



THE EFFECT OF ROOT CANAL PREPARATION BY THREE DIFFERENT NITI FILE SYSTEMS ON DEVELOPMENT OF DENTINAL MICRO CRACKS.

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ABSTRACT

Cleaning and shaping with NiTi files has been shown to be associated with an increased incidence of dentinal micro cracks. There is no definitive perspective on whether small dentinal cracks can lead to root fracture. The present study was taken with the aim of evaluating root micro cracks caused by the different NiTi rotary systems such as ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) ProTaper Next, Wave One Gold and Diaket. Hundred human premolars extracted teeth for orthodontic reasons were divided into five groups of 20 each. Samples in each of the groups were instrumented with the given files and one group was left as control. Roots were sectioned horizontally at 2 mm, 4 mm, and 6 mm from the apex. Images of each section were captured at 20X magnification using a digital camera attached to stereomicroscope. Only two distinct categories were established as "no defect" and "defect". The incidence of dentinal defects between the groups was analysed by using the Pearson Chi-Square test at a significance level of $P < .001$. Results of this study show that differences have been found between NiTi rotary systems with regard to induction of dentinal micro cracks and also in relation to the specific third of the root (apical, middle or coronal) affected. Protaper Universal has been found to cause maximum dentinal micro cracks with maximum at apical third of roots. Wave One Gold causes very less micro cracks in dentin.

Keywords: NiTi, Dentsply Maillefer, Ballaigues

Introduction:

Vertical root fractures particularly in endodontically treated teeth are an on-going concern because of their high prevalence. The incidence of vertical root fractures is often hard to determine and they are very often connected with the incidence of dentinal defects or micro cracks. It is proposed that cleaning and shaping of the canals damages the root dentin which becomes a gateway to dentinal cracks and minute intricate fractures which may potentially develop into vertical root fracture, thereby causing failure of the

treatment.^{1,2} To state or deny any possible connection between such defect production and the eventual production of vertical root fracture needs to be investigated thoroughly. Several studies have reported a causal relationship between mechanical preparation of the root canal with nickel-titanium (NiTi) instruments and the formation of dentinal micro-cracks.³⁻⁶ There is no definitive perspective on whether small dentinal cracks can lead to root fracture⁷, however, these damages must be prevented as much as possible.^{8, 9} The incidence of micro cracks caused by instrumentation with these NiTi

rotary files have been found to be 12% to 60% by various studies.^{10, 11} It is proposed that the design, high taper and the high cutting ability of the new NiTi files are the main reasons associated with the development of dentinal defects, because they might generate damaging forces toward dentin.¹² To counter the drawbacks of the stainless steel instruments, various companies have come up with various endodontic instruments with enhanced flexibility and superior resistance to torsion fracture. There are no data in the literature on the comparative evaluation of different NiTi rotary systems such as ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next, Wave One Gold and Super Blue Files by Diaket on incidence of root micro cracks. ProTaper universal (Dentsply, Maillefer, Switzerland) rotary files are popular files for endodontic treatment with increased taper, thus they have active cutting motion and ultimately remove more dentin of coronal areas compared to other systems. Recently Dentsply introduced ProTaper Next for preparation of canals. ProTaper Next (PTN) shaping files have an off-centred rectangular design and progressive and regressive percentage tapers on a single file and are made from memory wire (M-wire) technology that has more flexibility and cyclic fatigue resistance. The constant demand for reduction of operators' fatigue and treatment time, has led to the appearance of the single-file techniques. The WaveOne Gold (Dentsply Sirona Endodontics, Ballaigues, Switzerland) is a single-file reciprocating system manufactured using M-Wire technology, improving strength and resistance to cyclic fatigue by up to nearly four times in comparison with other brands of rotary NiTi files. These are used in reciprocating motion. It is assumed that the alternating counter clockwise and clockwise movement decreases the stress on the instrument.

Materials and methodology

In this experimental study hundred human premolars extracted teeth for orthodontic reasons were selected were selected. After selecting the teeth, the root surfaces were cleaned and specimens were placed in sodium

hypochlorite 2.5% for 10 minutes for disinfection. The crowns were removed 2 mm above cement-enamel junction. The working length was determined by inserting a size 15 file into the canal until tip of the file was visible. Roots were then mounted on jig secured in Hydrophilic vinyl polysiloxane impression material. X-mart Plus endomotor is used for canal preparation which is done by single operator only in all samples. Teeth were divided into five groups (n = 20).

1. Group 1 – cleaning and shaping done with ProTaper Universal files: Sx file was used to enlarge the coronal portion of the canal, and then, all files were used till the WL: S1 S2 F1 F2 F3 F4. The first two shaping files were used with a torque of 1.5 N.cm in a brushing motion along the root canal walls away from the root concavities before light resistance was encountered. The last four finishing files were used until the WL was reached with a torque of 2.5 N.cm.

2. Group 2 – cleaning and shaping done with ProTaper Next files: The ProTaper Next files were used in the sequence ProTaper Universal SX for coronal flaring and then ProTaper Next X1 (17/.04), X2 (25/.06) till the full WL for root canal shaping. Then X3 (30/.07) and X4 (40/.07) were also used till full WL for root canal finishing. All these files were used at a rotational speed of 300 rpm and 2.5 N.cm torque.

3. Group 3 – cleaning and shaping done with Super Blue Files from Diaket files: The configuration of Diaket files is same as Protaper Universal. Preparation is done up to F4 as master apical file.

4. Group 4 – cleaning and shaping done with Wave One Gold files: The WaveOne Large file is used in large canals. The tip size is ISO 40 with an apical taper of 8% that reduces towards the coronal end.

5. Group 5 – Left untreated (negative control group)

Each instrument was replaced after preparing four canals. Each canal was irrigated with 5% solution of sodium hypochlorite between each

instrument by using a syringe and a 30 gauge needle.

Stereomicroscopic Examination of roots:

Roots were sectioned horizontally at 2 mm, 4 mm, and 6 mm from the apex with a low speed saw 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.



Figure 1: Showing representative images of different groups

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.

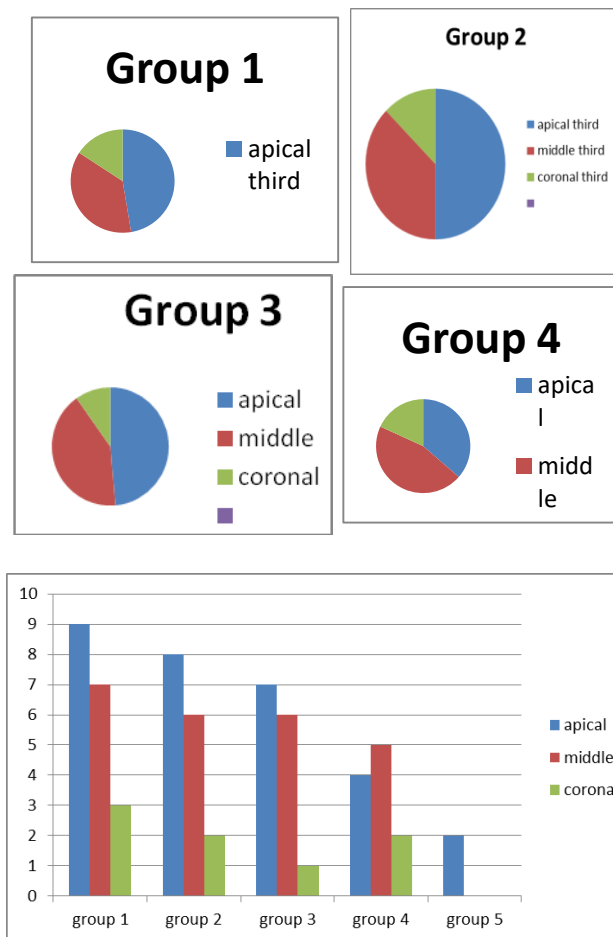
Results

In the apical third, Group 1 shows maximum number of defects/microcracks while Group 2 and 3 shows lesser number, Group 4 exhibits the least, [Table 1]. Group 5 shows least incidence of defects in apical third among all groups. In the middle third again, Group 1 shows maximum number of defects/

microcracks cases while Group 2 and Group 4 showed lesser number of cracks/fractures and Group 3 showed the least and Group 5 did not show any fracture cases. In the cervical third again, Group 1 shows maximum number of defects/microcracks cases while Group 2 and Group 4 showed lesser number of cracks/fractures and Group 3 showed the least and Group 5 did not show any fracture cases. In all of the groups maximum number of fracture cases was found in the apical third followed by equal number of fracture cases in the cervical third and the middle third. Comparison of results is shown by the graphical representation in graph 1.

Table 1: The number of teeth in which defects were observed.

Groups	Sample size (n)	At 3mm from apex (apical third)	At 6mm from apex (middle third)	At 9mm from apex (coronal third)	total
Group 1	20	9 (48.7)	7 (42.1)	3 (13.6)	19
Group 2	20	8(51.5)	6(33.2)	2(16.6)	15
Group 3	20	7(48.4)	6(34.1)	1(14.6)	14
Group 4	20	4(38.4)	5(41.4)	2(12.4)	11
Group 5	20	2(41.3)	0(0.0)	0(0.0)	2



Graph 1: Showing comparison between different groups

Discussion

Rotary instrumentation when compared with hand instrumentation remove more dentin because of greater friction and higher taper resulting in higher number of craze lines. Bier et al. also suggested that fractures did not occur immediately after canal preparation. However, craze lines occurred in 4%–16%, which may develop into fractures.^{13,14,15} The tip design, design of cutting blade, cross-sectional geometry, tip configuration, taper (constant vs. progressive), pitch (constant vs. variable) and flute form of various rotary instruments affect their cutting efficacy and hence propensity for micro crack formation.^{16,17,18} ProTaper universal files are most commonly used world-wide because of their aggressive preparations. Recently single file systems as well as NiTi instruments manufactured from M-wire were introduced. ProTaper NEXT and WaveOne Gold are manufactured with M-wire. Wave One Gold file has an offset parallelogram cross-section with alternating touches on the dentin with 2

edges apically and 1 coronally during a 360° rotation. The choice of the wave one single-file, reciprocating systems in the present study was made on the basis of claims that this type of kinematics is safer than the full-sequence rotary instrumentation.^{19,20} Dentmark has introduced Super Blue NiTi files with design specifications similar to ProTaper. This has been introduced as a cheaper alternative to reciproc blue with advantages claiming of protaper, hence it seems reasonable to check its safety for dentinal cutting. So the present study was taken with the purpose of investigating the effect of these nickel titanium rotary instrumentation on root dentine, by recording the appearance of dentine damage, whether it be a defect, micro crack, crack, craze line or fracture. Any of the defects is represented as a micro crack and irrespective of number of micro cracks root cross section is represented as defect or no defect. As the defects observed in control group are statistically insignificant, it was assumed that

sectioning does not introduce dentinal defects. According to the results of this study, the incidence of cracks was observed in all studied preparation systems and in apical, median and coronal sections from the apex. Results of our study show that ProTaper F4 file caused higher incidence of damage observed in this group as compared to any other group which is on similar lines with the study done by Rahman et al. and Liu et al.^{21,22} The higher incidence of fractures at apical third can be explained by higher stresses generated due to progressive taper of these files. These results are in concordance to results of Irina et al.²³ The results of this study show there is a correlation between NiTi treatment 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.²⁴ Even though this in vitro study did not reproduce the complete clinical scenario, it confirmed that all the NiTi rotary instrumentation systems studied resulted in dentine damage to varying degrees.

Conclusion

Within the limitations of this study differences have been found between NiTi rotary systems with regard to induction of dentinal micro cracks and also in relation to the specific third of the root (apical, middle or coronal) affected. Protaper Universal has been found to cause maximum dentinal micro cracks with maximum at apical third of roots. Wave One Gold causes very less micro cracks in dentin.

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