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Comparative evaluation of dentinal changes following retreatment by rotary NiTi retreatment files: An ex vivo stereomicroscopic analysis

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Abstract
The removal of root canal filling material during endodontic retreatment can be performed with hand or rotary NiTi instruments in combination with heat or solvents. Rotary NiTi instruments have been proposed for the removal of filling materials from root canal walls and various studies reported their efficacy, cleaning ability and safety. An increasing number of rotary nickel-titanium (NiTi) file systems have been marketed by various manufacturers for gutta-percha removal during endodontic retreatment. Instrumentation with rotary nickel-titanium (NiTi) instruments could potentially cause dentinal cracks, which may have the potential to develop into fractures. The purpose of the present study was to compare the incidence of root cracks on dentinal walls caused by different rotary retreatment files.

Keywords: Dentinal, rotary NiTi retreatment, stereomicroscopic

Introduction
Root canal therapy, despite having a high degree of success, may not lead to the desired response, and failure may occur. Non-surgical retreatment requires complete removal of the pre-existent endodontic filling material to allow for elimination of necrotic tissues and microbial populations. Safe and efficient removal of all root filling materials from the canal system is essential for optimal nonsurgical retreatment because it provides effective cleaning, shaping and filling of the root canal system [1, 2]. The contemporary techniques used to remove root filling material include the use of hand or rotary nickel-titanium (Ni Ti) instruments with or without heat, solvent and/or ultrasonic instruments. Specialized rotary instruments are now designed for retreatment. Various NiTi rotary instruments have been designed for root canal preparation; however, some NiTi systems have recently been developed for retreatment procedures such as R Endo (Micro Mega),Mtwo (VDW, Munich, Germany) Pro Taper R (Dentsply Maillefer, Ballaigues, Switzerland) and D-RaCe (FKG Dentaire, Switzerland) [3, 4, 5]. The use of rotary instrumentation in removing obturation material from the root canal system has been shown to be more effective than hand files [6]. The use of Ni Tirotary instruments have the advantage of removing gutta-percha and simultaneously shaping the root canals [7, 8]. A concern in some recent studies about rotary instrumentation is the formation of dentinal cracks and craze lines initially that may eventually develop into complete fractures or even vertical root fractures [9, 10]. The remaining dentin thickness (RDT) is important as it gives resistance to fracture of root canal treated teeth. Because retreatment requires more mechanical manipulations and further preparations of the root canal, it could be that more damage to the root canal wall is caused after these procedures. Recently Edge File™ XR Retreatment Ni Ti Rotary Files has been introduced which can be used both in reciprocating and rotary motors. So far no studies have evaluated the propensity of R Endo and Edge File re-treatment files for causing dentinal defects in comparison with Pro Taper R and Mtwo. The aim of this study was to evaluate and compare the formation of dentinal cracks caused by Pro Taper R, M two, R Endo and Edge File XR Ni Ti retreatment files.

Materials and methods

Ninety extracted single-rooted mandibular premolar teeth with straight canals, mature apices and without any cracks were selected for this study. The teeth were extracted for orthodontic reasons and were free of dental caries. Teeth were washed with 5.25% sodium hypochlorite and stored in 0.9% w/v saline solution. The teeth were stored in 10% formalin solution until they were used for the study. Teeth were decoronated at cementoenamel junction under water irrigation to obtain a standardized root length of 16 mm. A #10 K-file was introduced into the canal to check patency and then retracted 1 mm to establish the working length. Disposable sample collection tubes were loaded with medium-body, vinyl-polysiloxane (VPS) impression material (Coltene) andthe root samples were secured in it. All samples were then mounted on a customized marble jig to upright them and subsequently instrumented with 15 and 20 ISO size K-files (Dentsply Maillefer) to previously determined working length for creating a glide path. Chemo mechanical preparation was completed with ProTaper Universal rotary instruments (Dentsply Maillefer) by using a torque control motor (X-smart, Dentsply Maillefer) up to master apical file F3. Root canals were irrigated using 2 mL of 5.25% NaOCl between all instrument changes. The smear layer was removed by irrigation with 10 mL of 5.25% NaOCl, then with 10 mL of 17% EDTA, then with 10 mL of 5.25% NaOCl. Resino Seal sealer was introduced into the canal by means of a lentulospiral. Standardized F3 guttapercha cones were coated with sealer and placed into the root canal to the working length. The roots were re-examined for defects under a stereomicroscope; no visible external defects were detected. The specimens were then stored at 37^0C in 100% humidity for 2 weeks to allow for the complete setting of the sealers. Samples were mounted on a customised jig and guttapercha removal is carried out by rotary NiTi in a torque and speed-controlled motor (X-Smart Plus, Dentsply Maillefer) at the torque and speed recommended by the manufacturer for each specific system used in presence of a solvent RC solve. Samples were randomly divided into 4 groups each composed of 10 teeth viz; Group 1: ProTaper Universal retreatment files (n=20), Group 2: MTwo (n=20), Group 3: R Endo (n=20) and Group 4: Edge file XR NiTi files (n=20). Ten teeth were left as negative controls without doing any further procedure on them.

Group 1: Pro Taper R Universal retreatment file group. Canals were instrumented in a crown-down sequence using Pro Taper D1 file (0.09/0.30mm) to remove filling material from the coronal third of the canals. Middle and apical thirds of the canals were instrumented using ProTaper D2 (0.08/0.25mm) and ProTaper D3 (0.07/0.20mm) files respectively in brushing action. 5mL of 2.5% NaOCl was used after each instrument followed by a final rinse of 5mL saline. After reaching the working length, root canals were reshaped using S1, S2, F1, F2 and F3, respectively.

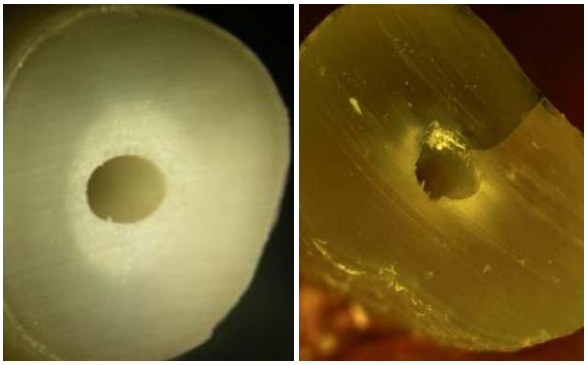
Group 2: Mtwo retreatment group. Mtwo R2 25/0.05 was used to empty the coronal and middle thirds of the root. Mtwo R 15/0.05 was used to reach the working length. Mtwo R files were used at a speed of 280 rpm and a torque of 1.2 Ncm and a brushing action was performed against the canal walls in a crown-down direction until the working length was reached. Final apical preparation was then performed using Mtwo file (size40, 0.04taper) at a speed of 280 rpm and a torque of 1.6 Ncm.

Group 3: R-Endo retreatment group. Re to remove the first 2-3 mm of the filling. R1 and R2 used to one third and two thirds of the working length. R3 and Rs used at the working length with a circumferential filing movement from the apical third to the coronal third. The final apical preparation was performed with a Hero 642 (Micro-Mega) instrument (size 40, 0.02 taper) at the working length at a speed of 350 rpm and a torque of 1.6 Ncm.

Group 4: Edge File XR retreatment file group. Flood the chamber with a root filling solvent. Keeping the chamber flooded, we used the following crown-down sequence: R1 (25/12) to R2 (25/08) to R3 (25/06) then to R4 (25/04). Using light medium pressure R4 is taken up to working length.
The retreatment procedure was considered complete when no gutta-percha or sealer was detected on the instrument surfaces or inside the root canal or dentinal walls.

Microscopic Observation

All roots were horizontally sectioned at 2 and 6 mm from the apex with a diamond disc under water cooling. Digital images of each section were captured at 20X magnification using a digital camera attached to a stereomicroscope (Olympus, Japan). Only two distinct categories were established as ‘‘no defect’’ and ‘‘defect’’ Roots were classified as defective if at least 1 of the 2 sections showed either a craze line, partial crack, or fracture. No defect was defined as root dentin devoid of any lines or cracks where both the external surface of the root and the internal root canal wall had no defects. Defects were defined as all lines observed on the slice that extended either from the outer surface into the dentin or from the root canal lumen to the dentin.



Representative images of no defect and defect

Statistical analysis

The incidence of dentinal defects between the groups was analysed by using the Pearson Chi-Square test at a significance level of $P<.001$. All statistical analyses were performed with SPSS version 13.0 for Windows.

Results

The number of roots with defects in each group is shown in Table 1.The unprepared canals had no defects, but defects were found in all other groups. Qualitative analysis showed the presence of dentinal micro cracks in 65% (n =12), 45% (n =9), 20% (n =4), and 20% (n =4) of the cross-section images in groups 1 (ProTaper R), 2 (Mtwo), 3(R Endo) and 4 (Edge File) respectively. There was a significant difference between the filled but unretreated group (control group) and between ProTaper R and all retreatment groups ($P<.001$); however, no difference was detected between retreatment groups ($P > .001$). Fractures were observed in all retreatment groups.

Table 1: The number of teeth in which defects were observed on any of two horizontal sections or both.

Group	n	At 2mm from apex	At 6mm from apex	Total
Group 1.ProTaper R	20	10	3	13
Group 2.Mtwo	20	7	2	9
Group 3.R Endo	20	3	1	4
Group 4. Edge File	20	4	0	4
Control Group	10	1	0	1

In this study, although cracks were observed in both levels, the number of teeth with cross-sectional cracks was 3 times higher at apical (2mm) level (Table 1).

Figure 1. Shows graphically the number of teeth presenting dentinal defects after retreatment procedures. Groups with different letters are statistically different at $P<.001$.

Discussion

The success rate of retreatment has been shown to be in the range of 80% healing. Yoldas *et al* indicated that root canal preparation with NiTi rotary systems and all additional subsquent procedures in endodontics, such as obturation and retreatment with rotary systems, can create fractures or craze lines [11]. Shemesh *et al* evaluated the incidence of dentinal defects after root filling with lateral compaction and passive compaction techniques. They observed a higher defect incidence in teeth filled with lateral compaction than in teeth that were filled by using passive compaction technique. Therefore here passive compaction technique was used [12]. A solvent was used to remove guttapercha as solvents aid in faster and easier filling removal [13]. In the present study, RC solve was selected as a solvent because it is known to be efficient for dissolving gutta-percha. Amongst rotary systems, ProTaper and Rendo retreatment rotary files were selected for our study as they have proved to be effective in guttapercha removal [14, 15]. And for comparison we choose recently introduced files Mtwo and Edge File. Each root was sectioned at 2mm and 6mm from apex. This sectioning method enabled direct inspection of the root canal wall at apical third and cervical level of the root, observing not only cracks, but also fracture lines [12]. In the current study, an optical stereomicroscope was used to visualize the defects in dentinal wall [18]. The results of current study show that defects were found in all groups but incidence of defects caused by Protaper R is higher than other retreatment files. Results of the current study showed that there is statistically significant difference in the appearance of defects when ProTaper R is compared with all the other groups. Also when comparison was done within the group there was significant difference between defects at apical and cervical level. These observations are in concordance with the studies done by Rui L *et al*, Bier CA *et al* [17, 18]. These results indicate that ProTaper R causes maximum dentinal defects. But results of our study are opposite to that of Huseyin S T *et al* and Gadhiya D *et al* [16, 19]. It has been reported that taper of the files could be a contributing factor in the generation of dentinal defects because of increased stress on the canal walls caused by the tapered files. The results of this study show there is a correlation between NiTi retreatment file design or taper type and incidence of dentinal defects as shown by Bier *et al*. because increased taper may cause more removal of tooth structure, leading to more defects [20].

Conclusion

Within the limitations of this *in vitro* study we conclude that all rotary NiTi retreatment files cause dentinal defects but incidence is more for ProTaper R and Mtwo retreatment files and Edge Endo file is a safer alternative during endodontic retreatment.

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