



Evaluation Of Dentinal Defect Formation Caused by Commercially Available Two Different Nickel–Titanium Rotary File Systems in Permanent Mandibular Premolars: An In Vitro Study

Kudrat Kang ^{*1}, Mehakjot Kaur Ghuman ², Kavneet Pannu³, Gagandeep singh Waraich⁴

1. BDS, Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital, Chandigarh, India.
2. BDS, Dasmesh Institute of Research and Dental Sciences, Faridkot, Punjab, India.
3. BDS, National Dental college and Hospital, Derabassi, Punjab, India.
4. BDS, National Dental college and Hospital, Derabassi, Punjab, India.

***Correspondence to:** Kudrat Kang, BDS, Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital, Chandigarh, India.

Copyright

© 2023 **Kudrat Kang**. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received: 02 May 2023

Published: 15 June 2023

Abstract

Background: Due to the stress that the numerous rotational endodontic instruments put on the root dentin during cleaning and shaping, root dentin flaws arise from root canal preparations. Consequently, the root canal treated teeth's long-term prognosis is made worse. A correct tool for root canal preparation is being created as a result of extensive research on rotary devices worldwide.

Aim: The aim of this study was to assess and compare dentinal defect formation caused by two commercially available different nickel–titanium (NiTi) rotary file systems in permanent mandibular premolars.

Materials and Methods: Total of 30 extracted mandibular premolars were selected for present In-vitro study. Hyflex EDM rotary files and ProTaper universal were used to instrument the root canals. With a slow-speed saw and water cooling, all roots were horizontally sectioned at 3, 6, and 9 mm from the apex. To assess whether a crack existed or not, the sections were examined with a stereomicroscope at a magnification of x 25. The result showing P value ≤ 0.05 was considered statistically significant.

Result: There was a significant higher incidence of microcracks at the 3mm, 6 mm and 9 mm levels of roots in both groups. The HyFlex EDM files produced less dentinal defect when compared with the protaper universal ($P < 0.05$) at 3, 6 and 9 mm.

Conclusion: Compared to HyFlex EDM, Protaper Universal demonstrated the largest percentage of defects. HyFlex EDM had the lowest percentage of root dentin deficiencies. Therefore, HyFlex EDM performs root canal preparation more effectively than Protaper Universal, preventing dentinal flaws or microcracks that could cause root fractures.

Keywords: Dentinal Defects, Rotary Files, Protaper Universal, Hyflex EDM

Introduction

A correct diagnosis, meticulous biomechanical preparation, and three-dimensional obturation of the root canal system are necessary for a successful endodontic therapy.[1] One of the most crucial elements for a successful root canal procedure is biomechanical preparation, which also affects the effectiveness of all following procedures. In order to accomplish a good endodontic procedure, it is necessary to thoroughly remove organic tissue, germs, and debris by increasing the canal diameter and forming a shape that allows a proper seal.[2,3]

The purpose of root canal instrumentation is to keep the original anatomy and canal course while removing diseased tissues and shaping the root canal into a smooth conical lumen.[4] The instrumentation procedure is a crucial stage that can impact the outcome of endodontic treatment. Inadequate instrumentation can result in issues including dentinal cracks and root fractures as well as mistakes such canal stripping and preformation. In addition to iatrogenic causes, it has been shown that parameters like file design and the alloy used to make these files have a direct bearing on the frequency and severity of such errors and problems.[5,6]

When the tensile stress limit of dentine is exceeded by stresses applied to a dentinal wall, dentinal defects result. Manufacturers have created files with asymmetrical cross sections, files with varying tapers, and files with alternate contact edges in an effort to lessen these stresses. These designs might lessen the file's tendency to screw into the canal, which would lessen the tensile pressures acting on the dentinal wall. [7,8]

The ProTaper universal file system, manufactured by Dentsply Maillefer in Ballaigues, Switzerland, has long been the industry standard in endodontics. They aid in creating a fully tapered canal with a uniform shape thanks to their efficient design and gradually tapered shape. It has been demonstrated that ProTaper Universal-prepared canals have consistently produced positive results in the accomplishment of every root canal procedure to date. Recently created rotary system called HyFlex® EDM (Coltene). HyFlex® EDM files follow the morphology of the canal due to their regulated qualities, which can considerably lower the risk of ledging, transportation, and perforation. HyFlex® EDM files' internal shape memory avoids stress during canal preparation by altering their spiral shape, hence reducing the development of microcracks and root dentin flaws. Hence Thus, the purpose of this present in vivo study was to evaluate the effect of HyFlex® EDM in comparison to that of Protaper® Universal, in forming root dentin defects in the surface of the root after root canal shaping.

Material and Method

For the current in-vitro study, newly extracted permanent mandibular premolars were gathered. Teeth were cleaned using an ultrasonic scaler to get rid of soft tissue, debris, or calculus deposits, and they were then stored in distilled water. The premolars were examined and evaluated using radiovisiography. 30 single-rooted premolar teeth with a single root canal and no anomalies were selected for this study. Exclusion criteria for the study included teeth with fractured roots, overly large canals, significantly curved roots, external or internal resorption, developmental anomalies, and teeth that had already undergone endodontic therapy.

The teeth were decorated with a diamond disc, resulting in roots that were around 16 mm long. The canal's patency was assessed using a no. 10 K-File (Mani, Japan) sample. After determining the patency, the samples were divided into three groups in an equal distribution.

The specimens were then split into two groups, with 15 specimens in each group. Protaper® Universal in Group 1 and HyFlex® EDM in Group 2. Orikam E; speed and torque regulated motor was used in both groups to prepare the canals. Using ProTaper Ni-Ti rotary files, canal preparation was carried out at 300 rpm in Group 1 (Protaper® Universal). For coronal expansion, SX was employed, and at the working length, the S1 and S2 files were used sequentially.

Except for the Glidepath file, which was used with 300 rpm and a torque of up to 1.8 Ncm in accordance with the manufacturer's instructions up to the working length, all files in Group 2 (HyFlex® EDM) were utilised at 500 rpm and up to 2.5 Ncm of torque. Initial files utilised were 25/0.12 Orifice Opener, #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland), 10/0.05 Glidepath File, and 25/ HyFlex One Shaping File. Before employing the next instrument, the root canals of the specimens in both groups were continuously irrigated with 5.25% sodium hypochlorite solution. Instrument flutes were frequently cleaned to look for wear or distortion.

Horizontal sectioning of all the roots was carried out at 9 mm (coronal), 6 mm (Middle), and 3 mm (Apical) using a diamond disk under water cooling. These sections were individually observed under stereomicroscope at $\times 25$ magnification, and photographs were taken using a digital camera. A crack is a flaw that starts in the inner root canal space and spreads to the outside of the tooth. All other flaws were not caused

by the canal wall, like craze lines, which were not considered cracks. i) No defect-root dentin free from crazelines or defects on the root surface (inner and outer). ii) Defects- all lines and cracks observed, which were extended to the external root surfaces. Chi Square were used to analyze the data. The result showing P value ≤ 0.05 was considered statistically significant.

Result

There was a significantly higher incidence of microcracks at the 3mm, 6 mm and 9 mm levels of roots in both groups. The HyFlex EDM files produced less dentinal defect when compared with the protaper universal ($P < 0.05$) at 3, 6 and 9 mm.

Section	Score	Groups		P Value
		Protaper Universal	Hyflex EDM	
9mm	No Defect	12 (80)	14 (93.3)	<0.05
	Defect	3 (20)	1 (6.7)	
6mm	No Defect	12 (80)	14 (93.3)	<0.05
	Defect	3 (20)	1 (6.7)	
3mm	No Defect	11 (73.3)	13 (86.6)	<0.05
	Defect	4 (26.6)	3 (13.4)	

Discussion

Chemo-mechanical root canal preparation's main goals are a complete cleansing of the root canal system and a sufficient increase in root canal diameter while maintaining the original path of the canal.[9] Even though they take time, historically established hand instruments are nevertheless a crucial part of this process. As a result, a number of rotary systems have been developed that not only have improved cutting efficiency but also save time. When performing mechanical root canal preparation, a practitioner frequently encounters VRF, which results in a material loss from the tooth.[10]

In addition to this, since the design of the file affects the concentrations of apical stress and strain, there may be a relationship between the designs of Ni-Ti instruments and the occurrence of VRFs.[11]

Because of their tiny size and delicate dentinal walls, mandibular premolars were chosen for this investigation because they are more susceptible to being damaged by instrumentation forces. The teeth were also simple to obtain because they had closed apices and had been extracted for orthodontic treatment.[12] Freshly extracted mandibular premolars were taken into consideration for the examination of dentinal defects since Rivera et al. claimed that mandibular premolars have a high prevalence of VRF. This is because instrumentation forces may have a greater impact on smaller dimensions and thin dentinal walls.[13]

The purpose of this present in vivo study was to evaluate the effect of HyFlex® EDM in comparison to that of Protaper® Universal, in forming root dentin defects in the surface of the root after root canal shaping. Result of our study showed that protaper universal rotary file produce more dentinal defect compared to hyflex EDM files.

The results of the present study are in accordance with the results by Bier et al., where the Protaper® Universal rotary files showed highest incidence of dentinal damage.[3] Root dentin defects or micro cracks were incident more in number in the apical 3mm sections of the root which may be due to maximum stress in the apical third of the root canals during cleaning and shaping by rotary files.[14]

A recent advancement in rotary endodontics is HyFlex® EDM. Electrical Discharge Machining, a cutting-edge manufacturing technique, is used to create these files. A file produced by the EDM method is very flexible and fracture-resistant. Compared to conventional Ni-Ti files, HyFlex® EDM files are up to 700% more resistant to cyclic fatigue. They can follow the anatomy of the root canal thanks to their regulated qualities, which lowers the danger of perforations, ledging, and transportations. The HyFlex® EDM's combination of flexibility, fracture resistance, and cutting effectiveness makes it feasible to minimise the amount of files needed for cleaning while maintaining the anatomy. HyFlex® EDM, which is offered as a modular system of sterile instruments, consists of Shaping, Glidepath, OneFile, Orifice Opener, and Finishing files and can be utilised with HyFlex CM files. HyFlex® EDM files' internal shape memory alters the spiral shape to reduce stress during canal preparation. The files can be brought back to their former shape and fatigue resistance using a simple autoclaving procedure. [15-18]

While performing root canal instrumentation, ProTaper universal files contain active rotating movements that increase the amount of stress concentration inside the canal.[19] According to Kim et al., the taper of files results in more stress being placed on the root canal walls. The ProTaper universal's progressive larger taper results in more coronal dentin being removed, which increases the frequency of flaws or microcracks. The danger of a fractured root increases with the amount of force produced during root canal instrumentation.[20] Due to these fractures in the root dentin, which are a consequence of endodontic treatment's primary purpose of making teeth resistant to fracture, both the treatment's success rate and its long-term survival rate are reduced. [21,22]

Conclusion

Within the limitations of the present in-vivo study, it can be concluded that

1. The defects were present in all three segments i.e. the apical third (3 mm) and 6 mm (middle third) and 9 mm (coronal third) sections.
2. Highest incidence of dentinal defects were seen in apical portion of root canal.
3. Hyflex EDM tends to produce less number of cracks as compared to Protaper universal rotary files.

References

1. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. *J Endod.* 2004;30:559-67.
2. Bier CA, Shemesh H, Tanomaru-Filho M, Wesselink PR. The Ability of Different Nickel-Titanium Rotary Instruments To Induce Dentinal Damage During Canal Preparation. *J Endod.* 2009;35(2):236–38.
3. Cheema J, Gupta AK, Minocha A. Comparison of Dentinal Cracks after Root Canal Preparation with Hand Files and Protaper NEXT, HYFLEX EDM, K3 XF and Twisted Rotary Files. *J Adv Med Dent Scie Res* 2018;6(5):30-35.

4. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 2006;39: 921–30
5. Hendi SS, Karkehabadi H, Eskandarloo A. Iatrogenic errors during root canal instrumentation performed by dental students. *Iran Endod J* 2018;13:126.
6. Abass AA, Fadhil HT, Albaaj FO. Dentinal Defects Induced by Offset and Alternating Contact Endodontic Rotary Files: An In Vitro Study. *Dent Hypotheses* 2022;13:53-6
7. Dane A, Capar ID, Arslan H, Akçay M, Uysal B. Effect of different torque settings on crack formation in root dentin. *J Endod* 2016;42:304–6.
8. Portenier I, Lutz F, Barbakow F. Preparation of the apical part of the root canal by the Lightspeed and step-back techniques. *Int Endod J*. 1998;31:103–111.
9. Torabinejad M, Walton RE, Fouad AF, eds. *Endodontics: Principles and Practice*. St. Louis, MO: Elsevier; 2015. p. 137.
10. Miguéns-Vila R, Martín-Biedma B, Varela-Patiño P, Ruíz-Piñón M, Castelo-Baz P Vertical root fracture initiation in curved roots after root canal preparation: A dentinal micro-crack analysis with Led transillumination. *J Clin Exp Dent* 2017;9:e1218-23.
11. Abou El Nasr HM, Abd El Kader KG Dentinal damage and fracture resistance of oval roots prepared with single file systems using different kinematics. *J Endod* 2014;40:849-51.
12. Bhavsar BA, Sharma P, Surana P, Badnaware S, Jadhav D, Jain A. Oval Root Canals Prepared With Two Different Endodontic Rotary Files: An In Vitro Study Comparing the Incidence of Dental Defects. *Cureus*. 2023 Mar 8;15(3):e35914. doi: 10.7759/cureus.35914. PMID: 37038573; PMCID: PMC10082335.
13. Rivera EM, Walton RE Longitudinal tooth cracks and fractures: An update and review. *Endod Topics* 2015;33:14-42.
14. Bier CAS, 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.

-
15. Pawar AM, Thakur B, Kfir A, Kim HC. Dentinal defects induced by 6 different endodontic files when used for oval root canals: an in vitro comparative study. *Restor Dent Endod*. 2019 Jul 29;44(3):e31. doi: 10.5395/rde.2019.44.e31. PMID: 31485427; PMCID: PMC6713082.
16. Iacono F, Pirani C, Generali L, Bolelli G, Sassatelli P, Lusvardi L, Gandolfi MG, Giordani L, Prati C. Structural analysis of HyFlex EDM instruments. *Int. Endod. J*. 2017 Mar;50(3):303
17. Gündoğar M, Özyürek T. Cyclic fatigue resistance of OneShape, HyFlex EDM, WaveOne Gold, and Reciproc Blue nickel-titanium instruments. *J. Endod*. 2017 Jul 1;43(7):1192-6
18. Devi TP, Kaur A, Priyadarshini S, Deepak BS, Banerjee S, Sanjeeta N. Microscopic assessment of dentinal defects induced by ProTaper Universal, ProTaper Gold, and Hyflex electric discharge machining rotary file systems – An in vitro study. *Contemp Clin Dent* 2021;12:230-4.
19. West JD. Introduction of a new rotary endodontic system: progressively tapering files. *Dent Today* 2001;20:50-7.
20. 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.
21. 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.
22. Shemesh H, Bier CA, Wu MK, Tanomaru-Filho M, Wesselink PR. The effects of canal preparation and filling on the incidence of dentinal defects. *Int Endod J* 2009;42:208-13.

