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COMPARATIVE STUDY ON SHAPING ABILITY OF THREE ROTARY SYSTEMS: PROTAPER UNIVERSAL, PROTAPER NEXT AND F360 IN CURVED ROOT CANALS OF EXTRACTED TEETH

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ABSTRACT:

Aim: to compare the shaping ability of three rotary systems: Protaper Universal, Protaper Next and F360 that have different file numbers during the preparation of curved root canals of extracted human molars.

Materials and methods: Thirty extracted molars with at least one curved canal were selected. The curvatures of root canals were determined (20^o-40^o) with (Autocad-software 2015) according to Schneider method. Then, the sample was randomly divided into three groups: each one had 10 curved canals. group1: prepared by Protaper Universal (PTU), group2 : prepared by Protaper Next (PTN), whereas group3: prepared by F360 single file. The straightening of curved canal, time preparation and change of working length were evaluated. Data were collected and statistical analyses were conducted.

Results: The PTU system resulted in more straightening during instrumentation compared to F360 ($P<0.05$). On the other hand, there was no significant difference between PTU and PTN regarding straightening of canal curvature ($P>0.05$). Furthermore, both systems: PTN and F360 were significantly faster than PTU during preparation of curved canals ($P<0,001$). During preparation, only one PTU file fractured, whilst there were changes of working length in five cases, but these were not significant among groups ($P>0.05$).

Conclusion: under the conditions of this study, it can be concluded that F360 single file maintained original shape of curved canals, and prepared them faster than multi-file systems. In the same way, the new generation PTN was faster than old one PTU, but during preparation both instruments caused the same straightening in curved root canals.

Key words: canal straightening, F360, protaper next, protaper universal, shaping ability.

INTRODUCTION:

The major purpose of root canal instrumentation is to create continuously tapering funnel from the apex to the access cavity, to maintain the orginal shape of root canal and to avoid iatrogenic damage to the canal system and root structure. [1-2] Many instruments that include hand and rotary systems have been introduced to prepare root canals. However, there are few instruments that can achieve the purpose of canal preparation particularly in curved canals [3-4-5].

Nickel-Titanium (Ni-Ti) rotary systems have showed good ability to maintain the orginal shape of severely curved canals [6-7-8]. Manufacturers have

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recently introduced different cross-sectional designs of rotary files, which in turn enables reduction the number of sequence files that use to prepare the curved root canals.

Among these, The ProTaper Next instruments PTN *(Dentsply Maillefer, Switzerland)*, which are made from M-wire, are an example of new fifth generation rotary systems [9]. The traditional rotary Protaper Universal system PTU *(Dentsply Maillefer, Switzerland)* has almost five files to prepare curved canal, whereas the new generation PTN have just two files to achieve that. These PTN instruments are characterized by an innovative rectangular cross section (Fig. 1). In addition, PTN files have been designed such that the centre of mass and the centre of rotation are offset. That means, during rotation, the files which have an offset design produce a mechanical wave of motion that travels along the active length of the file. This offset design serves to further minimize the engagement between the file and dentin [10].

The specific design features of PTN instruments consider being suited to prepare curved root canals [9]. Besides many Previous studies have emphasized the adequately shaping ability of PTN [9-11-12]. ProTaper Next instruments are available in size 17, 0.04 taper; size 25, 0.06 taper; size 30, 0.07 taper; size 40, 0.06 taper; and size 50, 0.06 taper, which are called X1, X2, X3, X4 and X5 respectively. However, some studies recommend using two files: X1 and X2 to prepare curved canals, whereas others recommend up to X3. [11-12]

Another recently introduced file is F360 single file *(Kommet Brassler, GmbH)*, which is made from Ni-Ti alloy. This file has creative double S cross-section that increases flexibility and improves cutting efficiency. Furthermore, the special F360 design features that include large chip spaces enhance the flushing out of debris and reduction the risk of instrument fracture.

The F360 instruments are available in four sizes; 25, 35, 45, 55 and taper; 0.04 for all. And yet, The single file F360 size 25 is just needed to prepare narrow and curved canals [13]. It is claimed that F360 file is really appropriate to prepare curved canals, and this single file could prepare the difficult canals faster than other multi-files systems [13]. However, at the moment there are only limited studies available regarding the shaping ability of this particular file [13-14-15].

The aim of the present study was to compare the shaping ability of three rotary systems : Protaper Universal, Protaper Next and F360 in curved root canals of extracted teeth. Where this study focused on strightening of curved canals, working time and changing of working length.

MATERIALS AND METHODS:

Extracted teeth

A total of thirty (N=30) extracted molars were selected, where the inclusion criteria included: intact crown, no visual root resorption, no previous root canal treatment, and at least one curved root. An access cavity was achieved using diamond round bur on a high-speed handpiece, then crowns were flattened to get definite reference point. The canals were controlled for apical patency with a root canal instrument of size 10 K-file *(Mani Japan).* Only the mesial canal whose apical diameter was compatible with size 15 K-file was chosen. Next, the working length (WL) was obtained by measuring the length of the initial instrument size 10 at the apical foramen minus 1 mm. All selected molars were embedded into moulds that made of silicon-based impression material *(Silaplast- Futur Detax Germany)* to maintain a constant position during radiograph.

For determination of canal curvature, standardized radiographs were taken prior to instrumentation with the initial root canal instrument of size 15 that inserted into the curved canal. the tooth mould was placed in a tooth holder on specific device [9] that contained a E-speed film *(Kodak Japan)*, which in turn was aligned so that the long axis of the root canal was parallel and as near as possible to the surface of the film. The X-ray tube *(Yakang China)* was aligned perpendicular to the root canal. The exposure time was (0.12 s; 70 kV, 7 mA) with a constant source-to-film distance of 40 cm and an object-to- film distance of 5 mm, and as the same conditions as for all radiographs. The films were developed and fixed in chemical solutions *(Pro Kodak, USA)* and dried by the same operator for all films, and then the radiographs were scanned to get digital images.

The canal curvature degree and radius were determined according to Schneider method [16] and by using computerized program AutoCad-Software 2015 (Fig.2). Only the canals with curvatures more than 20^o and less than 40^o and radius lengths between 4 – 9 mm were included in this study. The sample was then randomly divided into three similar groups (N1=N2=N3=10) according to canal curvature and radius, where the homogeneity of the three groups in respect to the mentioned two parameters was assessed using analysis of variance (ANOVA) table (1).

Root canal preparation:

The preparation sequences were as follows:

Group A (PTU): the five Protaper Universal files were used according to the crown-down approach as follow:

- SX was used at two-third of working length (WL)
- S1 (size 17, taper 0.02–0.11) until reaching 2mm before (WL)
- S2 (size 20, taper 0.04-0.115) until reaching 2mm before (WL)
- F1 (size 20, taper 0.055–0.07) at WL
- F2 (size 25, taper 0.055–0.08) at WL

Group B (PTN): the two Protaper Next files were used as follow:

- X1 (size 17, taper 0.04) until full (WL)
- X2 (size 25, taper 0.06) until full (WL)

Group C (F360): the single file F360 (size 25, taper 0,04) was used until reaching the full (WL).

All instruments were set into permanent rotation handpiece that is powered by a torquelimited electric motor (X-smart – Dentsplay, Switzerland). For each file the individual torque and speed rotation were set according to the instructions of manufacturer. Furthermore, all canals were prepared by one operator, and each file was used to enlarge only three canals. All files were used in a gentle in-and-out pecking motion. During instrumentation, each canal was irrigated by 2 ml of (5.25% NaOCl) after each file and at the end of instrumentation with 5 ml of (0.9%NaCl) using plastic syringe with 28 gauge needle(Changzhou Kangfulai Medical Thing Co) that inserted into canal as deep as possible.

Evaluation of canal preparation:

At the end of instrumentation, The curvatures of the canals after instrumentation were reevaluated based on radiographs using the same initial technique which has been mentioned before. Where the last file that was used at the end of the preparation was inserted into canal before the radiograph was taken. Moreover, the assessments of the canal curvatures before and after instrumentation were accomplished on Autocad by a second examiner who was blind in respect of all experimental groups.

In the present study, there were four parameters to evaluate. First, the straightening that occurred because of instrumentation was calculated as difference between the canal curvature prior to and after instrumentation. Second, The time for canal preparation which included total active preparation, instrument changes within the sequence and irrigation was recorded. Third, the number of fractured files during enlargment was also recorded. Fourth, the changes of (WL) were adapted as nominal parameter; to clarify, the change of working length was considered just when the final length was (1 mm or more) shorter than the original length. While in the other situation, there were no changes of (WL).

Statistical analysis:

For comparisons of the different groups regarding canal straightening and preparation time,the (ANOVA) test and *post hoc* (LSD) test were conducted. Whereas, the Chi-square test was used for fractured instruments and changes of working length. The level of statistical significance was set at (P < 0.05) and all statistical analyses were performed on (SPSS-program, version 15).

RESULT:

The mean straightening of the curved canals is shown in table (2). There were statistically significant differences among the three groups regarding straightening of curved canals (P<0.05). Furthermore, the (LSD) test showed that PTU system caused more straightness than F360 system during preparation of curved canals (P<0.01) where the (Fig 3) show the straigntening that was caused by PTU , whilst there were no statistically significant differences between PTN system and other systems (P>0.05).

In addition, table (3) shows the mean time taken to prepare the curved canals with the different files. The (LSD) test demonstrated that F360 file was faster than PTU and PTN systems in preparation of curved canals (P<0.0001), and PTN system was also faster than PTU system (P<0.0001).

During rotary preparation of 30 curved canals, only one PTU (S2) file was broken, whilst there were changes of working length (shorter than original WL) in five cases, where the results are summureized in table (4). However, there were no statistically significant differences among groups concerning the number of frucured files or working length changes (P>0.05).

DISCUSSION:

Many anatomical and histological studies have proved the complex anatomy of the root canal system including canal curvature, which is considered as a major challenge during canal instrumentation[17,18]. Therefore, the aim of the present study was to evaluate the capacity of three rotary systems in maintaining the orginal shape of curved canals of extracted teeth.

The double-file PTN and single file F360 were included in this study because of their unique designs, where the manufacturers presume that this innovative designs enhance the instrumentation of curved canals. However, the rotary PTU system was used in this study as a stander system for comparing the new systems with it.

It is a fact that the human teeth have a lot of variables like root canal length and width, dentine hardness, irregular calcifications and canal curvature that can affect on the canal preparation and make standardization difficult. On the other hand, the human extracted teeth can really reproduce the clinical situation better than resin blocks [19]. Furtheremore, about 95% of related study have used extracted teeth in their expermints [20].

For evaluation the canal curvatures, the study followed the Schneider method, which have been developed by shafer (2002) in order to calculate the cnanal curvatures and radii on computerized program (Autocad) [21]. Recently, the majority of studies that evaluate the shaping ability of rotary and hand systems have depeded on the shafer method to assess the canal curvatures.

The present study invistigated that the F360 file caused less straight in curved canals than PTU system, that could be because of the specific design (double S cross-section) of F360. Furthermore, the PTU instruments have different taper along file which can affect directly on the original shape of curved canal. The PTU taper, moronver, is greater than F360 taper which is also constant. Hence, the prepared shape of curved canal will adapte with the shape of the file that prepared this canal. In the same way, Bruklein and and his colleagues concluded that the single-file F360 preserved the original anatomy of severely curved canal well [13]. Beides, Saleh and his colleagues also illustrated that the F360 file produced centered preparation during instrumentation S-shaped canals which are considered more difficulte than curved canals that were included in this study[22]. However, Guelzow and his colleagues found that PTU system maintained the canal curvature as well as other commen multi-file systems, although the mentioned study prepared the curved canals upto F3 file, whereas the present study prepared them only upto F2 file [23].

One the other hand, the present study demonstrated that there was no statistically significant difference between PTU and PTN systems in respect to the straightening of curved canal. This finding is in agreement with observation of Bürklein and his colleagues, even the curved canals in the last study were prepared up to file (size 40) compared to file size (25) in the present study [24]. However, Hui Wu and his colleagues study showed that PTN system maintained the canal curvature better than other multi-file systems including PTU [25]. It has to consider that the mentioned study depended on resin blocks rather than extracted teeth.

There was no significant difference between single-file F360 and double-file PTN regarding straightening of curved canals. This result is in agreement with observation of Berkan and his colleagues who demonstrated both PTN and single-file Oneshape systems produced similar canal transportation and volume changes, where the canal shape was evaluated by CBCT [26] .

In the present study, the F360 was faster than both systems PTU and PTN, further the PTN was faster than PTU in instrumentation of curved canals. Where the PTU system need about five files to prepare one canal compared to only one F360 file and two PTN files that are used to do that. Consequently, the time that is needed to change files, irrigation and active preparation decreases in respect to the reduction of file number. This result is agreement with the findings of Ferara and his colleagues who confirmed the superiority of PTN system to PTU system in instrumentation rapid of curved canals [27]. Further, Khaly Bane and his colleagues study showed that all single-file systems had saved time well during curved canal preparation [28].

During preparation, only one file (PTU, S2) was broken during instrumentation. So that, to prepare ten canals in each group, about twenty files were used for PTU group compared to eight PTN and only four F360 files were used for other groups.

In addition, the result of this study considered working length to be change only if it was 1 mm or more shorter than original WL, because this measurement reflects the clinical situation well. There were five cases where the working length changed after instrumentation, however, there were no significant differences among three groups. In the same way, Khaly Bane and his colleagues confirmed no difference between PTU and PTN in term of changing of work length [28] .

CONCLUSION:

Within the limitations of this study, F360 single file respected original canal curvature well compared to PTU, and it prepared curved canals rapidly. The file number of rotary system influencd on the time required for instrumentation, in other word, the less file number were used, the less time was required for preparation.

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TABLES:

Table (1) Characteristics of teeth and homogeneity test before instrumentation.

Systems	Canal curvature (degree)			Radius (mm)		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max
PTU	28.4 ± 6.3	20	38.7	6.2 ± 1.5	4.3	8.7
PTN	29.5 ± 6.1	20.4	39.3	6.7 ±1.4	4.5	8.8
F360	26.3 ± 5.6	20.9	35.5	6.6 ±1.8	4.3	8.8
P-value	0.48			0.73		

Table (2) The mean straightening and SD of curved canals prepared with three rotary systems

Systems	N	Mean	SD	Min	Max
PTU	9*	6.3[a]	4.2	1.4	12.5
PTN	10	4	4	1.8	9
F360	10	1.6[a]	0.5	1.6	2.3
P-value	0.007				

*One canal was excluded because of fractured file.

Values with the same superscript letters (a) were statistically different *LSD test* ($P<0.01$)

Table (3) Mean preparation time and SD with three rotary systems

Systems	N	Mean	SD	Min	Max
PTU	9	251[a]	17	230	278
PTN	9	173[a]	31	130	236
F360	10	92[a]	19	63	120
P-value	0.0001				

Values with the same superscript letters (a) were statistically different *LSD test* ($P=0.0001$)

Table (4) Number of fractured files and change of working length

Systems	Fructured	WL change
PTU	1	2
PTN	0	1
F360	0	2
P-value	0.36	0.75

FIGURES:

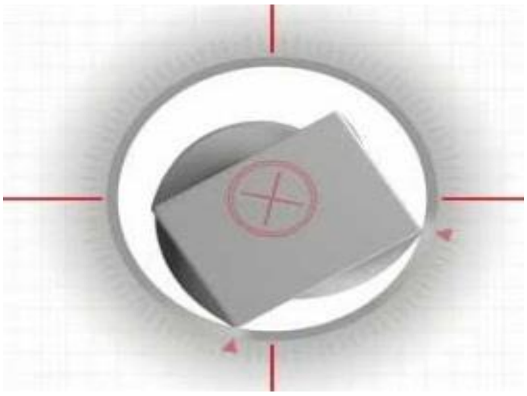

Figure (1) PTN file cross-section

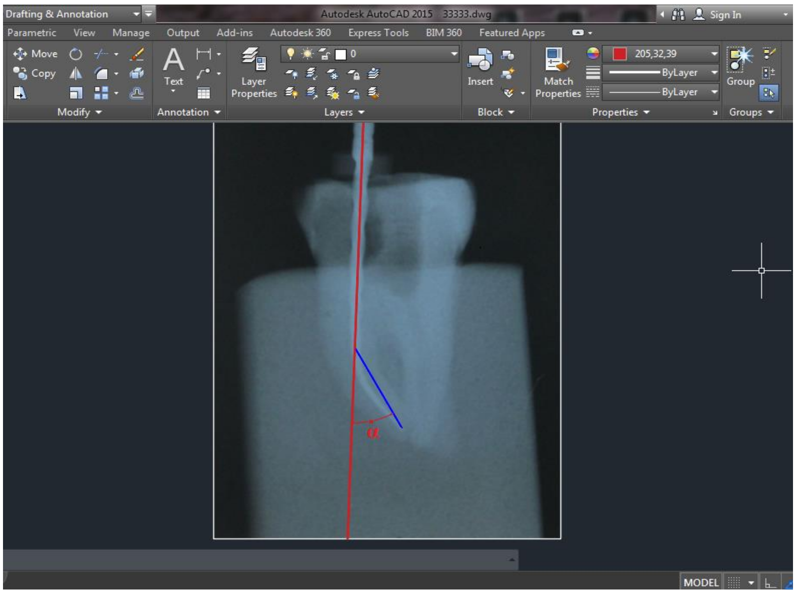

Figure (2) determination of canal curvature degree on AutoCad- 2015

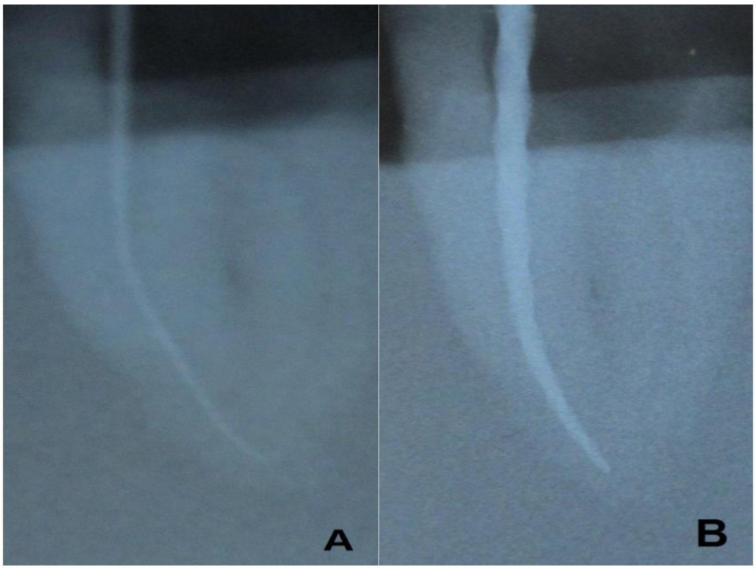

Figure (3) straightening resulted from PTU preparation A: before, B: after