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EVALUATION OF SURFACE TOPOGRAPHIC CHANGES OF THREE DIFFERENT NITI ROTARY FILE SYSTEMS: A SEM STUDY.

Dental Science

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ABSTRACT

Objective: This invitro study aimed to evaluate the surface topographic changes of ProTaper Universal, NeoEndo Flex and ProTaper Gold nickel titanium endodontic rotary instruments after root canal preparation. **Materials and Methods:** Forty-eight freshly extracted single rooted human teeth were selected and were randomly divided into three groups of sixteen teeth each and were instrumented with three different NiTi rotary file systems (Group I: ProTaper Universal, Group II: NeoEndo Flex, Group III: ProTaper Gold) according to manufacturers' instructions. All the instruments were evaluated for defects before use and after first, fifth and tenth use under scanning electron microscope (SEM). Scoring was given by a blind study. Results and Conclusion: The unused instruments did not show any significant surface defect. No significant difference was seen between the groups but the experimental results showed that NeoEndo Flex files had the least defects followed by ProTaper gold and ProTaper Universal instruments.

KEYWORDS

NiTi rotary instruments, Scanning electron microscope, surface topography

INTRODUCTION

Endodontic therapy involves the removal of infected and vital pulp structures and the subsequent cleaning and shaping and the obturation (filling) of the prepared space [1]. One of the most crucial steps in root canal treatment is root canal preparation as it determines the efficacy of treatment procedures. This step involves mechanical debridement of infected canal space, creation of space for medicament delivery, irrigants and optimized canal configurations for adequate obturation (Ove A. Peters,1999).

There was a shift of endodontic instruments traditionally made of carbon steel to instruments made of Stainless Steel alloy as stainless steel instruments were more corrosion resistant and had good cutting efficiency but they were less flexible. Hence there arose a need for more flexible materials[2].

William J.Beuhler alongwith Frederick Wang discovered NiTinol at the Naval Ordnance Laboratory in 1959. Nitinol alloys exhibit shape memory effect and superelasticity[3].

The Niti files are more flexible than stainless steel files and superior in torsional fracture resistance. The flexibility of nitinol is due to its low modulus of elasticity and the superior fracture resistance is attributed to the ductility of the alloy. The traditional NiTi files have become popular, but several other methods to improve the performance of NiTi and to make them more efficient and more resistant to deformation and fracture have been tried.

Separation of rotary nickel–titanium (RNT) has become a conundrum since their introduction by Walia et al. in 1988. The reported incidence of separation is 1.3%–10% in the literature, of which 44.3% are due to cyclic fatigue and 55.7% due to torsional failure. Cyclic or flexural fatigue occurs due to repeated compression/tension cycles to the point of maximum flexure causing fracture of the instrument. Torsional fatigue failure occurs, when there is binding of the tip of a rotary file while the shank of the handpiece keeps rotating, exceeding the elastic limit of the file. Separated instrument hinders disinfection and obturation protocols, leading to unsuccessful endodontic treatment. Removal of separated fragment is not only difficult, but none of the retrieval systems guarantee 100% success rate.Hence it is advisable to prevent the separation than to treat it. Therefore, several other methods like improvements in instrument design, manufacturing process, and movement kinetics to improve the performance of NiTi and to make them more efficient and more resistant to deformation and fracture have been tried [4].

One approach that has been implemented includes producing better NiTi alloys. NiTi wires have been subjected to various modifications, including different types of thermic treatments to optimize physical characteristics that result in greater elasticity and increased flexibility and resistance[5].

Fracture of NiTi instruments occurs with little or no visible evidence and hence use of aids such as magnification is critical as files that unwound could be visualized. Hence, the purpose of this study is to observe and reveal the surface features under the scanning electron microscope relevant to the failure process, and to gain insight into the mechanism for failure, so as to minimize the clinical failure of these instruments [2].

MATERIALS AND METHODS:

Forty-eight freshly extracted human single rooted teeth with straight narrow canals were collected and decoronated at the cementoenamel junction with a separating disc.The roots were then randomly divided into three groups of sixteen samples each. The working length of all teeth was established by the insertion of a compatible K-file into the canal until its tip is visible at the apical foramen and then by subtraction of 0.5 mm. All the teeth were instrumented with new set of files for individual groups and subgroups according to respective manufacturers instructions. Irrigation was carried out with 3% sodium hypochlorite (Vishal Dentocare, India) and 17% EDTA (PrevestDenPro, India).

GROUPING OF SAMPLES

GROUP 1(n=16): each subgroup was instrumented with a new set of ProTaper Universal (DentsplyMaillefer, Ballaigues, Switzerland)

rotary files
Sub-Group 1A (n=1)
Sub-Group 1B (n=5)
Sub-Group 1C (n=10)

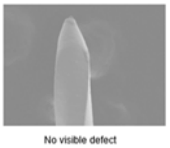
GROUP 2 (n=16): each subgroup was instrumented with a new set of NeoEndo Flex (NeoEndo, Orikam, India)rotary files
Sub-Group 2A (n=1)
Sub-Group 2B (n=5)
Sub-Group 2C (n=10)

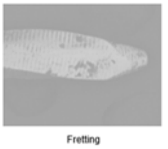
GROUP 3 (n=16): each subgroup was instrumented with a new set of ProTaper Gold (DentsplyMaillefer, Ballaigues, Switzerland) rotary files
Sub-Group 3A (n=1)
Sub-Group 3B (n=5)
Sub-Group 3C (n=10)

Sequence of files used:
Protaper Universal: S1, S2, F1, F2
NeoEndo Flex (4%): #17, #20, #25
ProTaper Gold: S1, S2, F1, F2

SEM EXAMINATION:
All the experimental instruments were examined under the Scanning Electron Microscope (HITACHI, SU1510) without gold sputtering and photomicrographs were taken at a range of magnification for each group before use, after first use, fifth use and tenth use.

SCORING CRITERIA [6]:
Surface defects
Score 1- No visible defect
Score 2 – Pitting
Score 3 - Fretting
Score 4 –Micro fractures
Score 5 – Complete fracture
Score 6—Metal flash
Score 7—Metal strips
Score 8—Blunt cutting edges
Score 9- Disruption of cutting edge
Score 10-Corrosion
Score 11-Debris


No visible defect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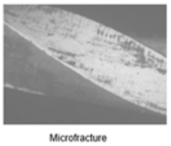
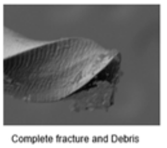
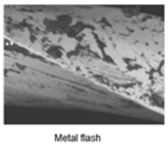
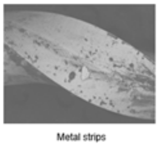
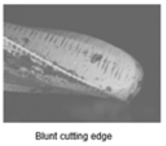
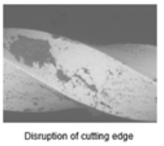

Microfracture


Complete fracture and Debris


Metal flash


Metal strips


Blunt cutting edge


Disruption of cutting edge

RESULTS:
The results were analysed and depicted as frequency and percentage of defects. There was no significant difference between the groups however the experimental results showed highest number of surface defects in Group 1 (Pro Taper Universal) followed by Group 3 (ProTaper Gold) and least in Group 2 (NeoEndo Flex) as shown in Table 1.

Table 1: Percentage of defects

USAGE	CRITERIA	GROUP-1 (PROTAPER UNIVERSAL)	GROUP-2 (NEOENDO FLEX)	GROUP-3 (PROTAPER GOLD)
UNUSED	No visible defects	100.00	100.00	100.00
AFTER ONE USE	Fretting	25.00	0	37.50
	Metal flash	12.50	25.00	25.00
	Metal strips	12.50	0	0
	Blunt cutting edges	0	0	12.50
	Disruption of cutting edge	0	12.50	0
	Debris	100.00	100.00	100.00
AFTER FIVE USES	Fretting	12.50	0	12.50
	Microfractures	0	13.30	0
	Metal flash	50.00	13.30	12.50
	Complete fractures	0	0	0
	Blunt cutting edges	12.50	0	0
	Disruption of cutting edge	37.50	0	12.50
	Debris	100.00	100.00	100.00
	Pitting	0	0	25.00
AFTER TEN USES	Fretting	37.50	0	37.50
	Complete fractures	12.50	0	0
	Metal flash	25.00	0	12.50
	Blunt cutting edges	25.00	13.30	37.50
	Disruption of cutting edge	25.00	0	0
	Debris	100.00	100.00	100.00

DISCUSSION:
Hand-held, stainless steel instruments have certain limitations such as prolonged time for preparation and chances of deviation led to the wide usage of nickel-titanium (NiTi) instruments in endodontics as NiTi instruments exhibit relatively greater accuracy and efficiency [5].

Even with the greater strength and flexibility, a major concern with nickel-titanium instruments is chances of fracture which can occur even without any visible defects of earlier permanent deformation. Therefore, visible inspection cannot be considered a reliable method [7]. The major clinical interest is the surface quality of the cutting surfaces after repeated usage [8].

In the present study forty-eight freshly extracted single rooted human teeth were selected and were randomly divided into three groups. Three different NiTi rotary file systems (three assorted file sets for each type) were selected (Group I: ProTaper Universal, Group II: NeoEndo Flex, Group III: ProTaper Gold) and cleaning and shaping procedure was carried out in all the three groups of sixteen teeth each according to manufacturers' instructions.

To evaluate the surface defects in the present study, scanning electron microscope was chosen as the files could be viewed in higher magnification and the same file can be examined after every usage as it does not affect their physical properties (Tripi et al)[2].

All the instruments were examined under the Scanning Electron Microscope before use. Each of these instruments of each group were subjected to one use to ten uses of simulated clinical instrumentation and observed at a range of magnification under SEM. The photomicrographs were taken in the apical and middle third of the file after single use, fifth use and tenth use and evaluated for surface changes and surface defects were recorded on the used and unused instruments.

According to the results, Group 2 that is Neoendo Flex showed the least number of surface defects even after tenth use followed by Protaper Gold and Protaper Universal. This can be attributed to the fact that NeoEndo Flex and ProTaper Gold have advanced metallurgy.

The ProTaper NiTi files with a unique feature of varying tapers over the length of its cutting blades which significantly improve flexibility, cutting efficiency and safety are a new generation of instruments for shaping of root canals. Another feature which enhances the cutting efficiency while reducing the rotational friction between the cutting blade and root canal dentin is their convex, triangular cross-section. The variable pitch and helical angle over their cutting blades reduces the potential of the file to inadvertently screw into the canal. Each instrument of the ProTaper file systems safely follows the secured portion of a canal due to their noncutting, modified guiding tip [9].

In the ProTaper system, the taper increases from tip to coronal area in case of shaping files (S), whereas the taper decreases in case of finishing files (F). Bergmans et al. have claimed that the instruments with increasing taper have enhanced flexibility at the tip and middle regions, and that the instruments with decreasing taper are stiffer and provide a larger taper in the important apical region [10].

ProTaper Universal (PTU) and ProTaper Gold (PTG) files come under this category. Both these file systems are available in eight sizes: SX (tip size 19 with a taper of 0.04), S1 (tip size 18 with a taper of 0.02), S2 (tip size 20 with a taper of 0.04), F1 (tip size 20 with a taper of 0.07), F2 (tip size 25 with a taper of 0.08), F3 (tip size 30 with a taper of 0.09), F4 (tip size 40 with a taper of 0.06), and F5 (tip size 50 with a taper of 0.05). PTU is a rotary system of conventional NiTi wire whereas the PTG system has the additional benefit of metallurgical enhancement through heat treatment [11].

Neoendo Flex Files utilize a proprietary heat treatment which gives it a very unique fiexibility, flutes do not open up when the stress levels are reached, yet the files does not present shape memory. [13].

Both ProTaper Gold and NeoEndo Flex files are subjected to post machining heat treatmentprocess after the machining of the files to overcome machining process defects, and to modify the crystalline phase structure. It has been reported that after thermal cycling, 2 stages of martensitic transformation of NiTi alloys occurs in contrast with the 1-stage transformation (A-M) that happens in Ni-rich NiTi alloys. After the manufacturing of the flutes of a files, post heat treatment is done. The temperature in the range of 370-510°C is used for a variable period of time. Files exhibit two stage specific transformation behaviour and high Austenite finish (Af) temperature around 50°C. These findings favour the higher resistance of these instruments to cyclic fatigue than PTU [14].

The increase of Af (Austenite finish) temperature of the alloy is the main advantage obtained. A mixed martensitic, R-phase and austenitic structure of the files occurs in intracanal temperature if the "Af" is superior to body temperature. Hence, significant increase in flexibility and flexural fatigue resistance is obtained with heat treated instruments [15].

ProTaper Gold and NeoEndo Flex files utilize CM wire technology. CM wire instruments do not rebound back to their original shape after being flexed. This characteristic confers greater flexibility, and the risk of deviation, instrument fracture, and perforations are reduced considerably. The improved flexibility of thermo mechanically treated NiTi files requires less pressure to be applied against the canal wall than with conventional NiTi files of the same size and taper[5].

Cyclic fatigue-to-fracture tests showed that 0.06 taper instruments had less resistance than 0.04 taper instruments to fracture. Studies by Shen and colleagues showed that instruments with progressively large tapers exhibited a high percentage of fracture as the defects and that the instruments with even taper showed unwinding deformations. Even taper and less taper instruments such as 0.04 can be considered safer in this regard than those that fracture spontaneously. Additionally, Guilford and colleagues, found that progressively tapered instruments failed rapidly with little rotation when comparing the torque required to fracture different types of rotary instruments [16]. This supports the findings of our study that NeoEndo Flex (4%) showed the least number of defects and least chances of failure.

CONCLUSION:

Within the limitations of this study, Neoendo Flex files had the least defects followed by Protaper gold and Protaper universal instruments showed the highest percentage of defects.

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