Comparative Evaluation of Dentinal Defects Induced by Hand Files, HyFlex, ProTaper Next and One Shape During Canal Preparation: A Stereomicroscopic Study

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Abstract

Aim: This study aims to evaluate and compare the incidence of dentinal defects induced by Hand Files, HyFlex CM, ProTaper Next (PTN), and One Shape during canal preparation. **Materials and Methods:** One hundred and fifty extracted mandibular premolar teeth with single root canal were selected. Specimens were then divided into five groups with thirty specimens each. Group I: Specimens were prepared with hand instruments. Group II: Specimens were prepared with HyFlex CM rotary files (Coltene) using a crown-down technique according to the manufacturer's instructions. Group III: Specimens were prepared with PTN rotary files (Dentsply) using a crown-down technique according to the manufacturer's instructions. Group IV: Specimens were prepared with One Shape Single file rotary system (MicroMega) using a crown-down technique according to the manufacturer's instructions. Group V: Specimens were used as a control and left unprepared. All roots were cut horizontally at 3, 6, and 9 mm from the apex. Sections were then viewed under stereomicroscope and dentinal defects were registered as "no defect," "fracture," and "other defects." **Statistical Analysis:** Results of the study were subjected to Chi-square test. **Results:** Results were expressed as the number and percentage of defected, partially defected and roots with no defects in each groups. **Conclusion:** Hand files and One Shape file system caused less root defects compared to PTN and HyFlex file systems.

Keywords: *Canal preparation, dentinal defects, Hand files, HyFlex CM, One Shape, ProTaper Next*

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Introduction

The aim of endodontics is to achieve a three-dimensional flawless seal of the root canal system. Perfect designing of the canal diameter and canal form that allows us to conquer this objective is of prime importance. 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 thereby failure of treatment.

It has been seen that these dentinal cracks and minute intricate fractures could later propagate into vertical root fracture (VRF) if the tooth is subjected to repeated stresses from endodontic or restorative procedures. Indeed, evidence of recent years concentrate on the findings that VRFs are probably caused by a propagation of smaller, less pronounced defects and not by force practiced during preparation or obturation.[1,2]

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An increasing number of rotary nickel-titanium (NiTi) file systems have been marketed by various manufacturers. These systems differ from one another in the design of the cutting blades, body taper, and tip configuration. Despite the obvious clinical advantages of these techniques over hand instrumentation, the influence of the design of the cutting blades is still controversial[3,4] and could generate increased friction and stresses within the root canal.[5] Rotary instrumentation requires less time to prepare canals as compared with hand instrumentation but result in significantly more rotations of the instruments inside the canal.[6] This may cause more friction between the files and the canal walls.

To cater the higher expectations of dentist and for the long-term success of root canal treatment newer and newer systems are being developed.

Whether it is rotary, Hand files or single file rotary system, they are assumed to cause limited frictional forces within the canal, hence creating dentinal defects. Hence, there is a need to study the effect of different file systems on root dentin after endodontic preparations.

Hence, the purpose of the study was to compare and evaluate dentinal defects between Hand files, HyFlex, ProTaper Next (PTN) and One Shape file systems using a stereomicroscope.

Materials and Methods

Totally, 150 extracted mandibular premolar teeth with single and straight canals (5°–20°) were selected and stored in normal saline.

The coronal portion of the teeth was sectioned using carborundum disc in micromotor with continuous water cooling, leaving the roots 16 mm in length.

All the roots were observed with a stereomicroscope with ×20 magnification to exclude any cracks.

The cemental surface of the root was coated with light body impression material and embedded into the acrylic blocks to simulate the periodontal ligament and avoid the external reinforcement. Then the specimens were divided as follows:

- Group I: Thirty specimens were prepared with hand instruments. The initial length was determined by placing #10 file into the canal until it penetrated the apex. Canals were prepared using K-files up to master apical file size ISO number 25 and 3 step backs were given
- Group II: Thirty specimens were prepared with Endo Motor (X Smart Dentsply) and HyFlex CM rotary files (Coltene) using crown down technique according to the manufacturer's instructions
- Group III: Thirty specimens were prepared with Endo Motor (X Smart Dentsply) and PTN rotary files (Dentsply) using crown down technique according to the manufacturer's instructions
- Group IV: Thirty specimens were prepared with Endo Motor (X Smart Dentsply) and One Shape Single file rotary system (MicroMega) using crown down technique according to the manufacturer's instructions
- Group V: Thirty specimens were used as control and left unprepared.

In all the groups, canals were irrigated with 2.5% sodium hypochlorite (NaOCl) solution between each instrument and Glyde EDTA Gel (17%) was used during the preparation procedure. All roots were kept moist throughout the experimental procedures to prevent dehydration.

Sectioning and microscopic observations

All roots were cut horizontally at 3, 6, and 9 mm from the apex. Sections were then viewed under stereomicroscope. The appearance of dentinal defects was registered by the pictures that were taken digitally. To avoid confusing definitions of root fractures, three distinguished categories were made: "no defect," "fracture," and "other defects" [Table 1].[7] Roots were classified as "defected" if at least one of the three sections showed either a craze line, partial crack or a fracture. Results were expressed as the number and percentage of defected roots in each group.[8]

Statistical analysis

The presence and absence of dentinal defects in each group were compared using Chi-square test. Any difference of $P < 0.05$ was considered as statistically significant.

Results

Root defects were classified as "no defect, other defects and complete cracks" [Table 1].[7,8]

The Hand files and One Shape file systems caused lesser root defects than the PTN and HyFlex file systems [Table 2 and Graph 1]. None of the samples

Table 1: Classification of defects

No defect	Root dentin devoid of any lines or cracks where both the external surface of the root and the internal root canal wall will not be present any evident defects
Fracture	A line extending from the root canal space all the way to the outer surface of the root
Other defects	All other lines observed that will not be seem to extend from the root canal to the outer root surface (e.g. - a craze line, a line extending from the outer surface into the dentin but will not reach the canal lumen, or a partial crack, a line extending from the canal walls into the dentin without reaching the outer surface)

Table 2: Appearance of crack *Groups crosstabulation

Appearance of crack	Groups					Total
	Control	Hand files	HyFlex CM	One shape	ProTaper next	
No crack	90	63	36	63	27	279
	100.0%	70.0%	40.0%	70.0%	30.0%	62.0%
Other defects (craze lines and incomplete crack)	0	27	36	18	27	108
	0%	30.0%	40.0%	20.0%	30.0%	24.0%
Complete crack	0	0	18	9	36	63
	0%	0%	20.0%	10.0%	40.0%	14.0%
Total	90	90	90	90	90	450
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Chi-Square tests

	Value	Df	*P*
Pearson Chi-Square	50.403(a)	8	0.000*
Likelihood Ratio	60.854	8	0.000
N of Valid Cases	450		

in the Hand files and control groups showed complete cracks, and of the three rotary systems, maximum number of complete cracks [Figure 1] were seen with PTN system. No defects [Figure 2] were observed at 3 mm level in all of the samples except for PTN group while maximum number of craze lines and incomplete defects [Figure 3] were seen at 9 mm level.

Maximum number of complete cracks occurred at 6 mm level (29.4%) [Table 3 and Graph 2]. Table 4 shows the appearance of cracks at different measurement levels for each file system.

In PTN group, at 9 mm level, 66.7% of samples had incomplete cracks while rest 33.33% had complete cracks [Table 4].

Discussion

Hand instrumentation which was the milestone of endodontic practice in the past though has lost its popularity, still remains integral part of canal preparation. In the last decades, many new NiTi rotary instruments have been developed and introduced by various manufacturers. Most clinicians prefer these systems because of their advantages such as saving time and better cutting efficiency. Nevertheless, some functions of NiTi rotary systems such as cleaning ability increased stress, and the inability to adequately prepare oval canals are still controversial. In addition, Kim *et al*. have found a potential relationship between the design of NiTi instruments and the incidence of VRFs. They concluded that file design affected apical stress and strain concentrations during root canal instrumentation.[9]

When NiTi rotary instruments are used, a rotational force is applied to root canal walls. Thus, they can create microcracks or craze lines in root dentin. The extent of such a defect formation may be related to the tip design, cross-section geometry, constant or progressive taper type, constant or variable pitch, and flute form.[10]

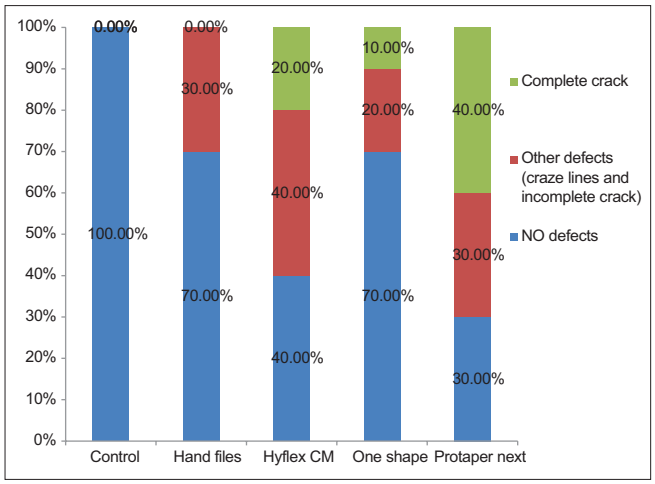
Mandibular premolars were selected for the study because of the high prevalence of VRF as reported by Tamse *et al*.[11] It was also reported that occlusal load on mandibular premolars during chewing is three times as high as the other teeth.[12]

Rotary instrumentation requires less time to prepare canals as compared with hand instrumentation but result in significantly more rotations of the instruments inside the canal. This may cause more friction between the files and the canal walls.[6]

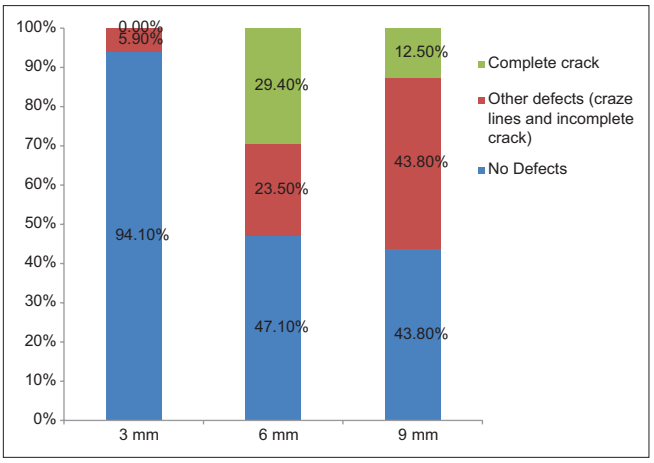
File design is also likely to affect the shaping forces on the root dentin. Forces generated during instrumentation have been linked to an increased risk of root fracture. During preparation, a canal is shaped by the contact between instrument and dentin walls. These contacts create many momentary stress concentrations in dentin. Such stress concentrations may leave dentinal defects in which VRF can initiate. Higher stresses in the root during instrumentation can be expected to increase dentinal defects and thus increase VRF risk.

PTN file is the newest innovation to the ProTaper® Universal system, which has been the gold standard in endodontics for many years. It has M-wire technology with an off-centered rectangular cross-section, giving the file a snake-like swaggering movement as it moves along the root canal, thus reducing the screw effect, the unwanted taper lock, and torque on any of the given file; thus decreasing the file root dentin contact. However, HyFlex® CM™ (Coltene) NiTi files have been manufactured utilizing a unique process that controls the material's memory, making the files extremely flexible but without the shape memory of other NiTi files. This gives the file the ability to follow the anatomy of the canal very closely, reducing the risk of ledging, transportation, or perforation.

In the present study, the size of the file was kept 25 with. 06 taper for all the rotary groups except HyFlex



Graph 1: the total percentage of defects and no defects with each group



Graph 2: the total percentage of defects and no defects at each level

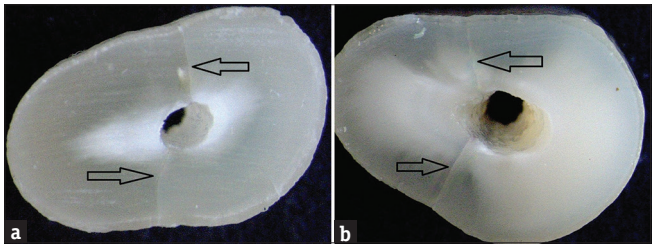


Figure 1: (a and b) complete crack

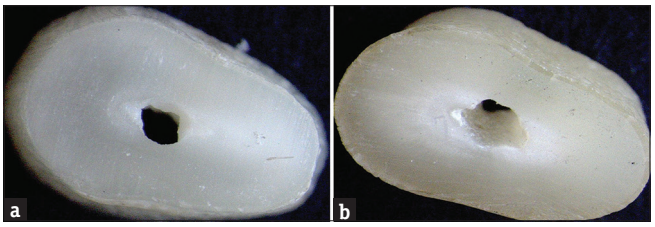


Figure 2: (a and b) no defects

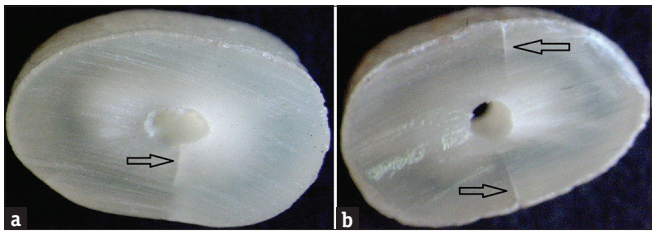


Figure 3: (a and b) other defects

Table 3: Appearance of crack *Measurement level crosstabulation

Appearance of crack	Measurement level			Total
	3 mm	6 mm	9 mm	
No crack	144	71	65	280
	94.1%	47.1%	43.8%	62.0%
Other defects (craze lines and incomplete crack)	6	35	67	108
	5.9%	23.5%	43.8%	24.0%
Complete crack	0	44	18	62
	0%	29.4%	12.5%	14.0%
Total	150	150	150	450
	100.0%	100.0%	100.0%	100.0%

Chi-Square tests

	Value	df	*P*
Pearson Chi-Square	43.551(a)	4	0.000*
Likelihood Ratio	49.410	4	0.000
N of Valid Cases	450		

in which the taper was. 04. The taper of the preparation could be a contributing factor in the generation of dentinal defects. Wilcox *et al*. concluded that the more root dentin that is removed the more likely a root is to fracture. Therefore, it may be concluded that PTN showed more number of complete cracks than HyFlex files but the difference was statistically insignificant.[8]

One Shape files (Micro-Mega, Besancon Cedex, France), one of the single-file systems introduced in the NiTi instrument family, are used in a traditional continuous rotation motion. They have a triangle cutting edge in the apical part, 2 cutting edges in the coronal part, and a cross-section that progressively changes from 3 to 2 cutting edges between the apical and coronal parts; this design offers an optimal cutting action. Therefore, it caused less damage than the HyFlex and the (PTN) system where the files were sequentially used. This is in agreement with previous reports that showed that more manipulations in the canal resulted in the accumulation of damage.[13]

The present study showed a significant difference between all the three levels, i.e., 9 mm, 6 mm and 3 mm. Maximum number of defects were seen at 6 mm level followed by 9 mm and least at 3 mm. In 2013, Liu *et al*.[14] reported that during the instrumentation procedure, the stresses generated at 1 mm short of the Apical Foramen were merely one-third of the stress at more coronal levels. Although cracks were observed in all 4 different levels,

Table 4: Groups *Appearance of crack *Measurement level

Measurement level	Groups	Appearance of crack			Total	Chi-square value	*P*
		No crack	Other defects (craze lines and incomplete crack)	Complete crack			
3 mm	Control	30	0	0	30	29.875	0.005*
		100.0%	0.0%	0.0%	100.0%		
	Hand files	30	0	0	30		
		100.0%	0.0%	0.0%	100.0%		
	Hyflex CM	30	0	0	30		
		100.0%	0.0%	0.0%	100.0%		
	One shape	30	0	0	30		
		100.0%	0.0%	0.0%	100.0%		
	Protaper next	24	6	0	30		
		80.0%	20.0%	0.0%	100.0%		
	Total	144	6	0	150		
		94.1%	5.9%	0.0%	100.0%		
6 mm	Control	30	0	0	30	56.394	0.000*
		100.0%	0.0%	0.0%	100.0%		
	Hand files	15	15	0	30		
		50.0%	50.0%	0.0%	100.0%		
	Hyflex CM	0	10	20	30		
		0.0%	33.3%	66.7%	100.0%		
	One shape	20	10	0	30		
		66.7%	33.3%	0.0%	100.0%		
	Protaper next	6	0	24	30		
		20.0%	0.0%	75.0%	100.0%		
	Total	71	35	44	150		
		47.3%	23.3%	29.4%	100.0%		
9 mm	Control	30	0	0	30	43.286	0.000*
		100.0%	0.0%	0.0%	100.0%		
	Hand files	20	10	0	30		
		66.7%	33.3%	0.0%	100.0%		
	Hyflex CM	0	30	0	30		
		0.0%	100.0%	0.0%	100.0%		
	One shape	15	7	8	30		
		50.0%	23.3%	26.7%	100.0%		
	Protaper next	0	20	10	30		
		0.0%	66.7%	33.3%	100.0%		
	Total	65	67	18	150		
		43.3%	44.7%	12.0%	100.0%		

the number of teeth with cracks in coronal levels were 3 times as much as that with apical surface cracks.

The use of different speed and torque settings for each file system could be a limitation of the present study. Peters stated that increased rotational speed was associated with increased cutting efficiency.[15]

Although fractures may be considered more important, we should not ignore the importance of other defects. They may propagate into complete fractures over time as a result of stresses produced during functional loadings or dental procedures.

Even though this was an *in vitro* study, in agreement with the previous studies, we can conclude that NiTi instruments tend to induce various degrees of dentinal damage during root canal preparation. On the other hand, hand instrumentation showed satisfactory results with no microcrack defects.[16]

Conclusion

Under the conditions in this study, the Hand files and One Shape file systems caused less root defects than the PTN and HyFlex file systems.

To the best of our knowledge, there are no data in the literature about the influence of the NiTi rotary files used in this study on the occurrence of root canal wall cracks. Therefore, more studies are required for complete research.

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Conflicts of interest

There are no conflicts of interest.

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