening of instrumented root. Design of the Protaper Gold file having triangular or modified triangular cross section resulting in less space for collection of dentine chips, thus generating stresses on the root dentinal wall.

Hyflex EDM files are produced by control memory treatment just like Hyflex CM file. EDM process created a rough and hard surface that could improve cutting efficiency of these files. Hyflex EDM files have tip size of 25 (0.08) taper. The taper is constant in apical 4 mm of instrum ent but reduces progressively up to 0.04 in coronal portion. This new file has three different cross-sections over the entire length of working part (rectangular) in apical part, trapezoidal cross-section in middle part, triangular in coronal part to increase fracture resistance, and cutting efficiency.

According to Peter et al. increased rotational speed is associated with increased cutting efficiency.[14] Recommended speed for Hyflex EDM is 500 rpm which is higher than Protaper Gold (300 rpm) files tested in this study. Thus, Hyflex EDM could result in less cracks than Protaper Gold files.

However the validity of this invitro study is well appreciated by having more number of clinical trials and hence further randomized controlled clinical trials are recommended.

CONCLUSION

Within the limitation of this in vitro study, it can be concluded that NiTi instruments may cause cracks on the root surface. Hyflex EDM tend to produce less number of cracks as compared to Protaper Gold.

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