Original Article

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COMPARISON OF DENTINAL DAMAGE INDUCED BY DIFFERENT NICKEL-TITANIUM ROTARY INSTRUMENTS DURING CANAL PREPARATION: AN IN VITRO STUDY

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ABSTRACT:

Aim: To compare dentinal damage caused by hand androtary nickel-titanium instruments using Protaper Next, K_3XF, and M_{two} system after root canal preparation.

Material and Methods: Seventy five freshlyextracted mandibular premolar were selected and randomly divided into five experimental groups of 15 teeth each and biomechanical preparation was done.Group 1: with unprepared teeth.Group 2: prepared with hand K-file. Group 3: withProtaper Next rotary system. Group 4: with K_3XF rotary system. Group 5: with M_{two}rotary system. Then, roots were cut horizontally at 3, 6, 9mm from apex and were viewed under Rapid X (V 2015 JLX). The presence of dentinal defects was noted.

Statistical analysis: Groups were analyzed with the Chi-square test.

Result: No significant difference was seen between the groups. No defects were found in unprepared roots and those prepared with hand files.Protaper Next, K_3XF, M_{two}preparations resulted in dentinal defects in 20%, 40% and 53% of teeth, respectively. More defects were shown in coronal and middle sections, and no defect was seen in apical third.

Conclusion: The present study revealed that the use of rotary instruments could result in an increased chance for dentinal defects as compared to hand instrumentation.

Keywords: Dentinal defects, hand files, rotary nickel-titanium files, RAPID X.

INTRODUCTION:

The ultimate goal of endodontic therapy is to achieve a three dimensional unblemished seal of the root canal system which is accomplished by the preservation of original course of canal and cleaning of entire root canal system. The biomechanical preparation is one of the major steps for removal of bacteria and debris in the root canal so as to achieve a successful endodontic treatment.[1]

Historically, stainless steel hand files have been used for achieving the goals of biomechanical preparation of root canal system. However, one of the main disadvantages of stainless steel hand files is that as the size of the file increases, the stiffness of the increases.

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This can lead to procedural errors such as canal transportation, apical zipping, canal ledges, and strip perforations especially in thin and curved canals.[2,3]

To avoid this damage, nickel-titanium instruments with shape memory and greater flexibility were developed. Canals prepared with NiTi instruments showed superior cleaning, less canal transportation and perforations. But nickel-titanium instruments carry inherent risk of instrument fracture and root dentinal crack formation. These root dentinal cracks further progress to root fractures resulting in failures of root canal treatment. NiTi instruments increases the risk of dentinal crack formation which can later propagate into VRF if the tooth is under repeated application of stress by occlusal forces, obturation and retreatment.[1,2,3]

Complexities in the preparation of root canal may be attributed to variations in the design of the cutting instruments, taper, or composition of the material from which it is made.[2] Hand instrumentation – the mile stone of endodontic practice in the past – though have lost popularity, still remains the integral part of canal preparation.[3]

Rotary Niti instruments in the canal may result in more friction, to due increased taper and various cutting edge designs, which may increase dentinal defects and microcrack formation in comparison to hand file.[4,5] Possible relationship between the design of NiTi rotary instruments and incidence of VRF was found by Kim *et al.,* and it was concluded that the design of the file affects strain concentration and the apical stress during instrumentation of root canal.[5]

There are several factors which may be responsible for the formation of root dentinal cracks such as force of instrumentation, technique of obturation, retreatment cases, high concentration of sodium hypochlorite used as irrigant, different shaping procedures with different cutting blades, taper and tip configuration. All these factors will ultimately lead to VRF during obturation.[6,7]

The goal of this study is to compare the damage caused by different NiTirotary instruments in root dentin after endodontic preparation.

MATERIALS AND METHODS:

Seventy five single rooted freshly extracted mandibular premolars were selected and cleaned with periodontal scaler and stored in purified water. Teeth with curved roots, calcified canals, extracanals, and teeth with developmental anomaly or resorption were excluded from the study. The teeth were decoronated at coronal portion by using a diamond disc, leaving roots approximately of 16mm in length. All the roots were inspected with RAPID-I (V 2015 J LX) x 12 (Figure.1), to exclude teeth with preexisting cracks or any craze lines from this study. The patency of the canal was established using a #10 K file. Then the roots were randomly divided into 5 experimental groups of 15 samples each.

- Group 1: Left unprepared and served as control.
- Group 2: Prepared using stainless steel K-files (DentsplyMallifer) upto to file #40 using step back technique.

In remaining three groups, canal patency was established with a #10 K file. Then a size #15K file was introduced into the canal until it was visible at the apical foramen. The working length was determined by subtracting 1mm from its measurements.

- Group 3: Prepared using ProTaper Next (Densplymallifer) rotary system (Figure.2) at a constant speed of 300 rpm in following sequence X1; X2 using a crown down technique with light apical pressure (recommended torque is 2Ncm, adjustable up to 5.2Ncm according to practitioners experience). Canal preparation was finished with X2 (25\.06)
- Group 4: Prepared using K3xf (Sybron endo) rotary system (Figure.3) sequentially at the speed 350-500 rpm using a crown down technique with light apical pressure (recommended torque is 3Ncm). Canal preparation was done upto file 25 \ .06 till working length
- Group 5: Prepared using M two(Sweden and Martin, Padova, Italy) rotary system (Figure.4) sequentially at the speed of 250-300 rpm using crown down technique with light apical pressure (recommended torque is 1-2Ncm) . Canal preparation was done upto file 25\.06 till working length.

Flutes of instruments were cleaned and frequently checked for any sign of distortion or wear. In all the groups 5% sodium hypochlorite was used between each instruments used in the canal.[8]

Sectioning and Microscopic evaluation:

- Sectioning of all roots was done perpendicular to the long axis 9, 6 and 3mm using a diamond disc under cooling water.[7,8,9] Digital images of each sections of roots were captured using RAPID-I (V 2015 J LX) Two operators checked each specimen for the presence of dentinal damage. Roots were classified as “no defect”, “fracture” and “other defects” as described in the table.

Classification for identification of defects in the specimens

- 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 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 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)

Statistical Analysis:

- All the results were expressed as the number and percentage of defects in reach group. Chi – square test was used for statistical analysis of the groups. The level of significance was set at P = 0.05% using statistical package for social sciences (SPSS) 20.0.

RESULTS:

(Figure.5) is a bar chart representing the number of root defects in each group. Group 1 and Group 2 showed no defects in roots of unprepared group and K- file group respectively. Dentinal defects were seen in Group 3; Group 4; Group 5 i.e. Protaper next; K_3XF ; M_{Two}. Protaper next group showed least defects (3/15); k_3xf showed (6/15) and M_{two}showed highest defects (8/15). But the difference was not significant among all the rotary systems used in this study. Similarly the defects were compared at 9; 6 and 3mm sections. At 3mm no defect was observed in all groups. Highest defects were seen at 6mm section of all rotary system in comparison with 9 mm sections. (Figure.6) is bar chart showing comparison of defects at 6mm in all rotary systems. (Figure.7) is a bar chart representing defects at 9 mm in all rotary systems. Result showed that no statisticalsignificant difference was seen for the presence of dentinal defects at coronal and middle thirds i.e at 9mm and 6mm.

Defect Distribution Among The Groups

File System	Defect	No Defects	Total
Pro Taper Next	3	12	15
K3 Xf	6	9	15
M-Two	8	7	15

Percentage Distribution Of Defect Among The Groups.

File System	Defect	No Defects
Protaper Next	20%	80%
K3 Xf	40%	60%
M-Two	53%	47%

DISCUSSION:

In the present study; in HFs, PTN, K_3XF, and M_{two}, the number and incidence of defects observed in the root dentin was found to be 0/15 (0%) , 3/15 (20%) , 6/15 (40%) , 8/15 (53%) respectively. Onnik et al were first to report dentinal defects as a consequence of canal preparation but only found small defects entirely within dentin that did not communicate with the canal wall[10]. Group 2 (HF's) showed no defects in roots. The results of our study are in accordance with Burklein et al; Yoldas et al; HIN at el; and Bier et al. who reported least amount or no defects caused by (HF's) during cleaning and shaping of canals[8,9,11,12]. This could be attributed to less aggressive movements of HF's in the canal as compared to engine driven files and less taper (0.02%).

Sectioning method used in the study could also result in dentinal defects. However both control and hand file group did not show any defect, we may conclude that the defects seen were not due to sectioning procedures used.

NAOCL is used as irrigating solution in the present study at a concentration of 5%. It is alkaline in nature and it reacts with organic tissue and can change the chemical structure and mechanical properties of the dentine observed bySim et al[13]. Slutzky et al observed that there is a marked decrease in microhardness of dentin when irrigation was done with NAOCL and it may affect crack propagation[14]. In this study all the teeth were irrigated with 5% NAOCL and same protocol was followed for all the groups. Roots prepared with HF's showed no defect, we can consider irrigation using NAOCL, did not contribute to the appearance of dentinal damage seems justified.

Excess removal of root dentin during root canal preparation and obturation of the canal with spreader may create fracture in the teeth [15].The important goal in endodontics is resistance to tooth fracture because such fractures mightcause decrease in the long-term survival rate[16]. In the presents study, no dentinal defect was seen in the HF group. The number of rotations required for complete root canal preparation is more with NiTi rotary instruments than with the HFs.

Kim *et al.*, stated that taper of the files is the responsible for increase of stress on the walls of the root canal; whereas[5], Bier *et al.*, stated taper of the files as one of the contributing factor for crack formation in root dentin[9]. In this study as the roots were prepared till 25/ 0.06. The taper was same for all the rotary systems used.

Rotational force is applied to the canals of the root by NiTirotary instruments, thus creating craze line or microcracksin root dentin. Formation of such defects may be associatedwith the design of tip, cross-sectional geometry, taper type(constant or progressive), flute form, and pitch (constant or variable) Al –Zaka et al. and Shemesh et al.[6,16].During canal preparation, it is shaped by the contact between instrument and the dentin walls. These contacts create many momentary stress concentrations in the dentin which may lead to dentinal defects.

In the present study, Protaper next showed least dentinal defects (3/15). It is similar to the results by Caper et al andshori et al.[17,18]ProtaperNext has a innovative off centered rectangular cross section. There is variable pitch for ProtaperNext files. Thus, it can be stated that design of the rotary files is not the only factor for defect formation in root dentin. Lam *et al*; stated that forces shaping the root dentin can be affected by the file design. Risk of root fracture is increased due to the forces generated during the root canal preparation.[19] ProtaperNext files have M-wire technology with 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.[20,21]

M-wire alloy NiTi material with controlled memory NiTi wire are flexible than those made from conventional NiTi wire. Thus, such flexibility of PTN rotary files may have contributed in less number of dentinal defects formation as compared to K_3xf and M_{two}.Capar*et al*; concluded that the swaggering motion and less taper of the PTN instruments could change the root canal volume to an extent as that of the higher tapered instruments.[17]

In group 4, showed 6/15 (40%) dentinal defects in examined roots which were prepared by K_3xf. K3xf instruments are identical to the previous K3 instruments in overall shape, but differ in that they undergo a proprietary Rphase heating treatment after the files are machined into their final shape. Decrease inincidence of crack formation with system could be due to its peripheral blade relief design of the file which claimed to reduce friction, facilitating its smoother operation. This feature controlled the depth of cut which prevented the files from over-engagement thus,protecting the root dentin from getting more damaged. This R phase treatment of the file provides superior cyclic fatigue resistance without any decline in the torsional or ultimate strength of the instruments and provides greater flexibility in comparsion to $M_{two.}$[12,22,23,24]

In group 5, showed the highest dentinal defect 8/15 (53%)with M_{two} the results of our study are in accordance withPratik et al files have active rotating movement resulting in high levels of stress concentration in root canal. M_{two}has S – shaped cross section and has two cutting edges which form long and almost vertical spirals. The backs of cutting edges are sharp to optimize cutting efficiency.[12,25]And it lack flexibility as compared to protaper next and k3xf. So this may be the reason for increased dentinal damage in the samples prepared by $M_{two.}$

Limitations:

1. Use of different speed and torque settings for each rotary system could be the limitation of our study. Increase in

the rotational speed is associated with increased cutting efficiency.[17]

2. Simulation of periodontal ligament was not done in the present study. Capar ID et al.[17] stated that simulation of the periodontal ligament is necessary for investigating the influence of forces on formation of crack or fracturestrength. Moreover, the periodontal ligament has viscoelastic property. It plays an important role in stress dissipation created by application of load to the teeth.

CONCLUSION:

Within the limitation of this in vitro study, Ni-Ti rotary instruments can induce various degrees of dentinal damage during root canal preparation. Reason may be more rotations and aggressive cutting which can generate increased stresses on the dentin wall and subsequent formation of dentinal defects. Instrumentation of root canals with Mtwo, K3XF, and ProTaper Next could cause damage to root canal dentin. ProTaper Next have tendency to cause less microcracks compared to other 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. 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. IntEndod J 2002;35:820-8.
3. Blum JY, Machtou P, Ruddle C, Micallef JP. Analysis of mechanical preparations in extracted teeth using ProTaper rotary instruments: Value of the safety quotient. J Endod 2003;29:567-75.
4. 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.
5. 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.
6. 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.
7. Milani AS, Froughreyhani M, Rahimi S, Jafarabadi MA, Paksefat S. The effect of root canal preparation on the development of dentin cracks. IrEndod J 2012;7:177-82.
8. 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.
9. 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.
10. 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.
11. Bürklein S, Tsotsis P, Schäfer E. Incidence of dentinal defects after root canal preparation: Reciprocating versus rotary instrumentation. J Endod 2013;39:501-4.
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.
13. Sim TP, Knowles JC, Ng YL, Shelton J, Gulabivala K. Effect of sodium hypochlorite on mechanical properties of dentine and tooth surface strain. IntEndod J 2001;34:120-32.
14. Slutzky-Goldberg I, Maree M, Liberman R, Heling I. Effect of sodium hypochlorite on dentin microhardness. J Endod 2004;30:880-2.
15. Shemesh H, Roeleveld AC, Wesselink PR, Wu MK. Damage to root dentin during retreatment procedures. J Endod 2011;37:63-6.
16. 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;42:208-13.
17. 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.
18. Shori DD, Shenoi PR, Baig AR, Kubde R, Makade C, Pandey S. Stereomicroscopic evaluation of dentinal defects induced by new rotary system: "ProTaper NEXT". J Conserv Dent 2015;18:210-3.
19. Lam PP, Palamara JE, Messer HH. Fracture strength of tooth roots following canal preparation by hand and rotary instrumentation. J Endod 2005;31:529-32.
20. ProtapernextTM flexible performance. Available from: www. dentsplymaillefer.com [Last accessed on 2017 Sep 09].
21. Protaper next flexible performance. Available from www.dentsplymaillefer. com [Last accessed on 2017 Sep 10]
22. Shen Y, Zhou HM, Zheng YF, et al. current challenges and concepts of the thermo-mechanical treatment of nickel-titanium instruments. J Endod 2013;39:163-72.
23. Ha J, Kim S, Cohenca N, Kim H. Effect of R-phase heat treatment on torsional resistance and cyclic fatigue fracture. J Endod. 2013;39(3):389-93.

24. Haapasalo M, Shen Y. Evolution of nickel–titanium instruments: From past to future. Endodontic topics. 2013;29(1):3-17.
25. Pratik Mavani, MadhuPujar, Veerendrauppin, HemantVagarali. Comparative Evaluation of root micro cracks by different rotary and reciprocating endodontic file systems. IOSR-JDMS Volume 14, Issue 9 Ver. II (Sep. 2015), PP 18-22.

FIGURES:

Figure 1- RAPID-I (V 2015 J LX)

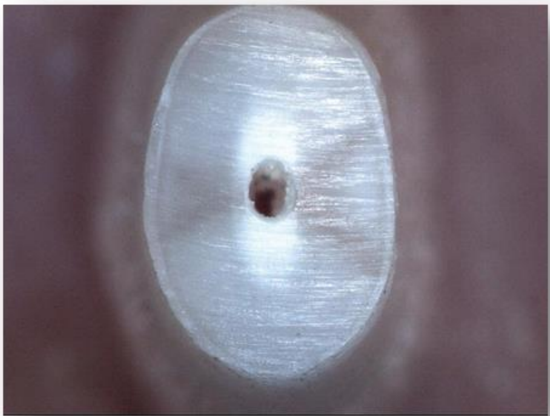

Figure 2- Tooth prepared using Protaper Next

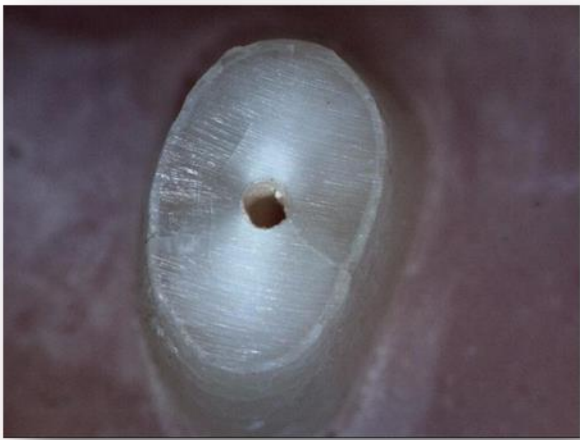

Figure 3- Tooth prepared using K3xf

Figure 4- Tooth prepared using M two

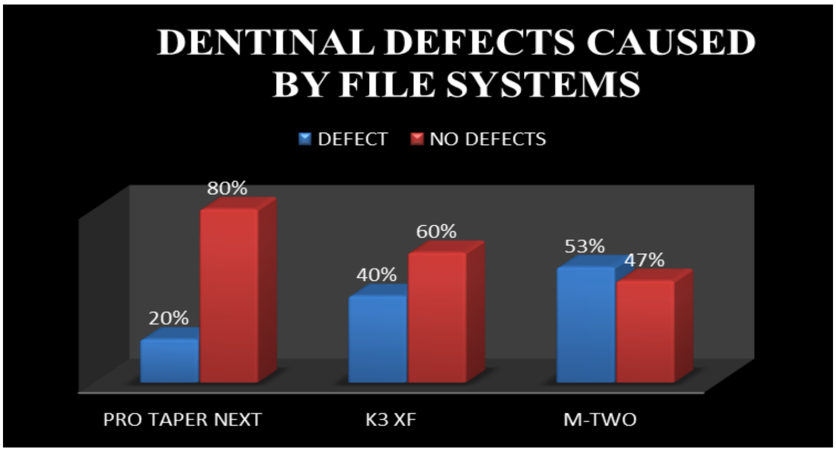

Figure 5- Dentinal defects caused by file system

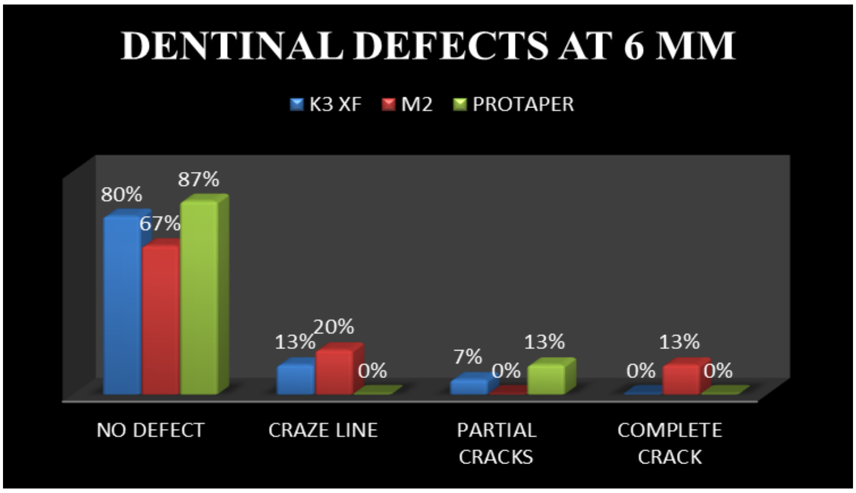

Figure 6- Dentinal defects at 6mm

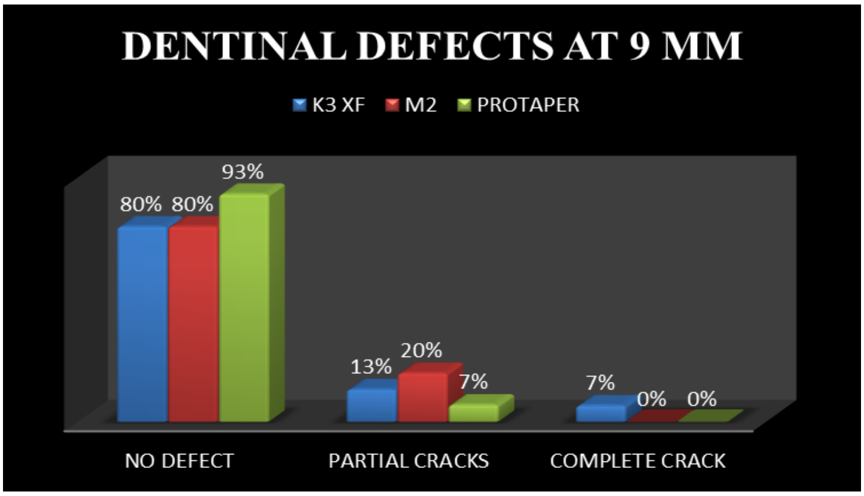

Figure 7- Dentinal defects at 9mm