Wear Resistance of Protaper Universal Rotary NiTi Retreatment Files- An SEM Study

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ABSTRACT:

Aim: To investigate the wear resistance of Protaper Universal (PTU) rotary retreatment files as correlated to the number of use. **Methodology**: Ten sets of three files each (n=30 files) of PTU retreatment files (D1, D2, and D3) were experimented with. They were inspected as received from the manufacturer for surface quality and imperfections using a stereo microscope (x40). Representative PTU samples were also examined using SEM. 40 freshly extracted double rooted maxillary premolars teeth were used for the study. Canals were prepared and obturated with Gutta Percha and Pulp Canal Sealer using continuous wave of compaction; after which they were grouped randomly into three groups of 40, 20, and 20 canals respectively. Un-filling of the obturated premolars canals of group I (40 canals) was done so that each instrument set (D1, D2, D3) was used in un-filling of 4 canals. This was followed by stereomicroscopic and SEM examination. The previous PTU files' sets were then used in unfilling of teeth of group II (6 canals unfilling), and group III (8 canals unfilling). Following canals' unfilling of each of the previously mentioned groups; PTU files were subjected to the same sequence of stereomicroscopic and SEM examination to examine the features of instrument's wear. The wear criteria perceived and studied were: No visible defect (NVD), Pitting (P), Distorted machine grooves (DG), Blade blunting (BB), Microfracture (MF), and Blade turnover (BT). **Results**: 67% of the as received instruments showed NVD. Two thirds of the used instruments showed rapid increase in the visible wear features after unfilling of 4 canals. On the other hand, all of instruments gradually showed different kinds of visible defect after being used in unfilling of 6 and 8 canals. Generally, highly significant difference were detected between most of tested instrument conditions as compared to the as received (p-value =0.000). Exceptions were MF after unfilling of 4 canals as stated above as well as after unfilling of 6 canals. **Conclusion**: Under the conditions of this study, Protaper Universal retreatment rotary files can be safely used in unfilling of 4-6 canals provided that no visible signs of distortion are noted.

Keywords: endodontic retreatment, Protaper Universal retreatment files, wear features.

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INTRODUCTION

The classic technique for gutta percha removal for retreatment of unhealed cases was through hand files coupled with or without solvents [1-3].This was partially facilitated coronally by heated pluggers [4,5] or Gates Glidden drills [6]. Ultrasonic removal of gutta percha filling was also reported [7-9] .Shortly after the introduction of NiTi rotary enlarging instruments systems they were recommended to be used in removal of root canal filling as an extension for their use; for efficiency [10-14] and for time saving [15,16]. It has been suggested that gutta-percha can be effectively removed using ProFile nickel-titanium rotary instruments [15, 17-19]. However, no one treatment alternative solely or in combinations seems to guarantee canal walls that are completely free of debris [1, 10, and 14].

ProTaper (PT) system (Dentsply Maillefer, Ballaigues, Switzerland) consists of three 'Shaping' files (Sx, S1 and S2) and three 'Finishing' files (F1, F2 and F3). They have varying taper over the length of the shaft and a triangular cross-sectional shape with convex sides [20]. The absence of radial land, supposedly, made these instruments perform a 'cutting' rather than a 'planning' action [20]. Patiño et al. [21] reported that instruments used more than eight times (in canals with mean curvatures of about 40 degrees) fractured more frequently than those used sparingly. As a limitation of NiTi instruments systems designed for canals preparation and shaping is that they should not be used to negotiate a constricted canal or a ledged canal and it should always be preceded by a negotiating initial hand file [22]. This is owed to the non active tip.

Recently, a new NiTi rotary system, PTU (Dentsply Tulsa, Tulsa, OK) was introduced [23]. It was specially designed for unfilling of the root canals in a preparation for retreatment. With respect to the original kit [20], the new system consists of three PTU retreatment files, D1, D2, and D3 as well as two new Pro-Taper finishing files, F4 and F5.The three PTU System retreatment files have different lengths, tapers, and apical tip diameters. They are designed to facilitate the safe unfilling of the root canals. The D1 instrument has a length of 16 mm, a tip of 0.30 mm, and a 0.09% taper. It is designed with an active tip to facilitate initial penetration into the filling material; The D2 instrument has a length of 18 mm, a tip of 0.25 mm, and a 0.08% taper. It is used for removal of filling material from the middle third of the root. The D3 instrument has a length of 22 mm, a tip of 0.20 mm, and a 0.07% taper and designed for removal of filling material from the apical third up to the working length.

Many investigations were conducted on the factors contributing to NiTi instruments distortion and /or separation during clinical use in canal's preparation [24-27]. Again the ability of these super elastic flexible instruments to maintain sharpness and resist wear, was also tested [28, 29], sometimes with recommendations on the safe number of use [21]. Efficiency of rotary NiTi instruments in unfilling root canals was also extensively assessed [30-35].

In 2008 Giuliani et al [36] reported on the few number of studies investigating the efficacy of PTU Retreatment Files in removing intra-canal filling material during retreatment.

To date the wear features of this new retreatment system was not yet studied. Again growing emphasis on the single use of contemporary NiTi rotary instruments are stressed on [37]. The purpose of this study was to investigate the wear resistance of PTU rotary retreatment files as correlated to the number of use.

METHODOLOGY

Protaper Universal retreatment instruments system

A total of ten sets of three files each (n=30 files) of PTU retreatment rotary files (The new generation Dentsply / Maillefer-Swizerland) were used for the present study. Each of the retreatment file systems

used consisted of a file symbol (D1) which is a size # 030 ISO, 9% taper and 16mm length-for coronal filling removal, a file symbol (D2): a size #025 ISO, 8% taper and 18mm length-for middle filling removal, and a file symbol (D3): a size #020 ISO, 7% taper and 22mm length- for apical filling removal.

Teeth selection and preparation for retreatment

A total of 40 freshly extracted human double rooted maxillary premolar teeth were selected for the study (enclosing 80 canals). Collected teeth had intact crowns, fully developed roots, with no open, chipped, or fractured apices. They were chosen to have nearly comparable tooth length of 21mm and root curvatures of no more than 20 degrees as digitized using Digora. Teeth were radiographed from facial and proximal views to rule out pulp stones, canals' calcification or internal resorption.

Conventional access cavities were made for the selected teeth using high speed carbide burs under water cooling spray. Burs were renewed regularly whenever needed. Accesses were refined with ultrasonic tips and straight line accesses were confirmed for both canals in each premolar tooth. Canals were then negotiated with size #10 K-files until it appeared at the apex, flushed with it. Working lengths were recorded for each canal by subtracting 1mm from the files' projected length. Each of the premolars' canals were subjected to coronal flaring using Gates-Glidden drills of size # 4, 3, and 2 sequentially. They were then instrumented with K-files to a standard apical size of 35 and step backed to size 60 K-files. Before each new instrument size use, irrigation with 5.25% NaOCL was made and apical patencies checked with size #10 K-file. During the whole procedure of canals' preparation K-files enlarging instruments were whipped clean, checked for distortion and distorted instrument was changed immediately. Generally, K-files were discarded regularly after use in 10 canals and new set were used. Prepared canals were then finally flushed with 1ml of EDTA (17%) irrigating solution for 1min followed by NaOCL (9 ml) and dried with paper points. All prepared canals were obturated with Gutta Percha and Pulp Canal Sealer (Kerr, Romulus, MI) using continuous wave of compaction technique by System B. Back filling was then completed with Obtura II to the canals orifices. Access cavities were restored with glass ionomer.

Obturated teeth specimens were stored in100% humidity at 37C° for 7 days for complete sealer setting.

Teeth specimens grouping

Obturated teeth were grouped randomly into three groups as follows:

Group I: comprising 40 canals in 20 premolar teeth specimens.

Group II: comprising 20 canals in 10 premolar teeth specimens.

Group III: comprising 20 canals in 10 premolar teeth specimens.

Testing PTU instrument sets were done according to their sizes and number of use in un-filling of the obturated canals specimens in the following sequence:

Stereomicroscopic examination

All the thirty instruments (10 D1, 10 D2, and 10 D3) were inspected as received from the manufacturer for surface quality and imperfections if present using a stereo microscope at a standard position and fixed magnification of 40x. Features examined were: no visible defect, pitting, distorted machine grooves, blade blunting, micro-fractures, and blades turnover. Instruments' inspection using the stereomicroscope was then repeated for each instrument after being used in the un-filling of 4, 6, and 8 canals (of groups I, II, and III respectively).

Scanning Electron Microscopic examination

Representative samples from each file size - as received and then after each un-filling sequence - were selected, ultrasonically cleaned in absolute alcohol for 90 seconds and examined at a higher pre-selected standard magnifications using the scanning electron microscope (Quanta Environmental SEM) for the same features mentioned above.

Un-filling of the obturated premolars canals

Un-filling of the obturated premolars canals of group I (40 canals) was done so that each instrument set (D1, D2, D3) was used in un-filling of 4 canals. Gutta-Percha filling was removed following the manufacturer rules and sequence of use in a crown down manner. File penetration was carried out by exerting slight apical pressure and a light brushing motion at a constant speed of 500 rpm for D1 and 400 rpm for D2 and D3, with a torque of 3 Ncm. in an electric motor (X-Smart; Dentsply Maillefer) with no solvent added. D1 file was used for coronal filling removal, D2 for middle third filling removal, and D3 for apical filling removal. Files were repeatedly withdrawn, debris removed, and canals irrigated with 5.25% NaOCL after each file size used. Instruments were then collected, subjected to ultrasonic cleaning in alcohol for 10 minutes before autoclaving. Stereomicroscopic as well as SEM examination was followed for the same features and at the same standard position and magnification as mentioned above.

Instruments were then returned back to be used in the un-filling of teeth of group II, so that each instrument set (D1, D2, D3) was used in un-filling of 2 more canals totaling 6 canals. Ultrasonic cleaning and autoclaving was also repeated and microscopic examination followed as mentioned before.

Same procedure was followed with teeth of group III so that each instrument set now was used in un-filling of 8 canals. Stereomicroscopic as well as scanning electron microscopic examination was done using the same standards as mentioned above.

Statistical analysis

Results were tabulated and subjected to statistical analysis using the Cochran's Q test. The level of significance was set at p-value <0.001.

RESULTS

Stereomicroscopic examination

Results of wear features as related to the instruments' number of use are presented collectively in tables 1, 2 and figure 1. The wear criteria perceived and studied were: No visible defect (NVD), Pitting (P), Distorted machine grooves (DG), Blade blunting (BB), Microfracture (MF), and Blade turnover (BT).

Stereomicroscopic examination of the as received instruments revealed no visible defects (NVD) in 20 out of the 30 instruments examined (66.66%). NVD were detected in 33.33% of files after unfilling of four canals, while after preparation of 6 and 8 canals all studied instruments suffered various types of defects (table1 and figure 1). Statistically high significant differences were detected between all tested instrument conditions (p-value =0.000)

Surface pitting (P) was detected sparingly on the new (as received) instruments surface (6.66%). This result was found to be statistically insignificant (p-value =0.004). Surface pitting however, increased markedly after unfilling of 4, 6, and 8 canals to reach to 40%, 63.33%, and 66.66% of the studied instruments respectively. This increase was found to be highly significant as compared to the as received condition (table 2). On the other hand the in-between groups comparative statitistics revealed statistical insignificance in 4 vs. 6 and 4 vs. 8 canals unfilled (p-value =0.043, p-value =0.021 respectively).

The "as received" files showed regular undistorted and uniform machine grooves as appeared under the stereomicroscope with no visible distortions. Distorted machine grooves

TABLE (1) Wear features of Protaper Universal Retreatment Files as received, after 4, 6, and 8 canals' unfilling

Protaper condition Criteria	As received No. (%)	4 canals unfilled No. (%)	6 canals unfilled No. (%)	8 canals unfilled No. (%)
No visible defect (NVD)	20 (66.66)	10 (33.33)	0 (0)	0 (0)
Pitting (P)	2 (6.66)	12 (40)	19 (63.33)	20 (66.66)
Distorted machine grooves (DG)	0 (0)	6 (20)	14 (46.66)	17 (56.66)
Blade blunting (BB)	5 (16.66)	17 (56.66)	25 (83.33)	30 (100)
Microfracture (MF)	0 (0)	0 (0)	7 (23.33)	12 (40)
Blade turnover (BT)	3 (10)	18 (60)	22 (73.33)	25 (83.33)

started to appear after unfilling of 4 canals where 20% of files showed this phenomenon. Progressive increase in this defect was found after unfilling of 6 and 8 canals to account for 46.66 & 56.66 % of the studied instruments respectively (table1 &figure 1). Compared to the as received condition, there was a highly significant difference after unfilling of 4, 6, and 8 canals. Alternatively, statistically insignificant difference was detected on comparing the increase in features of distorted machine grooves after unfilling of 6 canals with those of 4 canals unfilling (table 2).

Figure 1 shows a tremendous increase in blade blunting (BB) that was detected comparing the unused files with those used in unfilling of 4 canals (16.66% and 56.66% respectively). The number of instruments that showed features of wear at the stereomicroscopic level of magnification (40x) was found to be directly proportional to the number of unfilled canals (17, 25, and 30 after unfilling of 4, 6, and 8 canals respectively-table1). Statistical analysis revealed generally, high significant differences among all studied groups. Exception was found when group II was compared to group I (table 2).

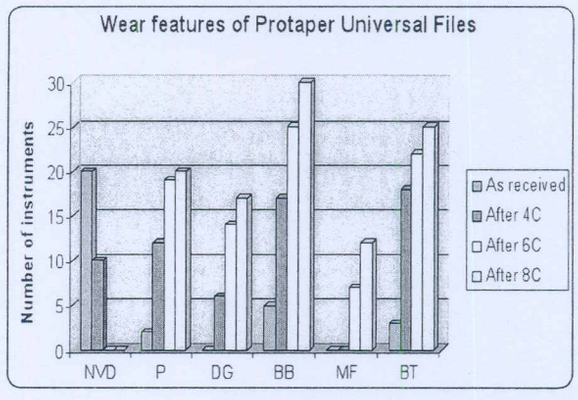

Fig. (1) Wear features of Protaper Universal Files as received and after use in unfilling of 4-8 canals

Microfracture (MF) was not detected for any of the examined files as received as well as after unfilling of 4 canals. It started to appear however after unfilling of 6 and 8 canals to account for 23.33% and 40% of the total number of studied instruments respectively (table 1 and figure 1). The increase in the number of instruments showing MF was found to be statistically insignificant in group I and highly significant in group III (p-value =0.007, p-value =0.000 respectively). High statistical significance was found also when group I was compared with group III.

Blade turnover (BT) followed a similar pattern to that of blade blunting. It was detected in 10% of the as received files, then, markedly and rapidly increased after unfilling of 4 canals (60%). This tracked a gradual increase in BT with the increase in the number of unfilled canals (table 1 and figure 1). Accordingly, a statistically high significant difference was found between the as received files and each of the used file groups (I, II, and III). Conversely, statistical insignificance was recorded with the increase in the number of unfilled canals (table 2).

Scanning electron Microscopic examination

Representative samples of the PTU Retreatment files were selected for further investigation of features of wear using higher magnification under SEM.

Most of the as received instruments showed generally minimum visible defects, uniform flutes, regular machine grooves, lowest blade irregularities, wear or surface pitting as shown in figure 2 a and b.

Generally all of the selected instruments showed more than one type of surface defect which was in direct relation to the number of use in canal's un-filling. Figure 3 is a composite SEM micrograph of a size "D3" PTU instrument's tip and the first three flutes after un-filling of 4 canals. Few debris accumulations were shown near to the instrument's tip figure 3 a. Figure 3 b revealed starting of features of blade blunting. However, widening and disruption of machine grooves was clearly detected after unfilling of 6 canals (figure 2 c and d). This occurred principally at the central part of the instrument's second flute between the consecutive blades. Blade blunting and irregularity are also evident. This was clearly and successfully captured in figure 2 c and d. After unfilling of 8 canals; marked distraction at the central part of the machine grooves at the file's second flute was detected in D2 PTU Retreatment file resulting in cracks and microfractures at the same site (figure 2 e and f).

Blade blunting and irregularities as well as debris accumulation are also clearly seen (Figure 4 a and b). Tip turnover was detected in some of the examined instruments mostly of size D2 (Figure 4 c and d).