



**THE INCIDENCE OF DENTINAL MICROCRACKS CAUSED BY  
HAND VERSUS DIFFERENT ROTARY INSTRUMENTS AFTER  
BIOMECHANICAL PREPARATION: AN IN VITRO STUDY**

**Dr. Neetu Jindal<sup>1\*</sup>, Dr. Rubal Khetan<sup>2</sup>, Dr. Yogesh Kumar<sup>3</sup>, Dr. Renu Aggarwal<sup>4</sup> and  
Dr. Kanika Aggarwal<sup>5</sup>**

<sup>1</sup>Professor Department of Conservative Dentistry & Endodontics Surendera Dental College and Research Institute, Sri Ganganagar.

<sup>2</sup>Post Graduate Student Department of Conservative Dentistry & Endodontics Surendera Dental College and Research Institute, Sri Ganganagar.

<sup>3</sup>Director Principal and H.O.D Department of Conservative Dentistry & Endodontics Surendera Dental College and Research Institute, Sri Ganganagar.

<sup>4</sup>Reader Department of Conservative Dentistry & Endodontics Surendera Dental College and Research Institute, Sri Ganganagar.

<sup>5</sup>Senior Lecturer Department of Conservative Dentistry & Endodontics Surendera Dental College and Research Institute, Sri Ganganagar.

Article Received on 22/01/2016

Article Revised on 12/02/2016

Article Accepted on 03/03/2016

**\*Corresponding Author**

**Dr. Neetu Jindal**

Professor Department of  
Conservative Dentistry &  
Endodontics Surendera  
Dental College and  
Research Institute, Sri  
Ganganagar.

**ABSTRACT**

**Introduction:** The objective of this study was to evaluate the behaviour of different stainless steel and NiTi instruments on root canal dentin. **Materials and Methods:** Fifty single-rooted premolars were selected. All specimens were decoronated and divided into one control and four experimental groups, each group having 10 samples. Group I is control group, Group II: Hand K-files (Mani), Group III: Pro Taper Universal (PT; Dentsply Maillefer), Group IV: Mtwo

(VDW, Munich, Germany), and Group V: Hyflex (Coltene-Whaledent, Allstetten, Switzerland). Roots of each sample were sectioned at 3, 6, and 9mm from the apex and were then viewed under a stereomicroscope to evaluate the presence or absence of dentinal defects.

**Results:** In roots prepared with hand files (HFs) showed lowest percentage of dentinal defects than all the experimental rotary systems. The data was statistically analysed.

**Conclusion:** Within the limitations of this in vitro study, some endodontic preparation methods might damage the root and induce dentinal defects.

**KEYWORDS:** Dentinal defects; hand files, Microcracks, Protaper Universal, Mtwo, Hyflex.

## INTRODUCTION

The aim of endodontics is a three-dimensional unblemished seal of the root canal system which is achieved by perfect designing of the canal diameter and canal form. The biomechanical preparation is one of the major step for removal of bacteria and debris from the root canal to achieve a successful endodontic treatment.<sup>[1,2]</sup> During root canal instrumentation there are complications such as perforations, ledge formation, transportation of canal, and formation of cracks in the root dentin.<sup>[3,4]</sup>

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, causing failure of treatment.<sup>[5,6]</sup> As a result of craze lines or microcracks, there might be occurrence of root fracture that propagates due to repeated application of stress by the occlusal forces.<sup>[7,8]</sup>

Traditionally, root canal preparation was carried out by stainless steel endodontic files. Although these instruments are stiff and more resistant to fracture but sometimes during root canal instrumentation of curved canals, dentists might end up in complications such as perforations, ledge formation, transportation of canal and formation of microcracks in the root dentin.<sup>[3,4]</sup>

In recent years, advances in rotary nickel-titanium (NiTi) instruments have led to new designs and techniques of root canal preparation that overcome the complications which are seen with stainless steel instruments. But rotary instrument by its innate behaviour in the canal may result in more friction, which may increase dentinal defects and microcracks formation in comparison to hand instruments.<sup>[9,10]</sup>

So there is need to study the behaviour of different stainless steel and NiTi instruments on root canal dentin. The aim of this in vitro study was to evaluate the incidence of dentinal microcracks caused by Hand versus different rotary instruments (Protaper Universal, Mtwo and Hyflex file systems) after biomechanical preparation.

## MATERIALS AND METHOD

Fifty single-rooted premolars were selected (figure 1) and stored in distilled water. Teeth with curved roots, calcified canals, extracanals, and teeth with developmental anomaly or resorption were excluded from the study by taking pre- operative radiograph.

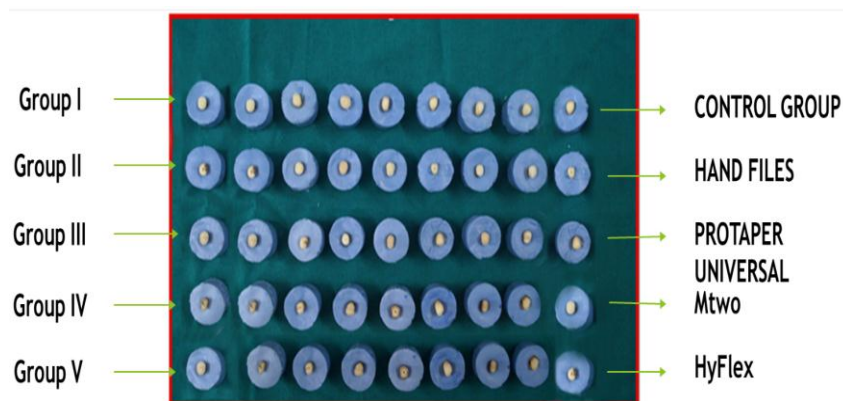


**Figure 1. Fifty Mandibular Premolars.**

The teeth were decoronated at coronal portions by using a diamond disc, leaving roots approximately of 15mm in length. After decoronating the samples, roots were again inspected with transmitted light for detecting any cracks or craze-lines by using a stereomicroscope under 45X.

A silicon impression material was used to coat the surface of roots to simulate periodontal ligament space. Therefore, 8mm of tooth is embedded in silicone mould and leaving 7 mm tooth structure coronally.

Then 50 samples were divided into five groups; each group contains 10 samples. (figure 2).



**Figure 2. Division of Samples.**

Patency of the canals were established using a #10 K-File. The working length of the canals were determined by inserting 15 no. K- file.

The root canals were irrigated with 2.5% sodium hypochlorite solution after each instrumentation. All the samples were biomechanically prepared except control group.

In all the experimental groups, biomechanical preparation was done by hand and rotary file systems till #30 file. In rotary file systems preparation of the canals was done by using speed and torque controlled endo-motor (X-SMART; Dentsply, Maillefer). The root canal shaping procedures were performed according to the manufacturer's instructions for each instrument system. After preparation, final rinse of all the samples were done with 5 mL of normal saline. To evaluate the incidence of microcracks, sectioning of all the roots were done perpendicular to the long axis at 3, 6, and 9 mm using a diamond disc under water coolant.

To rule out the dentinal defects whether these are.

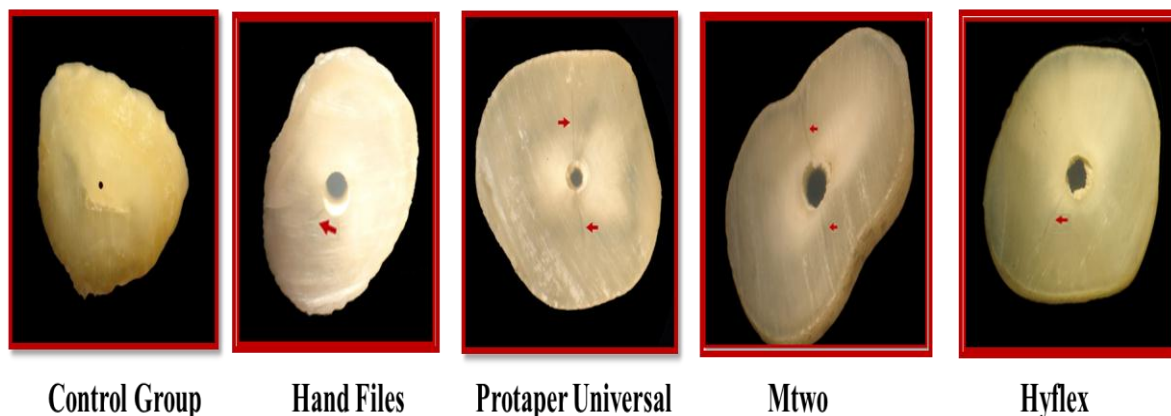
### 1. No Crack

Root dentin devoid of any lines or cracks where both the external surface of the root and the internal root canal wall will not present any evident defects.

### 2. Crack

All lines observed on the section that extended either from the outer root surface into the dentin or from the root canal lumen to the dentin. This also included teeth with a complete crack, which was defined as a line extending from the inner root canal space all the way to the outer surface of the root and incomplete crack is defined as a line extending from the canal walls into the dentin without reaching the outer surface.

Digital images of presence or absence of cracks and their location were noted for all sections and were captured by using 45X stereomicroscope with digital camera. (figure 3). Pictures were blindly scored by 2 calibrated observers as crack or no crack.



**Figure 3. Stereomicroscopic images showing dentinal defects in different groups.**

## RESULTS

Results were expressed as the number and percentage of dentinal defects in roots for each group (Table1). A chi-square test was performed to compare the appearance of dentinal defects in roots between the experimental groups by using the SPSS/PC version 15 (SPSS Inc, Chicago, IL) (Table 2). The level of significance was set at 0.03.

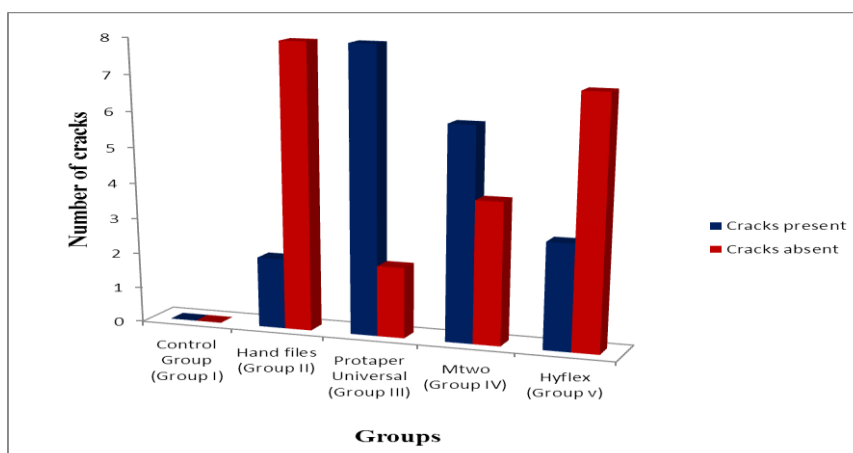
Graph 1 is a bar chart representing the number of root defects in each group. Hand files group showed lowest defect (2/10) followed by Hyflex (3/10), Mtwo (6/10) and Protaper Universal (8/10). Statistical significant difference was seen between Hand files, Protaper Universal and Mtwo groups ( $P < 0.05$ ).

**Table 1: The number of teeth with different types of dentinal defects after biomechanical preparation.**

Groups	Samples Size (N=10)	Cracks Present		Cracks Absent	% of Cracks
		Complete	Incomplete		
Control Group (Group-I)	10	0	0	0	0%
Hand Files (Group- II)	10	0	2	8	20%
Protaper Universal(Group-III)	10	4	4	2	80%
Mtwo (Group-IV)	10	2	4	4	60%
Hyflex (Group-V)	10	0	3	7	30%

**Table 2: Intra- group comparison test between different experimental groups.**

Groups	Chi square	p value
Group II vs Group III	7.2	0.007
Group II vs Group IV	3.33	0.06
Group II vs Group V	0.27	0.61
Group III vs Group IV	0.95	0.33
Group III vs Group V	5.05	0.02
Group IV vs Group V	1.82	0.18



**Graph 1: The Number of Teeth with Different Types of Dentinal Defects After Biomechanical Preparation.**

## DISCUSSION

As results showed among all the experimental groups, Hand files (Group II) showed the lowest incidence of dentinal defects because of less taper of the instruments thereby reducing the damage to root canal walls. Instrumentation with hand files did not demonstrate damage to the root canal wall. This result is also in agreement with several other studies<sup>[10,11]</sup> and could be attributed to the less aggressive movements of the hand files in the canal compared with engine-operated files.

Among experimental groups, rotary files showed maximum dentinal defects as compared to hand files. According to Yigit DH *et al*, when NiTi rotary instruments were used, a rotational force was acted on root canal walls. Thus, due to forces, microcracks or craze lines were formed in root dentin as compared to hand files. But such defects formation might be related to tip design, cross section geometry, taper type of NiTi instruments. Even the results of present study were in favour of this study.<sup>[12,13]</sup>

Pro Taper Universal (Group III) and Mtwo (Group IV) rotary files caused significantly more and complete cracks than hand files. As both groups have an active rotating movements in root canals that may result in high levels of stress concentrations on the walls and complete cracks formation.<sup>[14]</sup>

Previously, a Finite Element Analysis showed that tapered files always caused increased stress on the canal walls. Even *Bier et al* stated that the taper of the files could be a contributing factor in dentinal cracks formation. As more root dentin is removed, greater is the risk of initiating root fracture.<sup>[15,16]</sup>

Furthermore, significantly more rotations in the canal are necessary to complete a preparation with rotary NiTi files as compared with hand files.<sup>[17]</sup> This, in itself, may contribute to the formation of dentinal defects. Some of the defects seen did not connect with the pulp space. *Wilcox et al.*<sup>[18]</sup> speculated that the stresses generated from inside the root canal are transmitted through the root to the surface where they overcome the bonds holding the dentin together. *Onnink et al.*<sup>[19]</sup> speculated that a fracture contained within the dentin in one section could communicate with the canal space in an adjacent section. This was recently supported by nondestructive observations of dentinal defects induced in extracted teeth and viewed with Optical Coherence Tomography.



Among intra-groups comparison, the Protaper Universal (Group III) showed maximum dentinal defects as compared to Hyflex (Group V). The Protaper Universal finishing files (F1, F2, and F3) have more taper in apical third (0.07, 0.08, and 0.09, respectively) than HyFlex instruments (25/0.06, 30/0.06, and 40/0.04), which may explain the higher incidence of cracks observed in the Protaper Universal group.

Hy Flex file system has constant taper and is manufactured with M-wire alloy and controlled memory NiTi wire which have more flexibility than those made from conventional NiTi wire. Thus, they contributed to the small number (3/10) of cracks in this study.<sup>[20]</sup> Use of different speed and torque settings for each rotary system could be the limitation of this study. Increase in the rotational speed is associated with increased cutting efficiency and dentinal defects.<sup>[21]</sup>

## CONCLUSION

Within the limitations of this in vitro study, some endodontic preparation methods might induce the dentinal defects. The hand instruments induced minimal defects and among the rotary file systems, the use of instruments with controlled memory and constant taper induced less dentinal defects during biomechanical preparation.

## REFERENCES

1. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. *J Endod* 2004; 30: 559-67.
2. Bergmans L, Van Cleynenbreugel J, Beullens M, Wevers M, Van Meerbeek B, Lambrechts P. Smooth flexible versus active tapered shaft design using NiTi rotary instruments. *Int Endod J.*, 2002; 35: 820-8.
3. Blum JY, Machtou P, Ruddle C, Micallef JP. Analysis of mechanical preparations in extracted teeth using Pro Taper rotary instruments: Value of the safety quotient. *J Endod*, 2003; 29: 567-75.
4. Pasqualini D, Scotti N, Tamagnone L, Ellena F, Berutti E. Hand-operated and rotary Pro Taper instruments: A comparison of working time and number of rotations simulated root canals. *J Endod*, 2008; 34: 314-7.
5. Bier CA, Shemesh H, Tanomaru-Filho M, Wesselink PR, Wu MK. The ability of different nickel-titanium rotary instruments to induce dentinal damage during canal preparation. *J Endod*, 2009; 35: 236-8.
6. Kumaran P, Sivapriya E, Indhramohan J, Gopikrishna V, Savadamoorthi KS, Pradeep Kumar AR. Dentinal defects before and after rotary root canal instrumentation with three

- different obturation techniques and two obturating materials. *J Conserv Dent*, 2013; 16: 522.
7. Al-Zaka IM. The effects of canal preparation by different Niti rotary instruments and reciprocating Wave One on the incidence of dentinal defects. *M Dent J.*, 2012; 9: 137-42.
  8. Milani AS, Froughreyhani M, Rahimi S, Jafarabadi MA, Paksefat S. The effect of root canal preparation on the development of dentin cracks. *Ir Endod J.*, 2012; 7: 177-82.
  9. Schäfer E, Lau R. Comparison of cutting efficiency and instrumentation of curved canals with nickel-titanium and stainless-steel instruments. *J Endod*, 1999; 25: 427-30.
  10. Kim HC, Lee MH, Yum J, Versluis A, Lee CJ, Kim BM. Potential relationship between design of nickel-titanium rotary instruments and vertical root fracture. *J Endod*, 2010; 36: 1195-9.
  11. Souza Bier CA, Shemesh H, Tanomaru-Filho M, et al. The ability of different nickel-titanium rotary instruments to induce dentinal damage during canal preparation. *J Endod*, 2009; 35: 236–8.
  12. Al-Zaka IM. The effects of canal preparation by different Niti rotary instruments and reciprocating Wave One on the incidence of dentinal defects. *M Dent J.*, 2012; 9: 137-42.
  13. Yigit DH, Aydemir S, Yilmaz A-Evaluation of dentinal defect formation after root canal preparation with two reciprocating systems and hand instruments. *Biotec and Biotec Equipment*, 2015; 29(2): 368-373.
  14. West JD. Introduction of a new rotary endodontic system: progressively tapering files. *Dent Today*, 2001; 20: 50–2. 54–7.
  15. Bier CA, Shemesh H, Tanomaru-Filho M, et al. The ability of different nickel-titanium rotary instruments to induce dentinal damage during canal preparation. *J Endod*, 2009; 35: 236–8.
  16. Liu R, Hou BX, Wesselink PR, et al. The incidence of root microcracks caused by 3 different single-file systems versus the Pro Taper system. *J Endod*, 2013; 39: 1054–6.
  17. Pasqualini D, Scotti N, Tamagnone L, Ellena F, Berutti E. Hand-operated and rotary Pro Taper instruments: a comparison of working time and number of rotations in simulated root canals. *J Endod*, 2008; 34: 314 –7.
  18. Wilcox LR, Roskelley C, Sutton T. The relationship of root canal enlargement to finger-spreader induced vertical root fracture. *J Endod*, 1997; 23: 533– 4.
  19. Onnink PA, Davis RD, Wayman BE. An in vitro comparison of incomplete root fractures associated with three obturation techniques. *J Endod*, 1994; 20: 32–7.



20. Peters OA, Morgental RD, Schulze KA, et al. Determining cutting efficiency of nickeltitanium coronal flaring instruments used in lateral action. *Int Endod J.*, 2014; 47: 505–13.
21. Capar ID, Arslan H, Akcay M, Uysal B. Effects of protaper universal, protaper next, and hyflex instruments on crack formation in dentin. *J Endod.*, 2014; 40: 1482-4.