ORIGINAL RESEARCH

Comparative Assessment of Formation of Dentin Microcracks after Root Canal Preparation Using Hand, Rotary, and Reciprocating Instrumentation - An *In Vitro* Study

M. Amitha[1], M. S. Adarsha[2], N. Meena[3], N. Naveen Kumar[4], L. Upasana[5], N. Vathsala[6]

ABSTRACT

Introduction: It is generally accepted, there is a direct correlation between the root thickness and the ability of the tooth to resist lateral forces and avoid fracture, so the thinner the dentin, the tooth is more likely to fracture.

Aim and Objectives: This study was undertaken to compare the formation of dentinal microcracks under stereomicroscope when the following instruments: Hand K Files; ProTaper and ProTaper Next: Rotary files; and WaveOne and Reciproc systems: Reciprocating files were used to shape the root canal.

Materials and Methods: A total of 90 freshly extracted single-rooted human mandibular central incisor teeth were selected for the study that had been extracted for periodontal and/or prosthetic reasons. All roots were observed in a stereomicroscope under ×12 magnification to exclude any external defects or cracks and were discarded if any of these characteristics were found. The data arrived after evaluation of dentinal microcracks were subjected to statistical interpretation using the Chi-square test for analysis of differences between the groups at a 95% confidence level ($P < 0.05$).

Results: The number of dentinal microcracks formed by ProTaper Universal was highest ($n = 3$) followed by WaveOne ($n = 2$), ProTaper Next ($n = 1$), and Reciproc ($n = 1$), while the control group and hand K Files showed no dentinal microcracks as measured 3 mm from the root apex.

Conclusions: It is concluded that instrumentation of canals produced dentinal microcracks. Within the instrumented groups, there was a statistically significant difference found with ProTaper and WaveOne ($P = 0.025$).

[1]Private Practitioner, [2,3]Professor, [4-6]Reader

[1]Department of Conservative Dentistry and Endodontics, Bangalore, Karnataka, India

[2-4]Department of Conservative Dentistry and Endodontics, Vokkaligara Sangha Dental College, Bengaluru, Karnataka, India

[5]Deparment of Oral Medicine and Radiology, Vokkaligara Sangha Dental College, Bengaluru, Karnataka, India

[6]Department of Conservative Dentistry and Endodontics, Yogita Dental College and Hospital, Maharashtra, India

Corresponding Author: Dr. M. S. Adarsha, Department of Conservative Dentistry and Endodontics, Vokkaligara Sangha Dental College and Hospital, K.R Road, V. V Puram, Bengaluru – 04, Karnataka, India.
e-mail: adarshgowda11@gmail.com

Keywords: Dentinal microcracks, Hand instruments, Mechanical preparation, Reciprocating instruments, Rotary instruments.

How to cite this article: Amitha M, Adarsha MS, Meena N, Kumar NN, Upasana L, Vathsala N. Comparative Assessment of Formation of Dentin Microcracks after Root Canal Preparation Using Hand, Rotary, and Reciprocating Instrumentation - An *In Vitro* Study. Int J Oral Care Res 2018;6(2):S19-23

Source of support: Nil

Conflicts of interest: None

INTRODUCTION

Chemomechanical preparation of the root canal includes both mechanical instrumentation and antibacterial irrigation and is principally directed toward the elimination of microorganisms from the root canal system. From a biological perspective, mechanical instrumentation and chemical irrigation are the important contributors to a bacterial reduction in the infected root canal and the technical goals of canal preparation are directed toward shaping the canal so as to achieve the biological objectives and to facilitate placement of a high-quality root canal filling.[1] It is generally accepted that the amount of remaining dentin is directly related to the strength of the tooth and the thickness of the dentinal wall at the root circumference is critical. There is a direct correlation between the root thickness and the ability of the tooth to resist lateral forces and avoid fracture, so the thinner the dentin, the tooth is more likely to fracture. Besides other factors, stresses and forces generated during instrumentation have been linked to an increased risk of root fractures. Canal preparation involves dentin removal and may compromise the fracture strength of the roots that could at any stage induce fractures whether complete or incomplete. Endodontically treated teeth are susceptible to fracture in comparison with vital teeth.[2,3] The most often reported reasons have been dehydration of dentin, removal of tooth structure during root canal treatment, prolonged use of high concentrations of irrigation solutions, and excessive pressure during obturation. In recent times there have been significant technological advancements in root canal cleaning and shaping. New instruments have been developed employing

superelastic alloys and novel engineering philosophies, and there has been a notable departure from the ISO standard 2% taper (0.02 mm/mm) instruments.[4] The emergence of these NiTi rotary instrumentation has transformed 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. Recently, ProTaper Next (Dentsply Maillefer) instruments have been introduced that have an off-centered rectangular design, and progressive and regressive percentage tapers on a single file, which is made from M-Wire technology. Having an off-centered rectangular design decreases the screw effect, dangerous taper lock, and torque on any given file by minimizing the contact between the file and the dentin. Several studies have reported less number of the development of dentinal microcracks with ProTaper Next due to its instrument design. Nevertheless, some functions of NiTi rotary systems such as cleaning ability, increased stress, and the inability to adequately prepare oval canals are still controversial. Several studies have reported the development of dentinal defects, such as microcracks and craze lines, after root canal preparation with NiTi-based instruments. These dentinal defects can act as a trigger point for vertical root fractures (VRF) and may influence the long-term survival of endodontically treated teeth. In addition, Kim *et al*. have found a potential relationship between the design of NiTi instruments and the incidence of VRF where file design affected apical stress and strain concentrations during root canal instrumentation.[5,6] Not much data are available regarding the formation of dentinal microcracks when using hand instruments, rotary, and reciprocating instruments. This study was undertaken to compare the formation of dentinal microcracks under stereomicroscope when the following instruments: Hand K Files; ProTaper and ProTaper Next: Rotary files; and WaveOne and Reciproc systems: Reciprocating files were used to shape the root canal.

MATERIALS AND METHODS

This study was conducted in the Department of Conservative Dentistry and Endodontics, Vokkaligara Sangha Dental College and Hospital, Bengaluru. 90 freshly extracted single-rooted human mandibular central incisor teeth were selected for the study that had been extracted for periodontal and/or prosthetic reasons. The extracted teeth were cleaned of soft tissue, calculus, and debris with an ultrasonic scaler and were stored in saline until it was used for the study. All roots were observed in a stereomicroscope under ×12 magnification to exclude any external defects or cracks and were discarded if any of these characteristics were found. Mesiodistal and buccolingual radiographs were taken to verify the presence of a single canal. The specimens were divided into 6 groups (n = 15), 5 experimental groups, and a control group according to the type of instrument and motion of instrumentation as follows:

Group 1: Control, Group 2: K File Instrumentation Technique, Group 3: ProTaper Instrumentation Technique with Rotary Motion, Group 4: ProTaper Next Instrumentation Technique with Rotary Motion, Group 5: The WaveOne Instrumentation Technique with Reciprocating Motion, and Group 6: Reciproc Instrumentation Technique with Reciprocating Motion.

Access cavity preparations were done with Endo Access Bur No 2. The canals were located using a DG-16 endodontic explorer (Hu-Friedy, Chicago, IL, USA). Apical patency was determined by inserting an ISO #10 K file until it appeared at the apical foramen. The working lengths were determined by inserting an ISO #15 K file (Dentsply Maillefer, Ballaigues, Switzerland) into the root canal terminus and subtracting 1 mm from this measurement. A glide path was established through a size #15 K file (Dentsply Maillefer, Ballaigues, Switzerland). The root canals were irrigated with 2.5% sodium hypochlorite solution after each instrument change. Each instrument was changed after preparing four canals. A total of 12 mL 2.5% sodium hypochlorite was used in each canal. After preparation, the specimens from the prepared groups were rinsed with 5 mL of distilled water. All roots were sectioned horizontally at 3, 6, and 9 mm from the apex with a low-speed saw under water cooling (Minitom, Struer, Denmark). To prevent artifacts from dehydration in the samples, the teeth were kept moist in distilled water throughout all experimental procedures. The slices were then examined through a digital stereomicroscope (Carl Zeiss Discovery V20, Germany), and pictures were taken with a digital camera (Carl Zeiss, Germany) attached to the stereomicroscope at a magnification of ×30.

Statistical Analysis

The data arrived after evaluation of dentinal microcracks were subjected to statistical interpretation using the Chi-square test for analysis of differences between the groups at a 95% confidence level ($P < 0.05$).

RESULTS

The number of dentinal microcracks formed by ProTaper Universal was highest (n = 3), followed by WaveOne (n = 2), ProTaper Next (n = 1), and Reciproc (n = 1), while the control group and hand K Files showed no dentinal microcracks as measured 3 mm from the root

apex. The overall difference between the groups was significant ($P < 0.03$). [Table 1] Statistical analysis shows that canals instrumented with WaveOne resulted in a significantly greater number of dentinal microcracks ($n = 3$) than ProTaper Universal and ProTaper Next ($n = 2$), while hand K file ($n = 1$) showed the least number of dentinal microcracks as measured at 6 mm from the root apex. The number of dentinal microcracks was significantly different between the groups ($P < 0.014$). [Table 2] Presence of dentinal microcracks was observed at 6 mm ($n = 2$) and 3 mm ($n = 1$) after instrumentation of the root canals with ProTaper Next. No cracks were observed at 9 mm from the apex. However, there was no statistically significant difference ($P = 0.083$) at various levels of instrumentation with ProTaper Next. [Table 3] WaveOne constituted a significantly greater number of dentinal microcracks at 6 mm ($n = 3$) than at 3 mm ($n = 2$) from the root apex. The difference between various instrumentation levels was statistically significant ($P = 0.025$). [Table 4] Presence of dentinal microcracks after instrumentation with Reciproc was observed at 3 mm from root apex ($n = 1$) which was not significant. No cracks were seen at 6 mm and 9 mm from the root apex [Table 5].

Table 1: Incidence of dentinal microcracks after instrumentation with hand k files, ProTaper, ProTaper next, WaveOne, and Reciproc at 3 mm from root apex

Group	Dentinal microcracks				χ^2 value	*P* value
	No cracks	1 Crack	2 Cracks	3 Cracks		
3 mm						
Control	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	14	0.03*
K Files	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		
Protaper	12 (80.0)	0 (0.0)	0 (0.0)	3 (20.0)		
Protaper next	14 (93.3)	1 (6.7)	0 (0.0)	0 (0.0)		
Waveone	13 (86.7)	0 (0.0)	2 (13.3)	0 (0.0)		
Reciproc	14 (93.3)	1 (6.7)	0 (0.0)	0 (0.0)		

*Statistically significant *P*<0.05

Table 2: The incidence of dentinal microcracks after instrumentation with hand k files, ProTaper, ProTaper next, WaveOne, and Reciproc at 6 mm from root apex

Group	Dentinal microcracks				χ^2 value	*P* value
	No cracks	1 Crack	2 Cracks	3 Cracks		
6 mm						
Control	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	16	0.014*
K Files	14 (93.3)	1 (6.7)	0 (0.0)	0 (0.0)		
Protaper	13 (86.7)	0 (0.0)	2 (13.3)	0 (0.0)		
Protaper next	13 (86.7)	0 (0.0)	2 (13.3)	0 (0.0)		
Waveone	12 (80.0)	0 (0.0)	0 (0.0)	3 (20.0)		
Reciproc	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		

*Statistically significant *P*<0.05

Table 3: Incidence of dentinal microcracks after instrumentation with ProTaper Next at 3, 6, and 9 mm from the root apex

Groups	Dentinal microcracks				χ^2 value	*P* value
	No cracks	1	2	3		
	n (%)	*n* (%)	*n* (%)	*n* (%)		
Protaper next						
3 mm	14 (93.3)	1 (6.7)	0 (0.0)	0 (0.0)	3.000	0.083
6 mm	13 (86.7)	0 (0.0)	2 (13.3)	0 (0.0)		
9 mm	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		

Table 4: Incidence of dentinal microcracks after instrumentation with WaveOne at 3, 6, and 9 mm from the root apex

Group	Dentinal microcracks				χ^2 value	*P* value
	No cracks	1	2	3		
	n (%)	*n* (%)	*n* (%)	*n* (%)		
Waveone						
3 mm	13 (86.7)	0 (0.0)	2 (13.3)	0 (0.0)	5.000	0.025*
6 mm	12 (80.0)	0 (0.0)	0 (0.0)	3 (20.0)		
9 mm	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		

*Statistically significant *P*<0.05

Table 5: Incidence of dentinal microcracks after instrumentation with Reciproc at 3, 6, and 9 mm from the root apex

Group	Dentinal microcracks				χ^2 value	*P* value
	No cracks	1	2	3		
	n (%)	*n* (%)	*n* (%)	*n* (%)		
Reciproc						
3 mm	14 (93.3)	1 (6.7)	0 (0.0)	0 (0.0)	-	-
6 mm	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		
9 mm	15 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)		

DISCUSSION

Preparation of the root canal system is recognized as being one of the most important stages in root canal treatment. About 30 years ago, Schilder introduced the concept of "Cleaning and shaping of the root canals" that aims to prepare the canal space to facilitate disinfection by irrigants and medicaments and to provide for three-dimensional obturation of the root canal space. Thus, canal preparation is that essential phase of endodontic treatment that eliminates infection.[7] It is generally accepted that VRF strength is directly proportional to the amount of remaining tooth structure.[8] One of the potential factors which may influence propensity for VRF is the prepared canal diameter. Walton and Torabinehad (1996), Holcomb *et al*. (1987), Ricks-Williamson *et al*. (1995), and Wilcox *et al*. (1997) in their studies evaluated the relationship between the canal taper and fracture susceptibility of the roots. They found that increased canal width and taper weakened the root and also the magnitude of generated radicular stresses and root surface craze lines directly correlated with the canal diameter.[9] Excessive force during tooth extraction may create crack lines. Hence, all teeth were observed under a digital stereomicroscope (Carl Zeiss Discovery V20, Germany) at ×12 magnification and teeth without defects were selected. In this study, mandibular central incisors were prepared with Hand K Files; ProTaper and ProTaper Next: Rotary files; WaveOne and Reciproc systems: Reciprocating files up to size 25 and sectioned at 3, 6, and 9 mm from the root apex and observed under digital stereomicroscope of magnification ×30 for dentinal microcracks. Previous studies by Shemesh *et al*. (2009), Adorno *et al*. (2010), and Burklein *et al*. (2013) demonstrated that sectioning with a low speed saw under water cooling did not report crack formation in unprepared groups. Similarly, in this study, the control group showed no defects; therefore, any dentinal defects detected subsequently probably occurred during the instrumentation procedures.[10] ProTaper and WaveOne groups showed the highest number (n = 5) of dentinal microcracks, followed by ProTaper Next (n = 3). Hand K files and Reciproc showed the least number (n = 1) of dentinal microcracks. The K files with the square cross-section are more stable and stiff have less chip space between the threads, so a smaller amount of dentin is cut away from the canal walls. In this study, hand instrumentation did not cause much damage to the root canal. This was in accordance to previous studies by Ashwinkumar *et al*.,[11] Yoldas *et al*.,[6] and Hin *et al*.[12]

CONCLUSIONS

The following conclusions can be drawn from the present study:

- Instrumentation of canals produced dentinal microcracks.
- Within the instrumented groups, there was a statistically significant difference found with ProTaper and WaveOne (P = 0.025), while no statistically significant difference in dentinal microcracks after instrumentation with ProTaper Next, Hand K files, and Reciproc was noted. However, there was no statistical difference between the instrumented groups ($P > 0.05$).

REFERENCES

1. Young GR, Parashos P, Messer HH. The principles of techniques for cleaning root canals. Aust Dent J 2007;52:S52-63.
2. Sathorn C, Palamara JE, Palamara D, Messer HH. Effect of root canal size and external root surface morphology on fracture susceptibility and pattern: A finite element analysis. J Endod 2005;31:288-92.
3. Talabani MR, Ahmad SM, Noori AJ. Conservation of dentin thickness in the root canals orifice following two preparation techniques. Sulaimani Dent J 2014;1:80-5.
4. Kishen A. Mechanisms and risk factors for fracture predilection in endodontically treated teeth. Endod Top 2006;13:57-83.
5. Kim HC, Lee MH, Yum J, Versluis A, Lee CJ, Kim BM, *et al.* Potential relationship between design of nickel-titanium rotary instruments and vertical root fracture. J Endod 2010;36:1195-9.
6. Yoldas O, Yilmaz S, Atakan G, Kuden C, Kasan Z. Dentinal microcrack formation during root canal preparations by different niTi rotary instruments and the self-adjusting file. J Endod 2012;38:232-5.
7. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am 1974;18:269-96.
8. Singla M, Aggarwal V, Logani A, Shah N. Comparative evaluation of rotary proTaper, profile, and conventional stepback technique on reduction in enterococcus faecalis colony-forming units and vertical root fracture resistance

of root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:e105-10.
9. Rundquist BD, Versluis A. How does canal taper affect root stresses? Int Endod J 2006;39:226-37.
10. Helvacioglu-Yigit D, Aydemir S, Yilmaz A. Evaluation of dentinal defect formation after root canal preparation with two reciprocating systems and hand instruments: An *in vitro* study. Biotechnol Biotechnol Equip 2015;29:368-73.
11. Ashwinkumar V, Krithikadatta J, Surendran S, Velmurugan N. Effect of reciprocating file motion on microcrack formation in root canals: An SEM study. Int Endod J 2014;47:622-7.
12. Hin ES, Wu MK, Wesselink PR, Shemesh H. Effects of self-adjusting file, mtwo, and proTaper on the root canal wall. J Endod 2013;39:262-4.