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Evaluation of dentinal crack formation during root canal preparation using protaper gold, Mani silk files- *In vitro* study

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Abstract

Aim: To evaluate and compare *in vitro* the dentinal crack formation after instrumentation of root canals with Protaper Gold, Silk instruments.

Materials and methods: Forty 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), Mani Silk (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 followed by Mani Silk. Between Protaper Gold and Mani Silk group the difference was statistically insignificant ($P > 0.05$).

Conclusion: Mani Silk tend to produce less number of cracks as compared to Protaper Gold.

Keywords: Dentinal crack, Mani Silk, Protaper gold, Root canal preparation, Tooth fracture

Introduction

The primary aim of chemo mechanical preparation is to completely remove the microorganisms, pulp tissue and debris and enlarging the canal diameter to receive an obturating material [1]. At times, in the zeal of biomechanical preparation of the canal, we inevitably end up damaging the root dentin which becomes a gateway to dentinal cracks and minute intricate fractures or even vertical root fractures, thereby failure of treatment [2].

Pro Taper 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 [3]. Their design facilitates active cutting motion and removes relatively more dentin coronally compared with other systems. Pro Taper rotary files were reported to create more dentin damage than other rotary instruments [4]. To overcome their disadvantage, recent advancements have been made in Pro Taper rotary files. Now the Pro Taper legacy continues with Pro Taper Gold.

Pro Taper Gold features the same simplicity, smoothly tapered shapes and predictable performance you know and trust from Pro Taper Universal. Pro Taper Gold provides more than twice the resistance to cyclic fatigue as Pro Taper Universal. And that's an important advantage, because cyclic fatigue is the leading cause of file separation [5].

Silk's unique cross-sectional tear drop design cuts exceptionally well and resists fracture, which eliminates the "screwing-in" effect common with many other systems, while removing debris effectively and reducing instrument stress. Groundbreaking proprietary heat treatment provides excellent flexibility without sacrificing efficiency and safety.

Therefore, this study is to evaluate the dentinal microcrack formation during root canal preparation using latest NiTi rotary file systems namely, Protaper Gold and Silk.

Materials and Methods

Forty 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 assigned 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 sectioned 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 performed 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.

Mani Silk [Group 2]: The canals were prepared with Silk files sequentially according to the manufacturer's recommendations using the torque-controlled endodontic motor (X-Smart; Dentsply Maillefer). The Silk files were used in sequence of Orifice opener file 25/.08 followed by 20/.06 and 25/.06 up to working length.

All of the roots were sectioned perpendicular to the long axis at 3, 6 and 9 mm 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. 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 Mani Silk. Between Protaper Gold and Mani Silk group the difference is statistically insignificant ($P > 0.05$).

Table 1: Percentage of Dentinal crack at different level

| Group/Section | Protaper Gold | Mani Silk |
|---------------|---------------|-----------|
| 3mm | 53.3% | 46.7% |
| 6mm | 40% | 40% |
| 9mm | 40% | 26.7% |

Discussion

The introduction of rotary nickel titanium instrumentation has transfigured the Root Canal Treatment by reducing the operator fatigue, time required to complete the preparation and minimized the procedural errors as compared with hand instrumentation [6]. However the zeal of rotary root canal instrumentation could also result in excessive dentin removal generates increased stress and friction on root canal walls which may contribute to the initiation of dentinal cracks or craze lines [7].

Technological advancement in rotary NiTi instruments has led to new design, concepts and easier, faster and better root canal shaping. 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. Therefore 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.* [8].

Capar I.D *et al.* reported that use of larger files in shaping the root canals increase the incidence of dentinal defect formation [9]. 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 [10].

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 [10, 11]. In case of rotary Pro Taper 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. According to Peter *et al.* increased rotational speed is associated with increased cutting efficiency ^[12]. Recommended speed Mani Silk is 500 rpm which is higher than Protaper Gold (300 rpm) files tested in this study. Thus Mani silk file could result in less cracks than Protaper Gold files. Previous studies by Bier *et al*, Kim *et al* and Yoldas *et al* stated that the tip design of rotary instrument, cross-sectional geometry, constant or variable pitch, and taper, flute form could be related to crack formation ^[10, 11, 13] Mani Silk is having taper 0.06 which is less than Protaper Gold. This factor also could be reason for Mani Silk's less crack than Protaper Gold files.

Silk has a unique "tear drop" cross section. The tear drop cross sectional shape allows debris to be channeled out of the canal efficiently, keeps the file centered in the canal and significantly decreases the "screwing in" effect common with many other systems all the while cutting efficiently. Silk instruments are heat treated from their tip end to approximately 10 mm up the cutting flutes with a patented and proprietary process that provides exceptional strength and flexibility to the file. These features also could be reason for Mani Silk's less crack than Protaper Gold files.

However the validity of this *in vitro* 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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