ORIGINAL ARTICLE

VISUAL AND MICROSCOPIC EVALUATION OF THE SURFACE ALTERATIONS IN THE PROTAPER FILES AFTER SINGLE CLINICAL USE

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Background: Different studies have been conducted in which defects of Ni-Ti files were reported after multiple usages but limited data is available regarding the defects in the rotary Ni-Ti files subjected to single clinical use. The objective of this study was to determine the frequency of surface defects caused by fatigue in the rotary ProTaper files after single clinical use assessed with visual and microscopic examination methods. **Methods:** A cross-sectional study was conducted in the dental clinics of The Aga Khan University Hospital, Karachi, Pakistan. A total of 189 ProTaper Ni-Ti files (after single clinical use in multi-rooted molars) were analysed visually and then under stereomicroscope at 10X magnification for surface defects (straightening, denting, bending, twisting, pitting and change in length). Chi Square test was used to determine association between type of file and type of defect. Spearman's correlation test was used for determination of correlation between visual and microscopic examinations at 0.05 level of significance. **Results:** 19% of files showed straightening on visual assessment as compared to 66.1% under microscopic examination. There was a statistically significant association between the file type and the straightening of file (p-value $\leq$0.001). A weak correlation existed between visual and microscopic examination for all the defects, except for the change in length. **Conclusions:** The defects of ProTapers files are best detected by the microscopic examination. Straightening is the most common defect observed visually and microscopically. The first shaping and first finishing files underwent significantly more surface defects than the rest of the rotary files in the series.

Keywords: Defects; Evaluation; Instrumentation; Root canal; Root canal therapy

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INTRODUCTION

Nickel-titanium (Ni-Ti) instruments have become an important part of the armamentarium for root canal treatment. They are increasingly being used to facilitate the cleaning and shaping of root canals.[1] The low elastic modulus of nickel-titanium (Ni-Ti) rotary instruments permits it to be safely used in the curved root canals, and hence limiting the chances of iatrogenic complications like canal transportation, ledging and zipping etc.[2,3]

Ni-Ti rotary instruments are available in various cross-sectional designs and tapers. One of the most known Ni-Ti rotary instruments in endodontic practice is the ProTaper Universal rotary system. It has a symmetrical cross section with progressively larger, variable tapered shaft due to which more frictional forces are exerted when file touches the surrounding canal walls.[4,5] ProTaper Universal rotary files require high torque, making them more prone to metal fatigue.[3,5]

Separation of Ni-Ti files during clinical use is a serious procedural error and may occur without any warning even with a new instrument.[6] Instruments typically fracture in two different ways. In one case, the instrument shows visible defects including straightening, reverse winding, reverse winding with tightening of the flutes, denting or a combination of these defects. These visible defects lead to the instrument's torsional fracture. In the other case, the fracture occurs without any visible accompanying defects when the instrument does not bind but rotates freely in a curved canal.[7]

Sattapan *et al.* stated that files subjected to torsional fatigue exhibit signs of deterioration before fracture and proposed that all the files should be analysed before each use to reduce risk of separation in root canal systems.[7] Despite the manufacturer's recommendation of single use, clinicians frequently use such rotary files on multiple teeth and not uncommonly on different patients after autoclaving. The fitness of a file for reuse is mostly done by simple visual examination.[8] Asthana *et al.* reported that rotary files had 16.2% and 22.9% defects, when assessed with visual examination and stereomicroscope, respectively.[6] Different studies have been conducted in which defects of Ni-Ti files were reported after multiple usage[6–8] but there are very limited studies which reported defects on Ni-Ti files after single clinical use[9]. Therefore, we aimed to evaluate surface defects in ProTapers rotary files after single clinical use and assessed whether visual examination of such files is equivalent to microscopic examination for detecting such defects. The clinical

implication of this study would help in limiting the use of Ni-Ti files to single use and thus minimize the risk of file separation and other iatrogenic errors.

MATERIAL AND METHODS

A cross-sectional study was done in the dental clinics of the Aga Khan University Hospital, Pakistan. Exemption (4385-Sur-ERC-16) from ethical review committee of the institution was obtained before the start of the study. The duration of this study was of three months, i.e., September to November 2016. Sample size was calculated with WHO sample size calculator. The required number turned out to be 189 files. Brand new ProTaper Ni-Ti files were opened for every Root canal treatment and were used only once in the multi-rooted molars of 20–35-year-old subjects. All series of ProTaper files used were collected and separated from the clinic by one of the assigned staff. Additionally, only those files were included in the study which was used in the roots with less than 30-degree curvature as determined with the Schneider's method using digital radiograph. The files exhibiting any manufacturing defects judged with naked eye and the files used in teeth with calcified canals, internal root resorption, endodontic retreatment case or teeth subjected to procedural error were excluded from the study.

The selected ProTaper files were later ultrasonically cleansed and then placed in the sterilization pouches. These were marked by an identification number for recognition. All files were first analysed with naked eye under illumination and then were observed under stereomicroscope at 10X magnification (Olympus, Shinjuku, Tokyo, Japan). Photographs were taken to maintain the record of the observations of defects.

Following defects were assessed for their absence or presence on visual and microscopic examination and then recorded in study sheets[8]:

- Bent instrument/tip deformation
- Stretching/ straightening of twist contour
- Cutting edge dented
- Partial reverse twisting
- Change in length
- Fracture of instrument
- Pitting of instrument.

SPSS-22 was used for the data analysis. Descriptive statistics were used to determine the frequency of defects in the Ni-Ti files. Chi Square test was used to determine an association between type of file and type of defect. Spearman's correlation test was used for determination of any correlation between visual and microscopic examinations. Inter-examiner reliability was tested using Kappa statistics. Level of significance was kept at 0.05.

RESULTS

Out of 189 files, 51 files were S1, 49 were S2, 55 were F1 and 26 were F2, while only 8 files were F3. Figure-1 shows frequency of defects as seen with visual and microscopic examination. The most common defect on the visual examination was file straightening (19%), followed by change in length (15.3%) and cutting-edge denting (5.3%). When subjected to the microscopic examination, the cutting-edge denting turned out to be the most common defect, i.e., 71.4% followed by pitting (68.3%) and file straightening (66.1%).

Table-1 demonstrates an association between the type of file and the type of surface defect as assessed under visual examination. Most defects were observed in the S1 file. Table-2 shows a high correlation between file type and straightening of the file contours, cutting edge denting and pitting under microscopic examination. On correlating visual assessment with the microscopic assessment (Table-3), a strong correlation (r=0.904) was observed for a change in length of the file. For inter-examiner reliability, 10% of data was re-assessed by a second examiner. Kappa statistics showed an excellent agreement for all defects assessed visually. For microscopic assessment, the agreement between the two examiners ranged between 78–82%.

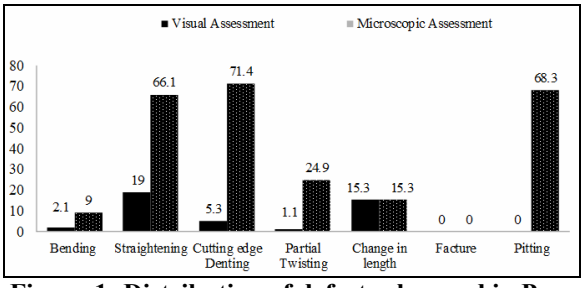

Figure-1: Distribution of defects observed in Pro-Taper files using visual and microscopic assessment methods

Table-1: Association of type of defects and type of file under visual evaluation

Defects	Identity of file					Total	*p*-value
	S1	S2	F1	F2	F3		
Bend Instrument	3	0	1	0	0	4	**0.372**
Straightening of Contour	28	7	1	0	0	36	**≤ 0.001**
Cutting Edge Dented	5	4	1	0	0	10	**0.237**
Partial Twisting	2	0	0	0	0	2	**0.311**
Length change	16	6	6	1	0	29	**≤ 0.001**

Chi Square test was applied at 0.05 level of significance. *n* =189

Table 2: Association of type of defects and type of file under microscopic evaluation

Defects	Identity of file					Total	*p*-Value
	S1	S2	F1	F2	F3		
Bend Instrument	7	5	4	1	0	17	0.641
Straightening of Contour	49	40	26	6	1	125	≤0.001
Cutting Edge Dented	41	32	37	20	5	135	≤0.001
Partial Twisting	14	5	20	8	0	47	0.009
Length change	16	6	6	1	0	29	0.008
Pitting	35	31	39	19	5	129	≤0.001

Chi Square test was applied at 0.05 level of significance. *n* =189

Table-3: Correlation between visual and microscopic examination

Defect	Correlation coefficient	*p*-Value
Bent Instrument	0.082	0.260
Straightening of Contour	0.319	<0.001
Cutting Edge Dented	-0.112	0.125
Partial Twisting	0.180	0.013
Change in length	0.904	<0.001

Spearman's correlation coefficient was applied at 0.05 level of significance

DISCUSSION

Intra canal instruments are exposed to various stresses during clinical use. In addition to operator related factors, the instrumentation technique and instrument design can also influence the magnitude of stress concentration and likelihood of instrument fracture.[9]

Preceding studies have reported incidence of instrument separation due to torsional and flexural fatigue but failed to report the type of defect that can be assessed before the file fractures.[10–13.] On the other hand, most studies have been done on the Ni-Ti files after being subjected to multiple time usage.[2,6,9,12] The manufacturers certainly recommend a single use of rotary file but endodontists practicing in resource restraint circumstances are compelled to re-use the rotary files with repeated autoclaving. For this purpose, the clinicians mainly rely on the visual signs of defects on the file. Surface defects are a major concern because they may lead to instrument separation during clinical use.[14] The proportion of defects on files reported after multiple use is significantly higher than single or limited number of uses.[2,6,9,12,15–17] In the present study, files used only once in a molar were assessed for torsional defects since flexural fatigue is unexpected and not accompanied by surface defects.[8] We observed that the overall frequency of file defect in our study is similar to the study conducted by Shen *et al.*[10] which was also conducted after single clinical use of files. The present study provides substantial evidence that even a single use of rotary file is detrimental and can cause instrument separation without a warning.

ProTaper universal files have a symmetrical cross section design with deep cutting flutes which reduce file engagement and improve flexibility of the instrument.[6–9] Although, designed for superior clinical performance, such files do exhibit defects. Most surface defects were observed in the S1 file, this finding needs to be understood within the context of the frequency of use. It should be noted that the operators did not use the entire series of files in every patient equally; some file numbers were used more frequently than others. However, the first file to be used was always the S1 and hence was invariably utilized the most in all teeth. Thus, it is not surprising that file S1 underwent most surface defects.

This study conveyed that 19.4% files are observed with straightening defect when assessed with naked eye but when assessed under 10x magnification, it rose significantly higher, i.e., 66.1%. Similarly, 71.4% files had cutting edge denting under microscope as opposed to only 5.3% under naked eye. Hence, visual examination clearly turns out to be a poor method to assess the clinical fitness of an endodontic rotary file for re-use. This is in accordance with the study done by Sattapan *et al.*[7] however*;* they mentioned only the frequency of torsional and flexural fatigue and did not explore the type of defect.

Various studies have employed scanning electron microscope (SEM) as the mode of examination to evaluate surface changes of Niti files.[2,6,8] It is evident that the higher the magnification, the more defects and changes can be detected. However, presence of higher magnification is not practically possible during the clinical use. Therefore, this study employed a logistically practical magnification of (10X). Such a magnification can easily be employed in an average clinic set up.

The strength of this study is good inter-examiner reliability. However, the primary limitation was that it was a single centre study and the results can only be extrapolated to single use of the files.

Within the limitation of this study, we conclude that the surface defects of ProTaper Ni-Ti files are best detected by microscopic examination. Straightening is the most common defect in Ni-Ti files observed

visually and microscopically. The first shaping and first finishing files underwent more changes than the rest of the files in the series.

Pro-Taper Ni-Ti files should be confined to single clinical use. If files are used more than once after sterilization, then their potential for fracture would increase. Clinicians must employ some form of magnification in the clinic step-up to assess the fitness of endodontic files even before using them, as visual assessment alone is not sufficient.

AUTHORS' CONTRIBUTION

SA: Drafting of the work & principle investigator. RG: Revised all steps of work carefully and did final approval. MG: Performed inter-examiner reliability. FR: Performed statistical analysis and provided final approval of the draft.

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