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Original Article

Effect of various single file systems on microcrack formation in root canals: Scanning electron microscope study

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ABSTRACT

Background: The aim of this study was to compare dentinal crack formation in root canal walls following 3 single file systems with continuous rotation under a scanning electron microscope (SEM).
Materials and Methods: In this SEM study, seventy mandibular premolars were randomly divided into 5 groups. 3 experimental groups (n = 20) and 2 control groups (n = 5) as follows: Group I: Neolix NiTi file system, Group II: OneShape systems, Group III: OneCurve file system, positive control: conventional Hand File system, negative control: unprepared. After root canal preparations, the roots were sectioned at 3, 6, and 9 mm from the apex with water irrigation. The sections were inspected in all directions under SEM at × 100 magnification to determine the presence of cracks. The Chi-square test was used to analyze the data. There is a statistically significant difference in the crack formation between the apical third (P = 0.012) and coronal third (P = 0.002) when comparing all the 5 groups. No significant difference is found in the middle third (P = 0.46). $P < 0.05$ is considered statistically significant.
Results: Maximum cracks in the apical third were seen with One Shape file 11 (55%) and in the coronal third with Neolix NiTi 14 (70%). There is a statistically significant difference in the crack formation only in OneCurve when comparing the apical, middle, and coronal third for the individual group (P = 0.042).
Conclusion: There was a significant difference in crack formation in apical and coronal third. OneCurve caused the least incidence of cracks when compared to other file systems. OneCurve file system can be a choice for canal preparation over Neolix Niti and OneShape.

Key Words: Dentin, electron scanning microscopy, endodontics, nickel–titanium alloy, root canal

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INTRODUCTION

Root canal treatment aims to eradicate tissue debris as well as microorganisms from the root canal system. Chemomechanical preparation (CMP) achieved through instrumentation provides a canal with a larger diameter, smoother walls, and optimal apical size to allow copious irrigation along with 3-dimensional obturation. CMP is critical for successful endodontic treatment outcome.[1] The evolution of file systems over the years from stainless steel hand files system

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to NiTi rotary file system has made CMP effortless and predictable. Normally while preparing the root canal, the multiple NiTi files of different diameters and taper are used to gradually enlarge the root canal. In the preparation of the root canal, the advent of the single file system (SFS) is an exciting all-new concept. In SFS, only one file is required to prepare the canal to an adequate size and taper, even in narrow and curved canals. In addition to shaping the canal, SFS reduces the working time, lowers cross-contamination, and reduces the instrument fatigue without compromising the cutting efficiency when compared to multiple file systems. SFS is developed for shaping the vast majority of canals, regardless of their length, diameter, or curvature.[2,3] Neolix Neoniti (NEOLIX, Chatres-la-Foret, France), OneShape files (Micro-Mega, Besanc¸on Cedex, France), OneCurve (Micro-Mega Company) are some of the recently introduced SFSs with continuous rotation used for CMP.[2]

CMP of root canal induces stresses on dentin and causes microcracks and craze lines into the root dentin. Propagation of microcracks and craze lines over a period of time may lead to vertical root fracture (VRF) which generates serious endodontic complication rendering the tooth for extraction.[4,5] Introduction of scanning electron microscope (SEM) has proved to be a valuable method for the assessment of the ability of endodontic procedures to remove debris from root canals, thus enabling comparison of instruments and instrumentation techniques. SEM images have been used to evaluate the effects of preparation methods on root canal surface, cleaning efficacy of various root canal instruments, and formation of dentinal defects in endodontic practice.[6] Khoshbin *et al*. found that Neolix caused significantly least number of cracks when compared with Mtwo and ProTaper file system.[4] According to Das *et al*., the incidence of crack observed in root dentin was greater after instrumentation with OneShape as compared to HEDM and ProTaper Next.

To the best of the author's knowledge, the literature lacks data on the effect of above mentioned three SFSs on dentin. Hence this study was conceptualized to compare dentinal crack formation in root canal walls following instrumentation with Neolix NiTi, One Shape, and OneCurve SFSswith continuous rotation, to the conventional Hand File system under SEM.

MATERIALS AND METHODS

This SEM study was performed after Institutional Ethical Committee (IEC) clearance (CDCRI/DEAN/ETHICS COMMITTEE/ENDO/PG-01/19). Freshly extracted, single-rooted, and single canalled 80 mandibular first premolars were collected. Teeth with apical foramen no larger than size #15 K-file with a maximum root curvature of 25°C were included in the study. Teeth with internal or external root resorption, external surface cracks (observed under ×25), root caries, open apex, or canal calcification were excluded (n = 10). The teeth were cleaned with an ultrasonic scaler and then disinfected using 2.5% sodium hypochlorite. They were stored in distilled water to prevent dehydration throughout the study. The crowns of all teeth were decoronated such that the remaining standardized root length is 17 mm that enabled straight-line access to the canal [Figure 1]. A silicon impression material was used for coating the external root surface so as to simulate periodontal ligament space. Care was taken to instrument the root canals immediately after setting of polyvinyl siloxane so as to avoid loss of properties of the impression material which is simulating the periodontal ligament [Figure 2a]. All roots were subsequently embedded in acrylic blocks [Figure 2b]. All samples were randomly divided into 3 experimental groups (n = 20 for each group) and 2 control groups (n = 5 for each group) as follows:

- Group I: Neolix NiTi file system (n = 20)
- Group II: OneShape systems (n = 20)
- Group III: OneCurve file system (n = 20)
- Positive control: Conventional Hand File System (n = 5)
- Negative control: Unprepared (n = 5).

The working length (WL) was established by inserting a size 10 K file to the root canal terminus and subtracting 1 mm from this measurement. Glide

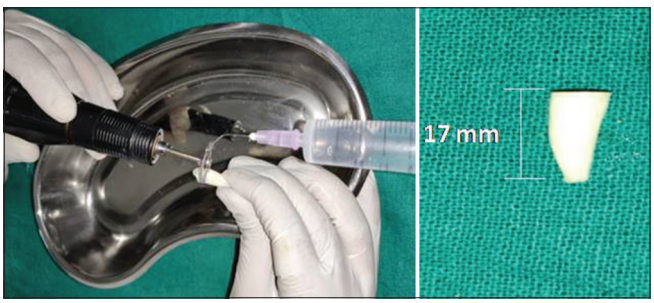


Figure 1: Crowns of all teeth were de-coronated so as to maintain the standardized root length as 17 mm.

path was prepared using size 10 Kfile up to the WL. Moreover, after each instrument, a size 10 Kfile was used to maintain the canal patency between all steps.

Group I: Root canal preparation with Neolix NiTi file system (n = 20)

Neolix files (Neolix Xavier, Châtres-la-Forêt, France) system has A1 and C1 files. Both files were used with a speed of 300–500 rpm and torque limit of 1.5 N/cm.[5] C1 (25/0.12 and 15 mm length) file was used for flaring of the root canal orifice [Figure 3a]. A1 (25/0.08) file was then passively used to prepare the middle and apical thirds of the canal. After each use, the file is removed from the canal, and debris is cleaned from the flutes using gauze. The root canals were rinsed with 5 mL 5.25% sodium hypochlorite solution. After reaching the WL a final rinse of the canal was performed.

Group II: Root canal preparation with OneShape systems (n = 20)

One-Shape (Micro-Mega, Besanc¸on Cedex, France) system consist of one instrument with a tip size of 25 and a constant taper of 0.06 File operates at Speed-350–450 RPM and Torque-2.5 N/cm^2. Canal preparation is accomplished with a slow in-and-out pecking motion. This movement is repeated till the WL [Figure 3b]. After each use, the file is removed from the canal, and debris is cleaned from the flutes using gauze. The root canals were rinsed with 5 mL 5.25% sodium hypochlorite solution. After reaching the WL a final rinse of the canal was performed.

Group III: Root canal preparation with OneCurve file system (n = 20)

OneCurve (Micro-Mega Company) system consists of a file with a tip size of #25 and a constant taper of 0.06 operating at a speed of 300 rpm and 2.5 N/cm^2 torque. Canal preparation is accomplished with slow in-and-out pecking till the file reaches the WL [Figure 3c]. After each use, the file is removed from the canal, and debris is cleaned from the flutes using gauze. The root canals will be rinsed with 5 mL 5.25% sodium hypochlorite solution. After reaching the WL a final rinse of the canal was performed.

Group IV: Root canal preparation with conventional Hand File system (n = 20)

Roots in the control group were instrumented with stainless steel hand K-files (Mani, Japan). #15 K-file was used as an initial file. Roots were prepared to apical size #25 and prepared up to size # 50 using a step-back technique with 1-mm increments [Figure 3d]. Root canal irrigation was completed with 5 mL 5.25% sodium hypochlorite after each file and a final rinse was performed.

After CMP, all the samples were sectioned horizontally at 3, 6, and 9 mm from the apex with the aid of a low-speed handpiece under water coolant using a diamond disc (thickness: 0.3 mm) [Figure 4]. Digital image of each section was captured at ×100 magnification using SEM roots with a crack in at least 1 section of the root were classified as cracked [Figures 5 and 6]. This included both complete and incomplete cracks originating from the root canal wall and extending to the root surface.

Data were analyzed using SPSS Version 21 (SPSS Inc., Armonk, NY, USA). Results were reported as the frequency of cracks in the 3 sections for each group. The Chi-square test was used to compare the frequency of cracks among the 5 groups, with $P < 0.05$ considered statistically significant.

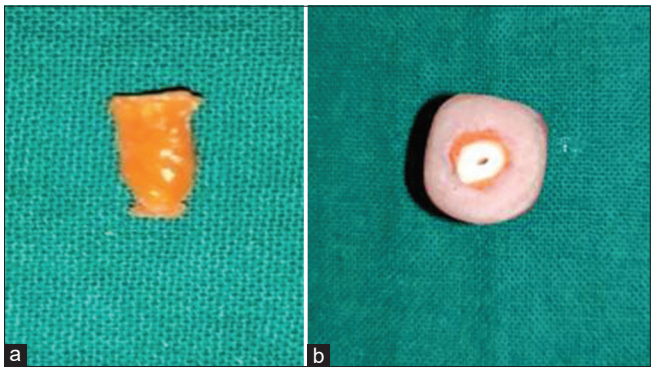


Figure 2: A silicon impression material was used for coating external root surface (a) and were subsequently embedded in acrylic blocks (b).

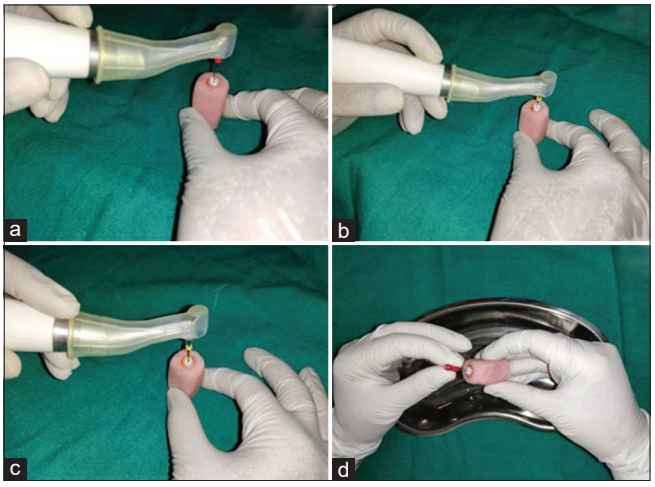


Figure 3: Root canal preparation done with Neolix NiTi (a), OneShape (b) OneCurve, (c) and conventional Hand File (d) system.

RESULTS

Evaluation of crack formation at various levels revealed that apical third (P = 0.012) and coronal third (P = 0.002) showed significant incidence of crack formation compared to middle third (P = 0.46) in all 5 groups [Table 1]. In Group I, 14 (70%) samples had a crack in the coronal third; however, there was no statistically significant difference in the incidence of crack at all 3 levels (P = 0.12). In One Shape file group, maximum cracks were seen in apical third (11 [55%]) but it was nonsignificantly different from other levels [Graph 1]. Moreover, in Group III, there was a statistically significant difference in crack formation with the highest incidence at the middle third (P = 0.042).

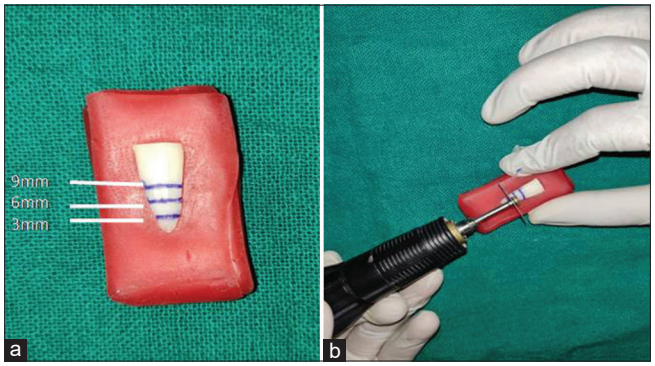


Figure 4: All samples were sectioned horizontally at 3, 6, and 9 mm from the apex with the aid of a low-speed handpiece using a diamond disc.

DISCUSSION

Root canal preparation using endodontic files is frequently associated with the formation of some dentinal defects.[7] Most of the NiTi instruments with different designs result in incomplete cracks, craze lines, or even VRF, and such defects should be prevented as it necessitates tooth extraction.[5,8] A significant association exists between the amount of dentin removed and crack formation, and excessive widening of the canal increases the risk of VRF.[7] Even in the absence of VRF, the presence of cracks can compromise the outcome of endodontic treatment.[1] The current study assesses the frequency of microcrack formation using 3 different SFS with continuous rotation and conventional Hand File system with the help of SEM. SFS with continuous

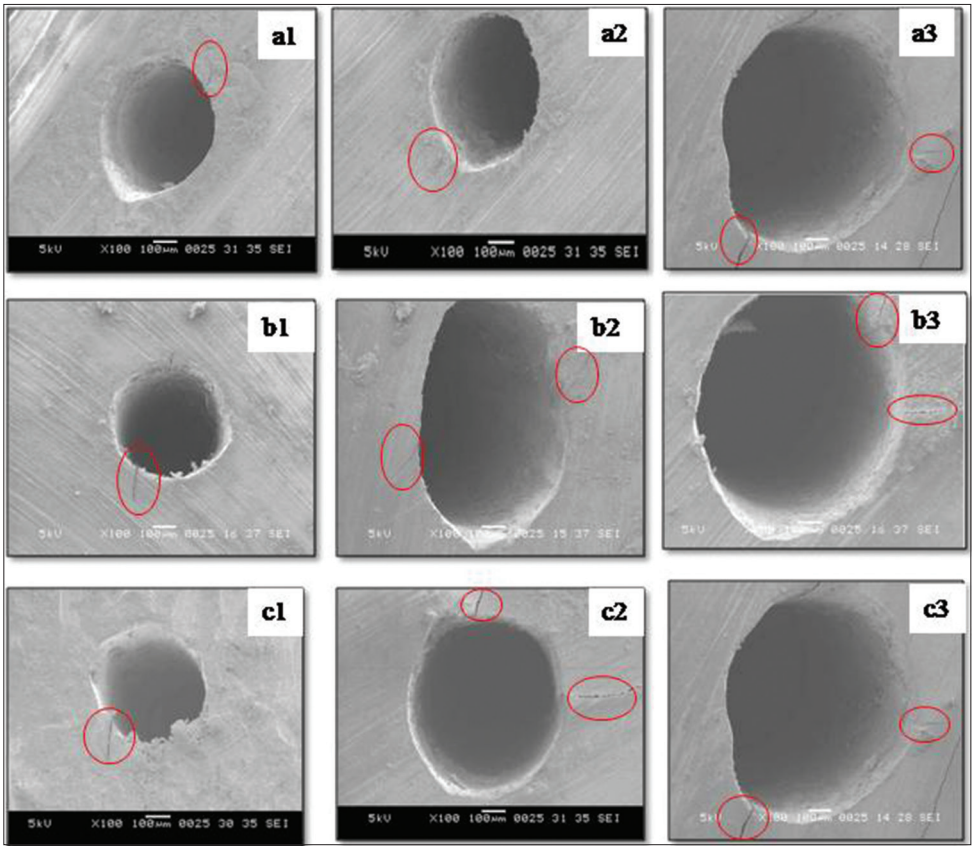


Figure 5: Digital image of each section at × 100 magnification using SEM (a) Neolix NiTi file system; (b) OneShape file system; (c) OneCurve file system. 1 - at apical third (3 mm); 2 – middle third (6 mm); 3 - coronal third (9 mm), respectively.

Table 1: Number and percentage of dentinal crack at apical (3 mm), middle (6 mm), and coronal third (9 mm)

Groups	File system	Apical third (3 mm) (%)	Middle third (6 mm) (%)	Coronal third (9 mm) (%)	*P*
Group I	Neolix NiTI	9 (45)	8 (40)	14 (70)	0.12
Group II	One Shape	11 (55)	7 (35)	4 (20)	0.070
Group III	OneCurve	2 (10)	9 (45)	5 (25)	0.042 (S)
Group IV	Hand File	2 (40)	2 (40)	3 (60)	0.85
Group V	Unprepared	0 (0)	0 (0)	0 (0)	
P		0.012	0.46 (NS)	0.002	

P<0.05 was considered to be statistically significant. NS: Not significant, S: Significant

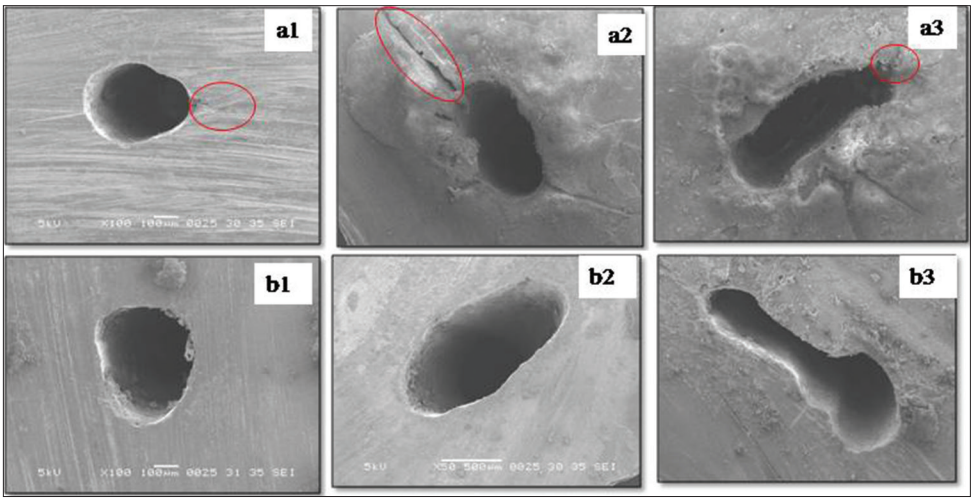
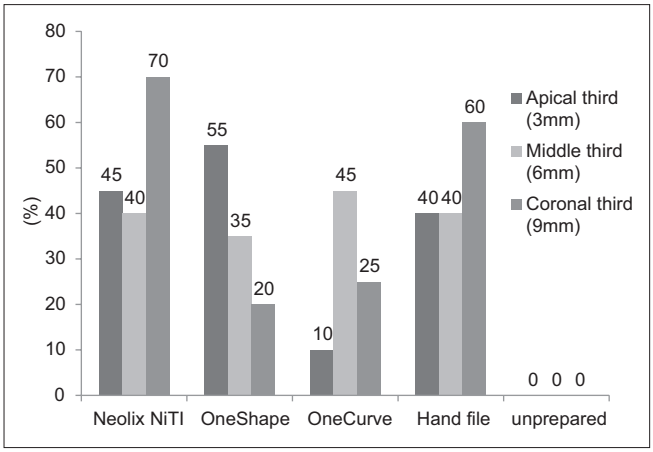


Figure 6: Digital image of each section at × 100 magnification using SEM (a) Hand File system; (b) unprepared. 1 - at apical third (3 mm); 2 - middle third (6 mm); 3 - coronal third (9 mm) respectively.

rotation was used because of their economic viability, unique design, and presterilized usage with zero cross-contamination.[9]

Mandibular premolars were selected for the study because of the high prevalence of VRF as reported by Tamse *et al*.[10] Acrylic blocks and a silicone impression material were used to simulate bone and periodontal ligament respectively. Periodontal ligament simulation acts as a major stress absorber and sways the outcome of such studies.[11] In this study, the apical master file was standardized using a file with a tip diameter equivalent to size 25. After canal preparation, all file systems showed dentin crack formation which was in accordance with previous studies.[11,12] In this study, OneShape file showed maximum number of dentinal cracks in the apical third (11 [55%]) and minimum in the middle third (4 [20%]). Das *et al*. reported similar results in their study.[13] It has a triangle cutting edge in the apical part, 2 cutting edges in the coronal part, and a cross-section that progressively changes from 3 to 2 cutting edges between the apical and coronal parts.[13] This design may affect shaping forces on root dentin these forces may cause root fracture.[14] This could be the probable reason for more cracks in the apical region. No statistically significant difference (P = 0.070) was seen between crack formation at apical, middle, and coronal third for OneShape. Neolix NiTi showed maximum cracks in the coronal third when compared to other file systems which was in accordance with Harandi *et al*.[5] The file is generated using a wire-cut electrical discharge machining process and has rectangular non-similar cross-sections all along its length this file has larger taper (0.08) and increased rotational speed (500 rpm) when compared to the other two file system which generate more stress thus causing dentin damage as suggested by Bier *et al*.[8] This result was contradictory to the results of Harandi *et al*. and Elham *et al*.[4,5] No statistically significant difference (P = 0.12) was seen between crack formation at apical, middle, and coronal third for Neolix NiTi.

OneCurve showed maximum cracks in the middle third and minimum in the apical third. OneCurve files are composed of a NiTi alloy that undergoes a patent protected heat treatment (C. Wire), which provided a shape-memory effect. It has the same tip size (size 25) and the constant taper (0.06) of their predecessors but has a different shape design. The



Graph 1: Percentage of dentinal crack at apical (3 mm), middle (6 mm), and coronal third (9 mm) for all groups

variable cross-sections with a triangular-shaped at the tip of the instrument and S-shaped near the shaft are claimed to allow effective cutting and centered trajectory.[15] The fie design could be the reason for more cracks in the middle third. It was seen that the experimental groups showed more crack formation than positive control which was in accordance with previous studies that stated rotary instruments cause more dentin damage.[16,17] Significant difference was seen (P = 0.042) between crack formation at apical, middle, and coronal third for OneCurve. A significant difference was seen in the apical third (P = 0.012) and coronal third (P = 0.002) when comparing all file systems.

It should be noted that this study had an *in vitro* design, though periodontal ligament was simulated using polyvinyl siloxane impression material, it doesn't provide the exact intraoral environment. As the extracted tooth becomes brittle, the incidence of a crack in such teeth increases. Thus, the generalization of results to the clinical setting must be done with caution. Future clinical studies are required to obtain more reliable results.

CONCLUSION

Within the limitation of this study, it can be concluded that all file systems produce some amount of crack. There was a significant difference in crack formation in apical and coronal third. OneCurve showed a minimal incidence of crack when compared to Neolix Niti and OneShape. Neolix NiTi showed the maximum number of cracks. OneCurve file system can be a choice for canal preparation over Neolix Niti and OneShape in such oval canals.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Shantiaee Y, Dianat O, Mosayebi G, Namdari M, Tordik P. Effect of root canal preparation techniques on crack formation in root dentin. J Endod 2019;45:447-52.
2. Sharma P, Goel M, Verma S, Sachdeva GS, Sharma N, Kumar V. Entering a new era in endodontics with revolutionary single file systems: A comprehensive review. EC Dental Sci 2016;5:1100-22.
3. Parimoo D, Gupta R, Tomer A, Rohilla S. Single file endodontics: boon or myth. Asian Pac J Health Sci 2016;3:102-5.
4. Khoshbin E, Donyavi Z, Abbasi Atibeh E, Roshanaei G, Amani F. The effect of canal preparation with four different rotary systems on formation of dentinal cracks: An in vitro evaluation. Iran Endod J 2018;13:163-8.
5. Harandi A, Mirzaeerad S, Mehrabani M, Mahmoudi E, Bijani A. Incidence of dentinal crack after root canal preparation by ProTaper universal, Neolix and SafeSider systems. Iran Endod J 2017;12:432-8.
6. Çiçek E, Koçak MM, Sağlam BC, Koçak S. Evaluation of microcrack formation in root canals after instrumentation with different NiTi rotary file systems: A scanning electron microscopy study. Scanning 2015;37:49-53.
7. 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.
8. Bier CA, Shemesh H, Tanomaru-Filho M, Wesselink PR, Wu MK. The ability of different nickeltitanium rotary instruments to induce dentinal damage during canal preparation. J Endod 2009;35:236-8.
9. Zinge PR, Patil J. Comparative evaluation of effect of rotary and reciprocating single-file systems on pericervical dentin: A cone-beam computed tomography study. J Conserv Dent 2017;20:424-8.
10. Tamse A, Fuss Z, Lustig J, Kaplavi J. An evaluation of endodontically treated vertically fractured teeth. J Endod 1999;25:506-8.
11. Kansal R, Rajput A, Talwar S, Roongta R, Verma M. Assessment of dentinal damage during canal preparation using reciprocating and rotary files. J Endod 2014;40:1443-6.
12. 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.
13. Das S, Pradhan PK, Lata S, Sinha SP. Comparative evaluation of dentinal crack formation after root canal preparation using ProTaper Next, OneShape, and Hyflex EDM J Conserve Dent. 2018; 21:153.
14. Lam PP, Palamara JE, Messer HH. Fracture strength of tooth roots following canal preparation by hand and rotary instrumentation. J Endod 2014;37:997-1001.

15. Serafin M, De Biasi M, Franco V, Angerame D. *In vitro* comparison of cyclic fatigue resistance of two rotary single-file endodontic systems: OneCurve versus OneShape. Odontology 2019;107:196-201.
16. Garg E, Sarfi S, Bali D, Garg AK. Comparative evaluation of dentinal defects induced by hand files, hyflex, protaper next and one shape during canal preparation: A stereomicroscopic study. J Int Clint Dent Res Organ 20171;9:16.
17. Vora EC, Bhatia R, Tamgadge S. Effect of three different rotary instrumentation systems on crack formation in root dentin: An *in vitro* study. Endodontology 2018;30:103.