

ORIGINAL RESEARCH

A stereomicroscopic analysis of dentinal micro cracks after root canal preparation using three different rotary instruments: An in vitro study

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Received: 21 March, 2023

Accepted: 25 April, 2023

ABSTRACT

Introduction: Root canal preparation is a crucial step in the success of endodontic treatment because of the debridement of debris, elimination of bacteria, and facilitating final obturation. Dentinal micro-cracks could be in a horizontal direction or vertical directions at different root levels. The present study aimed to evaluate dentinal micro crack formation after instrumentation with Pro Taper Next, Wave One Gold (Gold-wire) and Trunatomy (DENTSPLY) file systems under the stereomicroscope. **Materials and Methodology:** Forty single rooted teeth free from any defect were selected and divided into four groups (Control, PTN, WOG and Trunatomy). Experimental groups were instrumented with file system used in the study, and the control group were left unprepared. Samples were further decoronated and sectioned at 3 mm, 6 mm, and 9 mm from the apex perpendicular to the long axis and examined under a stereomicroscope at $\times 25$ for different types of micro-cracks (no fracture, complete fracture, partial fracture, and other fracture). **Results:** The tables that were demonstrated above denoted the microscopical observation of cracks in the root dentin area after instrumentation. At the coronal level, higher number of cracks was observed in group – 2 that is pro taper next. When microscopically observing the cracks at the middle portion, it has been observed that group – 2 showed higher cracks and in the apical portion, higher number of cracks were observed in group – 2. **Conclusion:** To conclude, it has been established from the study that all the Ni-Ti rotary files are capable of inducing the cracks during the root canal instrumentation. The maximum percentage of cracks was seemed to be noticed in the apical region.

Keywords: Nickel-titanium files, single file system, dentinal micro cracks, stereomicroscopy.

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INTRODUCTION

Root canal therapy has been proved to be an effective treatment modality in eliminating the endodontic diseases that are associated with multiple bacterial infections.¹ The precise canal preparation is an utmost step in determining the success of a root canal treatment wherein the apical enlargement greatly ensures the cleanliness and hence the quality of the root canal filling is improved to a great extent.² This preparation procedure usually accompanied with various defects such as fractures, cracks or craze lines in the root dentin. Therefore it is mandatory to investigate the root surface to analyse the

development of cracks on root dentin at various levels.^{3,4}

The instruments that were used for the root canal procedure has undergone lot of developments from its introduction in the mid-18th century by Edward Maynard by notching round wires using watch springs and then followed by piano wires that were milled into files which were capable of removing pulp and debris from the pulp space in the teeth. Though hand instruments were the first to be developed which had becomes almost unpopular in the recent days but still serves as an integral part in the root canal instrumentation.⁵ Earlier the files were developed

using stainless steel which could possibly clean the canal superficially and can create various aberrations like ledges, zips and elbows. In order to eliminate the drawbacks of the stainless steel files, NiTi files were developed in the mid-19th century by William Bueller in Silver springs, Maryland. The canals which were prepared using these NiTi instruments show increased cleanliness of the canals with minimal aberrations such as less apical canal transportation or perforations. These benefits were greatly attributed to the flexibility of NiTi instruments and enhanced specific design feature that can easily allow to maintain a natural canal curvature.^{6,7}

The instrumentation that were done in the root canal that is in the root dentin portion would probably weaken the roots to a greater extent and therefore the stresses that were generated inside the root canal would significantly higher in apical region and along the walls so that the distribution of the stresses could possibly leads to the development of the cracks and fractures. Therefore more number of bacteria might proliferate in these crack lines and later that establish the formation of biofilms on the root surface.⁸ the designs that were incorporated in the file systems would greatly affect the stress concentration and reduced stress in the apical region during the instrumentation. The various design elements such as different heat treatments, cross sectional shape and kinematics might influence the crack generation.⁹ Therefore the generation of the dentinal micro-cracks after root canal instrumentation should greatly be studied since it is utmost area of interest to many researchers. His present study aimed to evaluate dentinal micro crack formation after instrumentation with Pro Taper Next, Wave One Gold (Gold-wire) and Trunatomy (DENTSPLY) file systems under the stereomicroscope.

MATERIALS AND METHODOLOGY

Forty single-rooted teeth free from any defect were selected and divided into four groups (Control, PTN, WOG and Trunatomy). Experimental groups were instrumented with file system used in the study, and the control group were left unprepared. Samples were further decoronated and sectioned at 3 mm, 6 mm, and 9 mm from the apex perpendicular to the long axis and examined under a stereomicroscope at $\times 25$ for

different types of micro-cracks (no fracture, complete fracture, partial fracture, and other fracture)

All the single rooted teeth restored properly in thymol solution until their experimental application. All the selected teeth were observed under stereomicroscope in order to exclude the specimen teeth with cracks. All the teeth were sectioned under cold water with diamond disc of 16 mm from the apex. The root portions were completely covered with aluminium foil and then were inserted in an acrylic tube. The root was removed from the tube and a light body silicon based material was applied to fill the space that was earlier created by foil in order to simulate the periodontal ligament. The patency of the canal was checked using #8 hands K-file until it was visible in the apical foramen. The teeth were grouped as per the following:

Group – 1: Teeth were unprepared in order to serve as control group. (n=10)

Group – 2: The specimen teeth were instrumented using Pro taper Next files at a speed of 250rpm, torque 4Ncm in proper in and out motion.

Group – 3: Here the teeth were prepared using Wave One gold at a speed of 300 rpm, 4.5 Ncm in a gentle in and out motion.

Group – 4: The specimen teeth that were allotted in this group were instrumented using Trunatomy files.

All the extracted specimen teeth roots were sectioned at a perpendicular level along its long axis at 3, 6 and 9 mm from the root apex using diamond disc under water cooling.

All the slices were analysed using a stereomicroscope in order to determine the presence of cracks. The results were usually mentioned as the number and the percentage of cracked roots. Fischer's exact test was also being performed to determine the defects at different horizontal sections in each group.

RESULTS

All the details were identified for the number of roots in each individual group who are displaying cases in order to evaluate the stress. No cracks were eventually unobserved on the walls. Vertical root fractures were significantly uncommon to be observed. The Pro Taper next instruments caused fewer cracks (28%) than the Pro Taper universal instrument (56%) ($P < 0.05$)

Table 1: Comparison between unprepared, Pro Taper next, wave one gold and trunatomy in the coronal portion

At coronal portion	Groups				Total
	1	2	3	4	
Crack	0	5 (50%)	3 (30%)	2 (20%)	11 (27.5%)
No cracks	10 (100%)	5 (50%)	7 (70%)	8 (80%)	29 (72.5%)
Total	10	10	10 (100%)	10 (100%)	40 (100%)

Table 2: Comparison between unprepared, Pro Taper next, Wave One gold, trunotomy in the middle portion

At middle portion	Groups				Total
	1	2	3	4	
Crack	0	5 (50%)	3 (30%)	3 (30%)	11 (27.5%)
No cracks	10 (100%)	5 (50%)	7 (70%)	7 (70%)	29 (72.5%)
Total	10	10	10 (100%)	10 (100%)	40 (100%)

Table 3: Comparison between unprepared, Pro Taper next, wave one gold and trunatomy in the apical portion

At apical portion	Groups				Total
	1	2	3	4	
Crack	0	6 (60%)	4 (40%)	2 (20%)	12 (27.5%)
No cracks	10 (100%)	4 (40%)	6(60%)	8 (80%)	29 (72.5%)
Total	10	10	10 (100%)	10 (100%)	40 (100%)

The tables that were demonstrated above denoted the microscopical observation of cracks in the root dentin area after instrumentation. At the coronal level, higher number of cracks was observed in group – 2 that is pro taper next. When microscopically observing the cracks at the middle portion, it has been observed that group – 2 showed higher cracks and in the apical portion, higher number of cracks were observed in group – 2.

DISCUSSION

The major in root canal preparation that is the cleaning and shaping of the root canal system is considered to be deciding link since shaping effectively determines the efficacy and supremacy of the subsequent procedures. Conventionally, the cleaning and shaping of the root canals was primarily achieved by the use of stainless steel hand files but then various drawbacks had been reported thus it paved the way for the innovation of newer materials. The Ni-Ti alloys that were developed to overcome the demerits that were observed from stainless steel files were reportedly having certain unique characteristics that include super elasticity and shape memory. Super elasticity is that property that was observed with phase transformation upon the application of stress. His stress-induced martensitic transformation reverses spontaneously upon release of the stress; the material then returns to its original shape and size.^{10,11}

Dentinal cracks or root fractures occur when the tensile stress in the root canal wall exceeds the tensile stress of dentin. These defects or micro cracks form the basis of vertical root fracture in endodontic ally treated teeth when subjected to repeated cycles of the masticatory load. In a study done by *Vire* et al the prevalence of vertical root fractures was 10.9% in endodontic ally treated teeth.⁹ There are a wide variety of factors that could possibly affect the development of forces within the root that include file taper, file geometry, file metallurgy, canal morphology, the motion of which the rotary files used and thermomechanical treatment. This thermal treatment of Ni-Ti alloys include M-wire (DENTSPLY), R-phase wire (Sybron Endo) and controlled memory wire that have

been used to effectively optimise the mechanical properties of the files.

NiTi instruments are basically perceived to have high fracture risk during use, new designs have been marketed to lower fracture risks which may also alter the forces on a root during instrumentation and increase dentinal defects that predispose a root to fracture. A study was conducted by *Kim* et al. which concluded that the stiffer file designs generated higher stress concentrations in the apical root dentin during shaping of the curved canal, which raises the risk of dentinal defects.⁷ In this study, specimen was sectioned with the help of diamond disc running at low speed with coolant. No cracks were seemed to be observed in the control group that showed the sectioning methods do not have any effect on the cracks in the sections prepared for stereomicroscopic analysis.

In the current study, higher number of dentinal cracks was seen in Pro Taper next (group-2). This Pro Taper next is made out of conventional Ni-Ti and its motion and design of off-centred rectangular design that results in less space for the collection of dentinal chips and hence enables the generation of stresses on root dentinal walls. This observation is in concordance with the study conducted by *Li* et al which showed that the taper of the Pro Taper next that were used in their study contribute to the formation of dentinal cracks. Larger the taper, the more the root dentin were removed and more likely the root fracture is inevitable and unavoidable.¹² *Bier* et al stated that taper of files greatly influences crack formation. The orifice opener used in our study is a larger taper (8%) instrument which causes more stress concentration in the root dentin, leading to micro-cracks.¹³

Trunatomy is the newly developed file sequence system which is manufactured with the help of a slim Ni-Ti wire of 0.8 mm in maximum flute diameter and is having an off-centred parallelogram cross-section in design with an added advantage of special heat treatment that enabling this file system to exhibit greater flexibility and superior canal centering ability that preserves the tooth structure.¹⁴ Based on the study conducted by *Riyahi* et al observed that this trunatomy file system has greater cyclic fatigue

resistance when compared with Pro Taper Next as well as other twisted files.¹⁵ In an in vitro study conducted by Priya et al dentinal micro-cracks that were induced by reciprocating and conventional full-sequence rotary systems were evaluated and it was found that no new micro-cracks were observed after the root canal preparation with different Ni-Ti file systems.¹⁶

CONCLUSION

To conclude, it has been established from the study that all the Ni-Ti rotary files are capable of inducing the cracks during the root canal instrumentation. The maximum percentage of cracks was seemed to be noticed in the apical region. And the maximum number of dentinal micro-cracks was seemed to be associated with the Pro Taper next files when compared with Wave One and Trunatomy files.

REFERENCES

1. N. T. Priya, V. Chandrasekhar, S. Anita et al., "Dentinal microcracks after root canal preparation' a comparative evaluation with hand, rotary and reciprocating instrumentation," Journal of Clinical and Diagnostic Research, vol. 8, no. 12, 2014.
2. S. Burklein, K. Hinschitz, T. Dammaschke, and E. Schafer, "Shaping ability and cleaning effectiveness of two single— file systems in severely curved root canals of extracted teeth: reciproc and WaveOne versus Mtwo and ProTaper," Journal of Endodontics, vol. 45, no. 5, pp. 449–461, 2012.
3. 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(2):236-38.
4. Liu R, Hou BX, Wesselink PR, Wu MK, Shemesh H. The incidence of root microcracks caused by 3 different single-file systems versus the protaper system. J Endod. 2013;39(8):1054-56.
5. Shori DD, Sheno PR, Baig AR, Kubde R, Makade C, Pandey S. Stereomicroscopic evaluation of dentinal defects induced by new rotary system: "ProTaper NEXT" Jol of Conserv Dent 2015 May-Jun;18(3):210-213.
6. Garg S, Mahajan P, Thaman D, Monga P. Comparison of dentinal damage induced by different nickel-titanium rotary instruments during canal preparation: An invitro study. Jol of Conserv Dent 2015 Jul-Aug;18(4):302-305.
7. 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 JOE 2010 Jul;36(7):1195-1199.
8. E. S. J. Pereira, I. F. C. Peixoto, A. C. D. Viana et al., "Physical and mechanical properties of a thermomechanically treated NiTi wire used in the manufacture of rotary endodontic instruments," International Endodontic Journal, vol. 45, no. 5, pp. 469–474, 2012.
9. Tamse A. Vertical root fractures in endodontically treated teeth: diagnostic signs and clinical management. Endodontic Topics 2006 Mar;13(1):84-94.
10. Shen Y, Zhou HM, Wang Z, Campbell L, Zheng YF, Haapasalo M. Phase Transformation Behavior and Mechanical Properties of Thermomechanically Treated K3XF NickelTitanium Instruments. J Endod 2013;39:919-923.
11. Dane A, Capar ID, Arslan H, Akc,ay M, Uysal B. Effect of Different Torque Settings on Crack Formation in Root Dentin. J Endod 2016;42:304-306.
12. Li SH, Lu Y, Song D, Zhou X, Zheng QH, Gao Y, Huang DM. Occurrence of Dentinal Microcracks in Severely Curved Root Canals with ProTaper Universal, WaveOne, and ProTaper Next File Systems. JOE 2015 Nov;41(11):1875-1879.
13. Shemesh H, Bier CA, Wu MK, Tanomaru-Filho M, Wesselink PR. The effects of canal preparation and filling on the incidence of dentinal defects. IntEndod J. 2009 Mar;42(3):208-13.
14. Dentsply Sirona. TruNatomy Brochure. Available at: <https://www.dentsplysirona.com/en/explore/endodontics/trunatomy.html>. Accessed 26 Apr 2019.
15. Riyahi AM, Bashiri A, Alshahrani K, Alshahrani S, Alamri HM, Al-Sudani D. Cyclic fatigue comparison of TruNatomy, Twisted fle, and ProTaper next rotary systems. IntEndod J. 2020;8:1–4.
16. Priya NT, Chandrasekhar V, Anita S, et al. Dentinal microcracks after root canal preparation: a comparative evaluation with hand, rotary and reciprocating instrumentation. J ClinDiagn Res 2014;8(12): ZC70-2.