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TOPOGRAPHIC CHANGES OF TWO DIFFERENT Ni Ti FILE SYSTEMS AFTER MULTIPLE USES

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ABSTRACT

Aim: To study the topographic changes of protaper Next and Two Shape NiTi file systems after three uses.

Materials and Methods: Four sets of Protaper Next and four sets of Two Shape files were used to prepare MB canals of mandibular first molars. Twenty four mandibular first molars with nearly similar lengths (20 to 22 mm) and the mesiobuccal canals with curvature ranged from 20º - 40º were used. All teeth were subjected to access cavity, MB canal localization, WL determination and the teeth were randomly assigned to two groups, twelve for each according to the type of NiTi rotary files used. Group I, twelve MB canals were prepared by using the four sets of Protaper Next NiTi rotary files. Group II, twelve MB canals were prepared by using the four sets of Two Shape NiTi rotary files. Every set prepare three canals. All sets of Protaper Next including X1 & X2 and Two Shape including TS1 & TS2 were scanned under SEM before and after canal preparation in the same position at three parts: apical part, middle part and the critical point (3-5 mm from the file tip) and photographed. No visible defects, pitting, corrosion, fretting, micro cracks, fractures, metal strips, spiral distortion, blunt cutting edges, disruption of cutting edges or fatigue cracks were the criteria of surface deformations of files. All deformations were tabulated and compared before and after root canal preparation.

Results: PTN sets: one X1 showed disruption of cutting edges before and after use, one X1 showed disruption of cutting edges after use, two X1 and four X2 files showed no visible defects. TS sets: one TS1 showed disruption of cutting edges before and after use, three TS1 showed no visible defects. One TS2 showed pitting before and after use, one TS2 showed corrosion after use, one TS2 showed disruption of cutting edges and micro cracks after use and one TS2 showed no visible defects.

Conclusion: Based on the results of this study, it is safe to instrument up to three curved canals by PTN or TS rotary NiTi files without file fracture.

KEYWORDS: Protaper Next file, Two Shape file, Topographic changes, Multiple use.

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INTRODUCTION

Nickel Titanium endodontic instruments have been widely selected by endodontists for cleaning and shaping the root canals to facilitate obturation because they have much greater flexibility owing to their low elastic modulus and superelasticity compared with stainless steel endodontic instruments [1]. Also, it can prepare root canals with less apical aberrations and with an excellent taper and flow [2-4].

NiTi files are prone to fracture due to their fatigability as a result of stress during instrumentation of the root canal without any visible defects. Clinically, difficulty in removing fractured pieces of the broken files may compromise the outcome of endodontic treatment. So, routine glide path establishment can increase the lifespan of rotary instruments with a reduced risk of instrument fracture [5].

Fatigability that leads to NiTi endodontic instruments failure can be caused by flexural / cyclic fatigue or torsional fatigue. Flexural / cyclic fatigue occurs because of repeated compressive and tensile stresses accumulated at the point of maximum flexure when the file is used in a curved canal, depending on the radius of curvature and the type of filing action, which is the most destructive form of stress [6-8]. On the other hand, torsional fatigue occurs in two forms: Dynamic fatigue, which result from frictional forces that are caused by resistance of dentin to the file's cutting and static fatigue, which occurs during root canal preparation when the tip or any other part of the file is locked in, but the shaft continues to rotate [9]. Torsional fatigue normally shows plastic deformation followed by fracture and can be evaluated microscopically [10]. Therefore, examining the surface of endodontic files before every use would have an important impact on the identification of fracture initiation and file failure [11].

Many studies using scanning electron microscopy have revealed surface deformations as the presence of micro-fissures, machining marks, metal strips, pits, and blunt cutting edges on the surface of both new and used Ni-Ti rotary instruments [12-16]. These surface defects may initiate micro-cracks and play a role in the fatigue failure of instruments [17].

The total fatigue life of NiTi alloys consists of 3 stages: (1) crack initiation, in which micro-cracks form and start to grow preferentially along specific crystallographic planes followed by (2) crack propagation, in which the crack grows continuously, until (3) the crack reaches the point where the remaining material is overstressed and the result is the overload zone results. The overload zone features a typical dimple rupture or so-called ductile failure [17-19].

The root canal geometry (including the radius and angle of curvature), rotation speed (rpm), instrumentation force, instrument design (diameter, taper, and cross-sectional configuration) and the surface quality of files were found to be an important factors in fatigue fracture of Ni-Ti rotary instruments [6, 20-26].

NiTi rotary instrument intracanal separation caused by cyclic fatigue has remained a primary concern in endodontics practice, especially for root canals with severe curvatures even with a considerable improvement in file design, manufacturing methods, and preparation techniques. Therefore, to improve fatigue resistance of rotary instruments, the direction is to optimize the microstructure of NiTi alloys through novel thermo-mechanical processing or new manufacturing technologies. Recently, a new NiTi wire (termed M-Wire) has been developed through a proprietary thermo-mechanical processing procedure and showed significantly improved cyclic fatigue resistance on endodontic rotary instrument products in comparison with those made of conventional super-elastic NiTi alloys [27–31].

ProTaper next (PTN) file system (Dentsply Maillefer, Ballaigues, Switzerland) was produced from M-wire alloy used for root canal shaping in continuous rotation. It has greater flexibility and superior cyclic fatigue resistance compared with other conventional NiTi rotary instruments [32-37]. It is designed with rectangular cross section design for greater strength. The patented design's axis of rotation differs from the center of mass. As a result, only two points of the rectangular cross section touch the canal wall at a time with snake-like swaggering movement. This improved action creates an enlarged space for debris removal, optimizes the canal tracking and reduces binding [38]. Protaper Next is available in five instruments, X1 (size 17, 4% apical taper), X2 (size 25, 6% apical taper), X3 (size 30, 7% apical taper), X4 (size 40, 6% apical taper), X5 (size 50, 6% apical taper).

Recently, Two Shape rotary NiTi file system (Micro Mega, Besancon, France) is a new T-wire technology with integrating heat treatment for root canal shaping in continuous rotation. It has a new asymmetrical cross section for better negotiation of curvatures, preservation of the elasticity of NiTi, better resistance to cyclic fatigue, and more flexibility. The asymmetrical cross section reduces the risk of instrument fracture [41] and increases the efficacy of the circumferential brushing movements for efficient selective cleaning of the root canal walls [39]. It is supplied in two files, TS1 (size 25, 4% taper) and TS2 (size 25, 6% taper). The Two Shape sequence allows a better removal of suspended debris and respects the original root canal anatomy.

Asthana et al (2016) [40] concluded that, visible defects in NiTi files due to torsional fatigue were seen by naked eyes as well as by stereomicroscope. This study emphasizes that all the files should be observed before and after every instrument cycle to minimize the risk of separation.

Thus, the purposes of our study were to observe and compare the morphological alterations of PTN and Two Shape files before and after multiple use by scanning electron microscopy (SEM).

MATERIALS AND METHODS

Four sets of Protaper Next and four sets of Two Shape files were used in the present study to prepare MB canals of mandibular first molars. Twenty four mandibular first molars with nearly similar lengths (20 to 22 mm) and the mesiobuccal canals with curvature ranged from 20^o - 40^o were used according to the Schneider method [41]. Also, to determine the root canal curvature, mesiobuccal and buccolingual radiographs were taken according to parallel technique [42]. Only teeth with fully developed roots, with no internal or external resorption and no root canal treatment were included in this study. All teeth were kept in saline until used (Figure 1).

Fig. (1) Mandibular first molars with files in curved MB canals.

Samples preparation

All teeth were cleaned from external debris and soft-tissue remnants. The access cavities were prepared, and the MB canals were localized and explored with a size 10 K-type file (Dentsply/ Maillefer, Ballaigues, Switzerland). The mesiobuccal cusp tip in all teeth was flattened by an air motor hand piece and a diamond bur (Dentsply/ Maillefer, Tulsa, USA) to secure the reference point and standardize the working length (WL) of all teeth. A size 10 K-type file was passively advanced into the mesiobuccal canal for every tooth until the tip of the instrument penetrated and adjusted to the apical foramen to confirm the patency of mesiobuccal canals from their orifices to the separated apical foramina and this measurement was recorded. The working length was calculated by subtracting 1 mm from this measurement and recorded for every tooth.

Pre-instrumentation scanning

Before canal preparation started, all sets of Protaper Next including X1 & X2 and Two Shape including TS1 & TS2 were examined by scanning electron microscope (SEM) (JEOL, JSM-5300, Japan) with the flat part of latch end directed upward. Three areas of every file were photographed: at apical third, middle third and the critical point area which is 3-5 mm away from the tip of file [43].

Canal instrumentation

The teeth were randomly assigned to two groups, twelve for each according to the type of NiTi rotary files used for curved mesiobuccal canal preparation.

Group I

The twelve MB canals of this group were prepared by using the four sets of Protaper Next NiTi rotary files (Dentsply/ Sirona, Ballaigues, Switzerland), every set prepare three canals. Manual glide path with standard stainless steel size 10 K-file firstly established followed by proGlider (size 16, 2% apical taper) (Dentsply / Sirona, Switzerland) to ensure more safety during the use of the first NiTi rotary files. PTN files were used in the canals with the crown-down technique, driven by the DENTA PORT ZX endodontic motor (J. Morita, Japan) in rotational motion. The rotational speed was set as recommended, at 350 rpm with a torque of 2.5 N/cm. The preparation was performed using two files (X1 and X2) through a gentle in-and-out motion until the full WL was reached. The instrumentation sequence was as follows: X1 file (size 17, 0.04 taper) followed by the X2 file (size 25, 0.06 taper).

Group II

The twelve MB canals of this group were prepared by using the four sets of Two Shape NiTi rotary files (Micro-Mega, Cedex, Besancon, France), every set prepare three canals. The glide path was created for every MB canal with NiTi G-Files (Micro-Mega, Sanavis group, France) to ensure more safety during the use of the first NiTi rotary files. Manual glide path with standard stainless steel size 10 K-file firstly established followed by NiTi G1 (size 12, 0.03 taper) and NiTi G2 (size 17, 0.03 taper) to the working length. Two Shape files were used in the canals with the crown-down technique, driven by the DENTA PORT ZX endodontic motor (J. Morita, Japan) in rotational motion. The rotational speed was set as recommended, at 350 rpm with a torque of 2.5 N/cm. Progressive movement of every file was done in three up-and-down movements with upward circumferential brushing movement when feeling the resistance to reach the working length. The instrumentation sequence was as follows: TS1 file (size 25, 0.04 taper) followed by TS2 file (size 25, 0.06 taper).

After every file motion in the two groups, the files were with-drawn from the canals, the flutes were cleaned, and the root canals were irrigated by 2 mL of 2.5% sodium hypochlorite. Irrigation was performed in exactly the same manner for all the specimens with 27-G irrigation needle. Canal patency was checked with a size 10 K-file (Dentsply/

Maillefer, Ballaigues, Switzerland) between every file used 1 mm beyond the apical foramen. All canals were prepared by the same operator.

Post-instrumentation scanning

After canal preparation, all sets of Protaper Next including X1 & X2 and Two Shape including TS1 & TS2 were cleaned ultrasonically (Branson, B-220, USA) and re-examined by scanning electron microscope (SEM) with the flat part of latch end directed upward as done pre-instrumentation. The same three areas of every file were re-photographed as before: at apical third, middle third and the critical point area which is 3-5 mm away from the tip of file.

Examination criteria

The criteria used for checking the instruments' surface defects were adopted by Eggert et al. (1999) [15] and were as follows: No visible defects, pitting, corrosion, fretting, micro cracks, fractures, metal strips, spiral distortion, blunt cutting edges, disruption of cutting edges or fatigue cracks (Table 1).

The surface topographic changes of files after root canal instrumentation of curved MB canals of mandibular first molars were tabulated and compared with the surface topography of the files before instrumentation in the two NiTi rotary file systems used.

TABLE (1) Topographic deformations of protaper Next and Two Slape files before and after three uses

Criteria	PTN 1				PTN 2				PTN 3				PTN 4				2 Shape 1				2 Shape 2				2 Shape 3				2 Shape 4			
	X1		X2		X1		X2		X1		X2		X1		X2		TS1		TS2		TS1		TS2		TS1		TS2		TS1		TS2	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
No Visable defect	×	×	×	×			×	×	×		×	×	×	×	×	×			×	×	×	×	×		×	×			×	×	×	
Pitting																											×	×				
Corrosion																								×								
Fretting																																
Microcracks																																×
Fracture																																
Metal strips																																
Spiral distortion																																
Blunt cutting edges																																
Dis ruption of cutting edge					×	×				×							×	×														×
Fatigue fracture																																

(PTN)= Protaper Next file/ (2 Shape)= Two Shape file/ (B) = Before instrurrentation/ (A)= After instrurrentation three canals

RESULTS

X1 and X2 of each of the four Protaper Next and TS1 and TS2 of each of the four Two Shape file systems were examined by SEM two times; before instrumentation (B) and after three uses (A) (a total of 8 files in each file system). These files used to instrument twenty four curved mesiobuccal canals of mandibular first molars, twelve in each group. Surface topographic changes were examined for each file in the apical third, middle third and the critical point area which is 3-5 mm away from the tip of file regarding some criteria which are no visible defects, pitting, corrosion, fretting, microcracks, fractures, metal strips, spiral distortion, blunt cutting edges, disruption of cutting edges and fatigue cracks.

In Protaper Next group I, one out of four X1 files, disruption of cutting edge was observed on the apical part of the file before and after three uses but, no visible defects were observed in the middle part and the critical point of the file before and after use (Figure 2).

Another X1 file showed also disruption of cutting edge in the apical part and the critical point of the file after three uses with no visible defects were observed before use. No visible defects were observed in the middle part of this file before or after use (Figure 3).

The remaining two X1 files showed no visible defects neither before nor after three uses in the apical part, middle part and the critical point of the files.

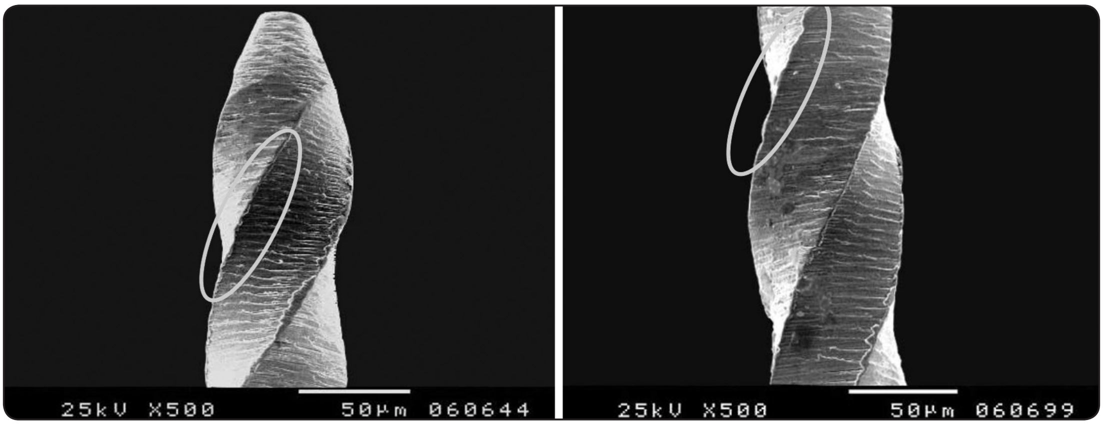
The four X2 files of the same group used in this study showed no visible defects neither before nor after three uses in the apical part, middle part and the critical point of the files (Figure 4) (table 2).

TABLE (2) Comparison between protaper Next and Two Shape files regarding to topographic deformations before and after three uses

Criteria	PTN files				Shape files 2			
	X1		X2		TS1		TS2	
	B	A	B	A	B	A	B	A
No Visable defect	3	2	4	4	3	3	3	1
Pitting							1	1
Corrosion								1
Fretting								
Microcracks								1
Fracture								
Metal strips								
Spiral distortion								
Blunt cutting edges								
Disruption of cutting edge	1	2			1	1		1
Fatigue fracture								

(PTN)= Protaper Next file/ (2 Shape)= Two Shape file/ (B)= Before instrumentation/

(A)= After instrumentation three canals



Before After

Fig. (2) Disruptions of cutting edge in the apical part of PTN X1 file before and after use.

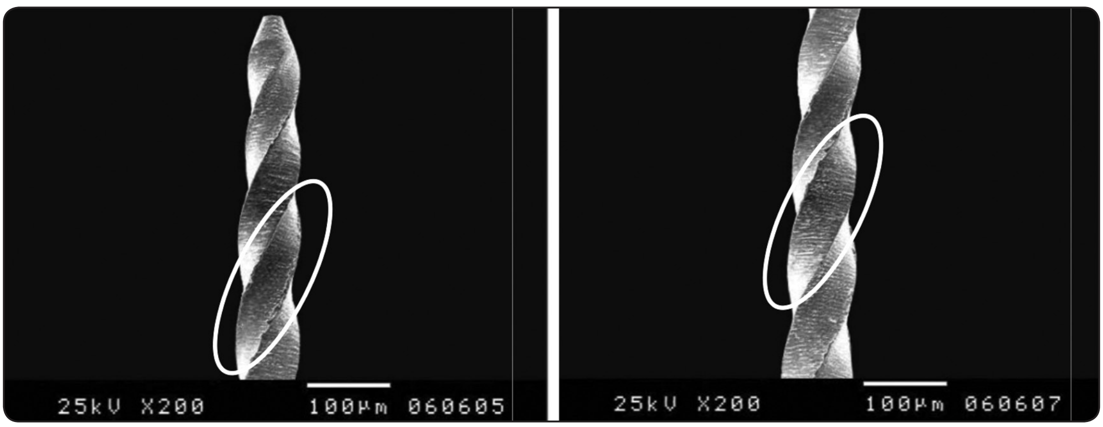


Fig. (3) Disruption of cutting edge in the apical part and the critical point of PTN X1 file after use.

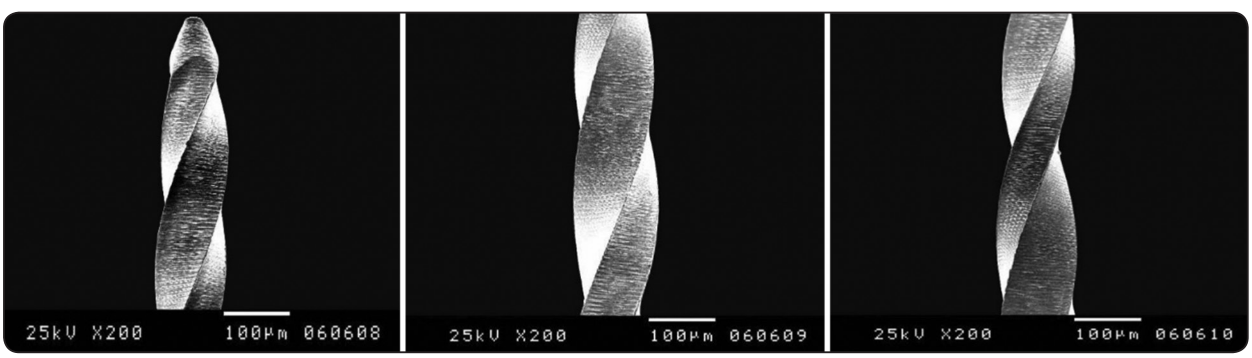


Fig. (4) No visible defects in the apical part, middle part and the critical point of PTNX2 file before and after use.

In Two Shape group II, one out of four TS1 files, disruption of cutting edge was observed on the apical part of the file before and after three uses but, no visible defects were observed in the middle part and the critical point of the file before and after use (Figure 5).

The remaining three TS1 files, showed no visible defects neither before nor after three uses in the apical part, middle part and the critical point of the files (Figure 6).

One out of four TS2 files, corrosion in the apical part, middle part and the critical point of the file was observed after three uses with no visible defects were observed before using (Figure 7).

Another TS2 file showed pitting in the apical part of the file before and after three uses with no visible defects was observed in the middle part and the critical point of this file before and after use (Figure 8).

The third TS2 file showed disruption of cutting edge and micro crack in the critical point of the file after three uses with no visible defects before use. Also, no visible defects were observed in the apical and the middle parts of this file before or after use (Figure 9).

The fourth TS2 file of this group showed no visible defects neither before nor after three uses in the apical part, middle part and the critical point of the files (Figure 10) (table 2).

No file fracture was observed either in PTN or TS file system after three uses to instrument curved mesiobuccal canals of mandibular first molars.

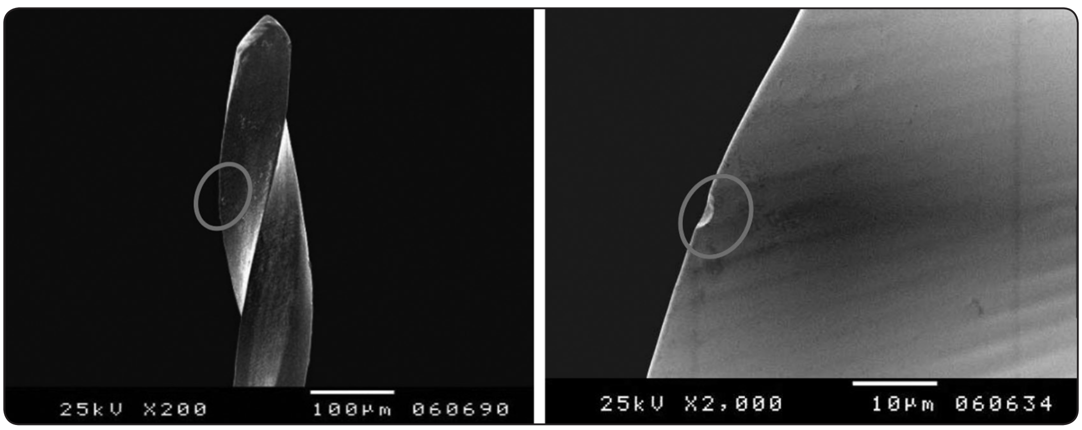


Fig. (5) Disruption of cutting edge in the apical part of TS1 file before and after use.

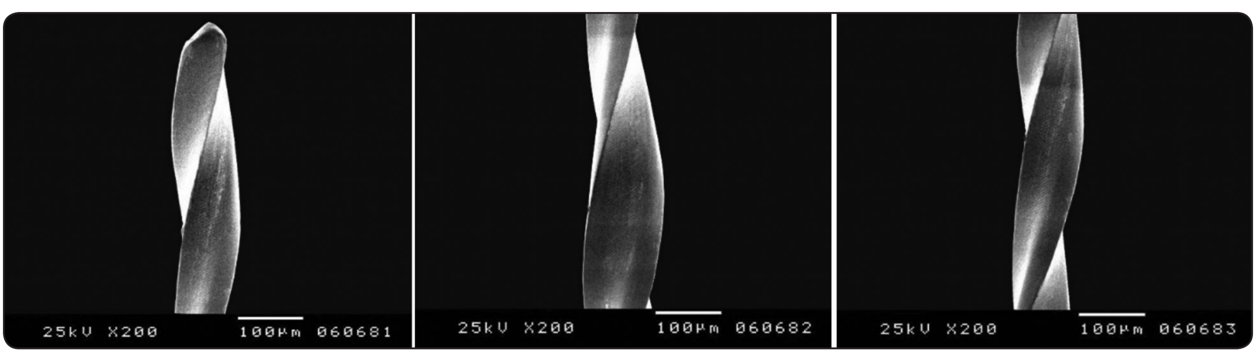


Fig. (6) No visible defects in the apical part, middle part and the critical point of TS1 file before and after use.

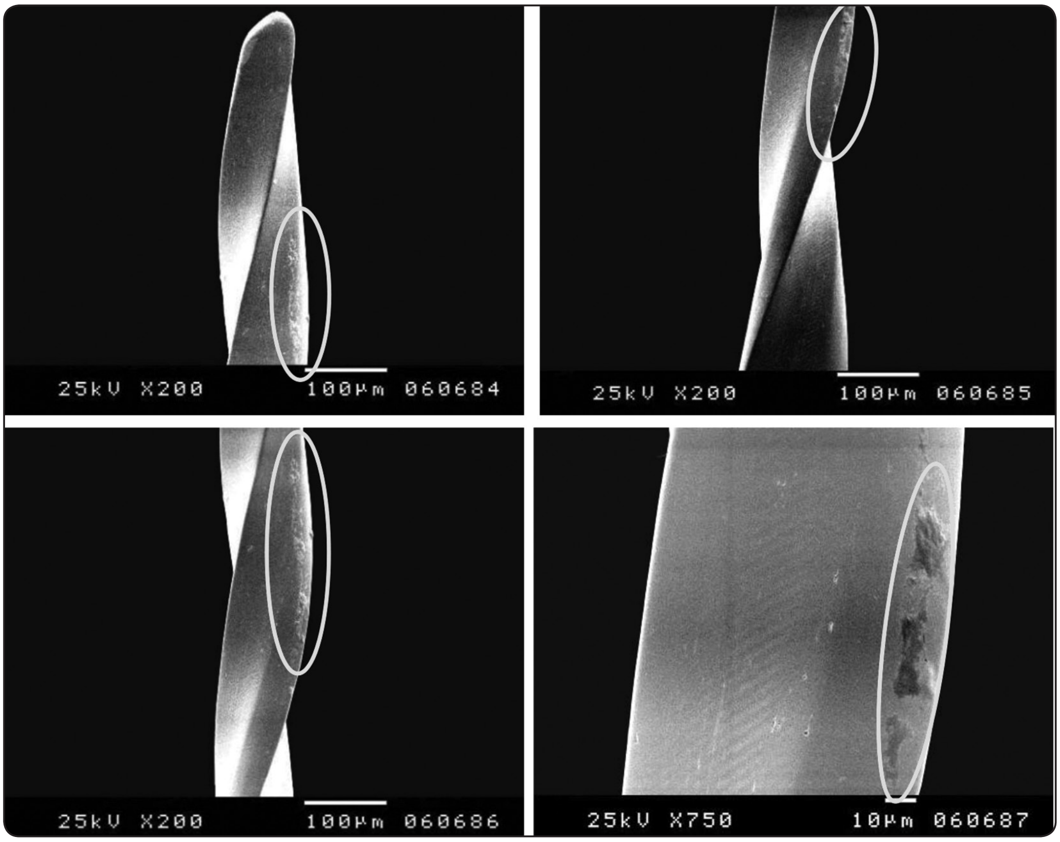


Fig. (7) Corrosion in the apical part, middle part and the critical point of the TS2 file after use.

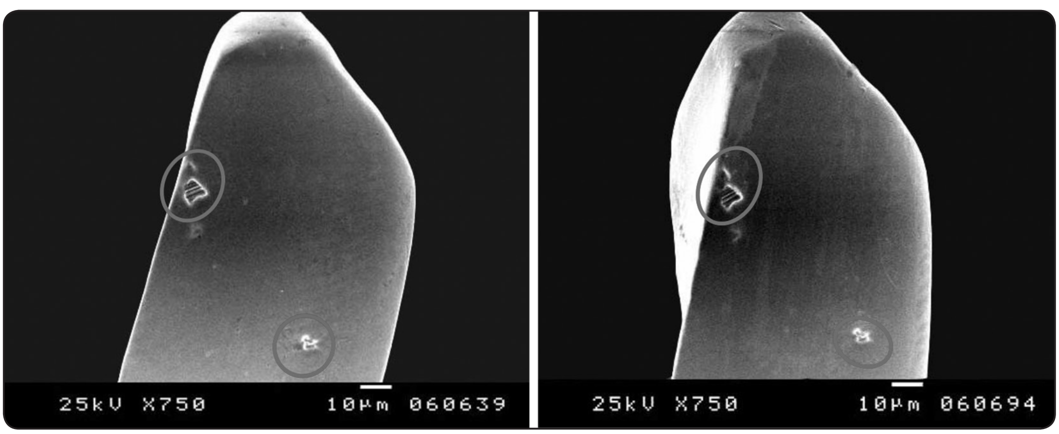
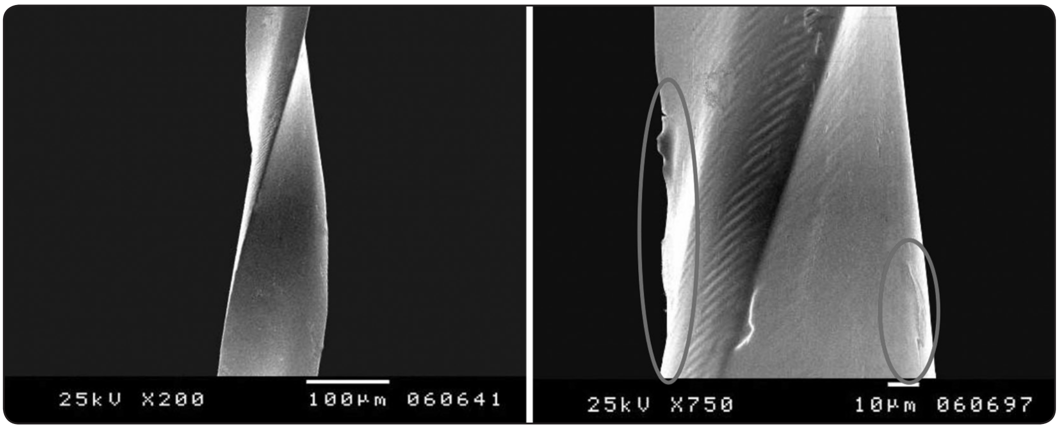


Fig. (8) Pitting in the apical part of the TS2 file before and after use.



Before After

Fig. (9) Disruption of cutting edge and micro crack in the critical point of TS2 file after use.

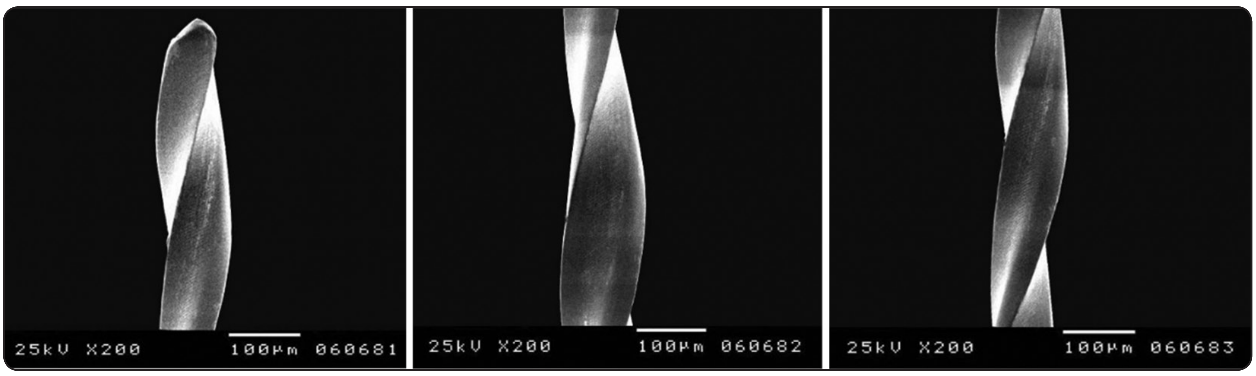


Fig. (10) No visible defects in the apical part, middle part and the critical point of TS2 file before and after use.

DISCUSSION

It is essential to examine the file surfaces before and after instrumentation to understand the changes that occur before the instruments fail. This will help in the selection and application of NiTi rotary instruments during root canal and reduce the risk of instrument breakage within root canals [44-45]. The evaluation was done before and after instrumentation of curved mesiobuccal canals of mandibular first molars in the same position by SEM observation and high-resolution images. SEM observation was proven to be useful in repeatedly evaluating surface defects without affecting the physical properties of endodontic files [16].

The topographic changes were examined in three areas: the apical third, middle third and critical point of the file (3-5 mm from the file tip) in accordance with Sattapan et al. (2000) [46] who indicated that these three areas are the most critical and the files tend to fracture close to their tip. Moreover, the tapering of the file increased toward the handle, making the bulk of the file much stronger than its tip [45].

Protaper Next (M-wire) and Two Shape (T-wire) file systems examined in this study were differed in metal alloys and designs. One PTNX1 showed disruption of cutting edge in the apical part before use and stayed unchanged after the third use. Another PTNX1 showed disruption of cutting edge in the apical part and the critical point after third use. One TS1 showed disruption of cutting edge in the apical part before use and stayed unchanged after the third use. One TS2 showed pitting surface in the apical part before use and stayed unchanged after the third use. Another TS2 showed corrosion in the apical part, middle part and critical point after third use. Another TS2 showed disruption of cutting edge and micro crack in the critical point after third use. This is in agreement with Castello-Escriva et al. (2012) [47] who reported that, the differences in surface topography among endodontic instruments may be related to use of different metal alloys or design features.

The NiTi alloy M-Wire exhibits increased resistance to cyclic fatigue. This is because of its unique nano-crystalline martensitic microstructure [29]. M-Wire instruments have shown to have superior resistance to fatigue-crack initiation compared with regular Super-Elastic (SE) wire files [48]. T-wire instrument is a new T-wire Technology with asymmetrical cross section. The manufacture claimed that, this type of wire is better to negotiate the curvature, preserve of the elasticity of Nickel-Titanium alloy, better resistance to cyclic fatigue, and more flexibility. The asymmetrical cross section reduces the risk of instrument fracture, Increases the efficacy of the circumferential brushing movements for efficient selective cleaning and respect the original root canal anatomy [34, 42].

In the current study, one PTNXI and one TS1 files showed Disruption of cutting edge and one TS2 file showed pitting on the file surface in the apical part before instrumentation that is mean during manufacturing procedure. This in agreement with Alapati et al. (2003) [13] who stated that, NiTi files manufactured via grinding procedure causes the formation of irregular areas such as pit, fissure, and metal folds. These irregular areas on the surfaces of files act as the starting point for the cracks which might cause fracture because of cyclic fatigue [14]. In curved canals cyclic fatigue caused by alternating tensile and compressive stresses may lead to deformations and may be ended by file breakage [49-50].

Micro crack was observed in the critical point of one TS2 file after third use in this study and no micro crack was detected in PTN files which was in contrast to Elemam et el. (2016) [43] who detect micro crack PTN files which are the results of a rotational bending of the file within the canal due to shear forces on the blades, which later combine to become the fatigue cracks [17].

Our result also revealed no file fractured after three uses in the two file systems although the occurrence of some topographic changes after three uses in the two file systems Unlike Ertas and Capar (2015) [51] who examined the separation incidence of the PTN, and revealed that, the most fractured PTN files were X1 files. Those instruments were the first used to penetrate and shape the full WL of the canal, and thus, they were more likely to suffer from fatigue. So we create glide paths before using the PTNX1 or TS1 files for decreasing file fatigue and reducing the number of file fractures [52].

Protaper Next (X1 & X2) and Two Shape (TS1 & TS2) are 'multi-file' systems. Thus, the X2 and TS2 files might be subject to less stress than X1 and TS1 [47]. This was in agreement with the results of the present study of PTN as no visible defects revealed in all X2 of the PTN system. But, the most topographic changes occur in TS2 of Two Shape file system.

The results of this study showed the low occurrence of topographic changes, no fracture incidence, and high resistance to cyclic fatigue compared to previous studies. This difference could be due to many factors; NiTi alloys such as the M-wire technology, which provides greater flexibility for the files along with the off-centered rectangular cross-sectional design [52]. Also improves the file's strength, gives the system high resistance to cyclic fatigue and the unequal contact between the PTN instrument and the root canal wall [35, 54-55] and introduction of T-wire technology with asymmetrical cross section.

Our in-vitro study was performed on extracted teeth, so, there was no need for file sterilization after each canal preparation as done in clinical situation for excluding the surface changes of NiTi files during sterilization.

The present in-vitro study evaluated the surface changes of PTN and TS rotary instruments before and after the third use under an SEM. The repeated use of NiTi files may cause the plastic deformation of the material [56]. If this happened, could result in inadequate preparation, insufficient cleansing, and shaping of the root canal system and lead ultimately to the fracture of the files [14]. So, it is essential to examine the file surfaces before and after instrumentation to understand the changes that occur before file failure and reduce the risk of file breakage inside the root canal especially the curved canals [47-48, 57].

CONCLUSION

Based on the results of this study, it is safe to instrument up to three curved canals by PTN or TS rotary NiTi files without file fracture.

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