Evaluation of the Shaping Ability of XP Endo Shaper: A Micro-Computed Tomography Study

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Abstract

The aim of the study: to assess the shaping ability of the XPES file compared to that of the ProTaper Universal (PTU) file using micro-computed tomography (micro-CT).

19 mesial roots (with 2 separate canals) of mandibular molars were selected and scanned using micro-CT. The mesial root canals were divided into 2 groups: XPES files were used to instrument the mesiobuccal canals (n=19) while PTU files were used to instrument the mesiolingual canals (n=19). Instrumentation was performed in a water bath (37 C) to mimic body temperature. The roots were scanned using micro-CT before and after instrumentation. Pre- and post-instrumentation images were superimposed using Adobe Photoshop CC at 3 different levels (2, 4, and 6 mm from the apex). ImageJ 1.51s software was used to evaluate and measure cross-sectional area change of the canal and canal transportation in different directions.

There was no statistically significant difference in the area change between the experimental groups. However, the mean mesial transportation in the PTU group was higher than that in the XPES group at 4 mm and 6 mm levels.

XPES instrumentation might reduce the magnitude of canal transportation in the middle third region of mandibular molars mesial canals.

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Introduction

Cleaning and shaping are critical aspects of successful root canal treatment [1]. The efficacy of irrigation and quality of obturation are determined by the final size and shape of the canal after mechanical preparation. Increasing the apical preparation size enables improved cleaning of canal walls[2,3]. However, this might lead to loss of working length, transportation, and many other endodontic mishaps[4]. Since the introduction of NiTi files by Walia et al. in 1988[5], no available system has been able to instrument the root canal walls completely. Therefore, researchers continue to develop different alloy treatments and file designs in order to create the ideal file.

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Nowadays, manufacturers are concerned more about increasing the cleaning efficiency with minimum working time by single file system production[6]. Multiple endodontic single file systems are available in the market including; self-adjusting file (SAF), Twisted File (TF), Reciproc, WaveOne, One Shape and XP-endo Shaper. XP-endo Shaper (XPES), a single file system, was introduced to the market in 2016 by FKG, France. The manufacturer claims that this file can contract and expand within the canal itself, such that it can access areas where conventional files cannot. The relatively small diameter and narrow taper (0.01) of this file provide it with extreme resistance to cyclic fatigue. However, torsional fatigue resistance has not shown an improvement relative to that of other instruments[7].

Micro-computed tomography (micro-CT) is a conservative and noninvasive technique to obtain two-dimensional (2D) and three-dimensional (3D) images[8]. It enables scanning of the same sample for multiple tests without damage[9]. Additionally, micro-CT can be used in various endodontic investigations, such as morphological studies, assessment of fractures and cracks, evaluation of obturation quality, and shaping ability[10,11].

Multiple published studies assessed the shaping ability of XPES[12-15]. XPES files are constructed from MaxWire alloy (Martensite-Austenite-electropolish-fileX). This file is relatively straight at room temperature (martensitic state); however, the file takes a predetermined shape (austenitic state) when it is at body temperature within the canal [16]. Some investigators considered the use of XPES file in the body temperature through irrigation with preheated sodium hypochlorite[14,15]. However, none of these studies evaluated the files while continuously exposed to controlled body temperature. Therefore, the objective of this investigation was to assess the shaping ability of the XPES file compared to ProTaper Universal (PTU) file at body temperature (inside a water bath) using micro-CT evaluation.

Materials and methods

This research was conducted in King Saud University, Riyadh, Saudi Arabia. The research protocol was approved by the Institutional Review Board (E-17-2646).

Specimen selection

Nineteen extracted mandibular molars were selected that had mesial roots with 2 separate canals (Vertucci Type IV) free from calcifications and pulp stones and a root curvature between 10-30 degrees [17]. The roots were sterilized in 10% buffered formalin. All teeth were decoronated and the lengths of the roots were standardized to 16 mm. The roots were split at the furcation area by using the Isomet 2000 Precision Saw (Buehler, USA). Straight and angulated conventional radiographs were obtained for all mesial roots to verify the inclusion criteria.

Pre- and post-instrumentation micro-CT scan

Roots were prepared for micro-CT scanning by mounting in clear acrylic blocks. The buccal side of each root was marked for the purpose of orientation. The roots were scanned before instrumentation (pre-instrumentation scan) using a Skyscan1172 (Bruker, USA) 100 Kv/98 uA scanner with a Hamamatsu 10Mp camera. The camera pixel size was 11.40 um with median filtering and flat field correction.

After instrumentation, all samples were scanned again using the same equipment, settings, and methods.

Sample preparation

The working length of all the canals was determined and confirmed by radiographs. Coronal flaring was performed for all canals using a Gates Glidden size 2 followed by preparation of a glide path for all canals with hand files (K file) up to size 15. RC-Prep® (Premier Dental, USA) was used as a lubricant. Canals were irrigated with 1 mL of 5% sodium hypochlorite (NaOCl) before and after each file.

Group 1 (n=19): mesiobuccal canals were instrumented using the XPES system. The files were mounted on an X-smart handpiece (Dentsply Tulsa Dental Specialties, Tulsa, OK) and used at a speed of 800 rpm and 1 Ncm torque according to the manufacturer instructions. The XPES file was used about 20 seconds, in three gentle strokes to the full working length. RC-Prep® was used as lubricant and 1 mL of 5% NaOCl was used for irrigation after instrumentation. Finally, roots were dried with paper points.

Group 2 (n=19): mesiolingual canals were instrumented using the PTU system. The files were mounted on an X-smart handpiece (Dentsply Tulsa Dental Specialties, Tulsa, OK) and used at a speed of 300 rpm and 1 Ncm torque according to the manufacturer instructions. The canals were instrumented with S1, S2, F1, F2, and F3. Each file was lubricated with RC-Prep® and 1 mL of 5% NaOCl was used for irrigation after each file. Finally, roots were dried with paper points.

All the roots were placed in a water bath at 37 °C during instrumentation to mimic the body temperature. All files were used three times and then discarded to prevent separation.

Shaping ability evaluation

Horizontal cross-sectional images were attained from pre- and post-instrumentation scans at distances of 2, 4, and 6 mm from the apex. Images were superimposed using Adobe Photoshop CC (Adobe, USA), and ImageJ 1.51s (NIH, USA) software was used to evaluate and measure cross-sectional area change of the canal by subtracting pre-instrumentation area from the post-instrumentation area. Transportation values were calculated at each level by subtracting pre-instrumentation diameter from the post-instrumentation diameter in four directions (buccal, mesial, lingual, and distal). The measurements of transportation were performed at distances of 2, 4, and 6 mm from the apex. The evaluation parameters have been illustrated in figure 1.

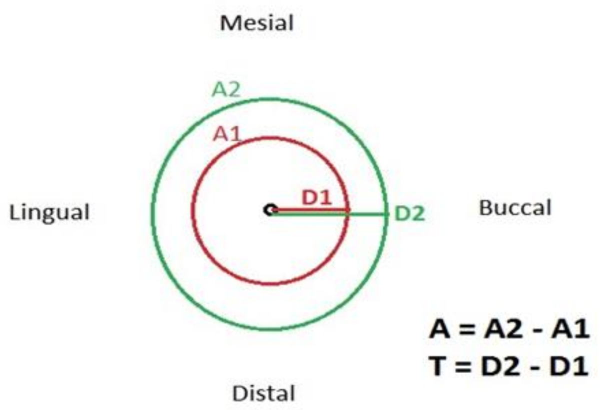

Figure 1. An illustration of the parameters measurements: Cross-sectional area changes (A) was calculated by subtracting pre-instrumentation area (A1) from the post-instrumentation area (A2). Transportation (T) values were calculated at each level by subtracting pre-instrumentation diameter (D1) from the post-instrumentation diameter (D2) in four directions (buccal, mesial, lingual, and distal).

One-way ANOVA with the Tukey post hoc test was used for comparison of the data; SPSS software (IBM, USA) was used to perform statistical analyses.

Results

Each root canal was evaluated using micro-CT images at three different levels (2, 4, and 6 mm); this yielded 57 images for evaluation.

Change in cross-sectional area:

The changes in cross-sectional area for each group at each of the three different dimensions are shown in Table 1. There was no statistically significant difference (P > .05) between the group instrumented using XPES files and the group instrumented using PTU files at all three dimensions.

Level	XPES		PTU		
	Mean	SD	Mean	SD	P value
6 mm	0.458	0.354	0.803	0.696	0.158
4 mm	0.470	0.282	0.637	0.407	0.276
2 mm	0.323	0.394	0.435	0.522	0.583

Table 1. Change in cross-sectional area mean and standard deviation (SD) in mm for XP-endo Shaper (XPES) and ProTaper Universal (PTU) files at 3 canal levels in mesial canals of mandibular molars.

Transportation:

Transportation value in four directions (buccal, mesial, lingual, and distal) at each level of the canals are shown in Table 2. There was no statistically significant difference (P > .05) between XPES and PTU groups at the 2 mm level.

		XPES		PTU		
Level	direction	Mean	SD	Mean	SD	P value
6 mm	B	0.053	.072	0.130	.175	.198
	M	0.108	.094	0.241	.189	.050*
	L	0.112	.107	0.063	.056	.195
	D	0.076	.078	0.125	.085	.184
4 mm	B	0.052	.076	0.069	.088	.647
	M	0.107	.056	0.184	.095	.034*
	L	0.046	.085	0.076	.089	.430
	D	0.072	.061	0.097	.109	.509
2 mm	B	0.037	.065	0.014	.033	.317
	M	0.099	.067	0.145	.161	.400
	L	0.035	.053	0.067	.080	.287
	D	0.075	.079	0.054	.050	.449

B: buccal, M: mesial, L: lingual, D: distal
*: statistical significance

Table 2. Transportation values mean and standard deviation (SD) in mm in four directions for XPES and PTU files at three canal levels in mesial canals of mandibular molars.

There was a statistically significant difference (P < .05) between the groups only in the mesial direction at the 4 and 6 mm levels (Figure 2 and 3). The mesial transportation values of the PTU group were higher than that of the XPES group.

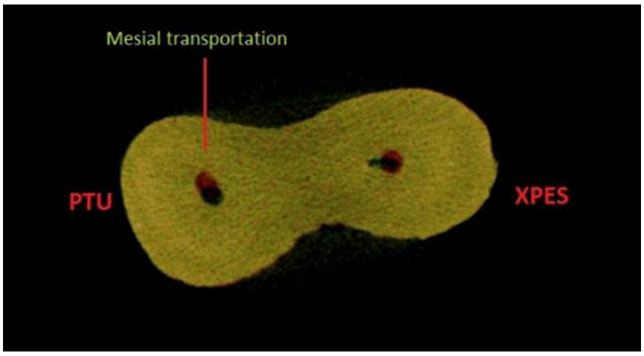

Figure 2. Micro-CT cross sectional image at 4 mm level; the pre-instrumentation image (red) superimposed the post-instrumentation image (green). The mesial transportation (arrow) value of the PTU group was significantly higher than that of the XPES group.

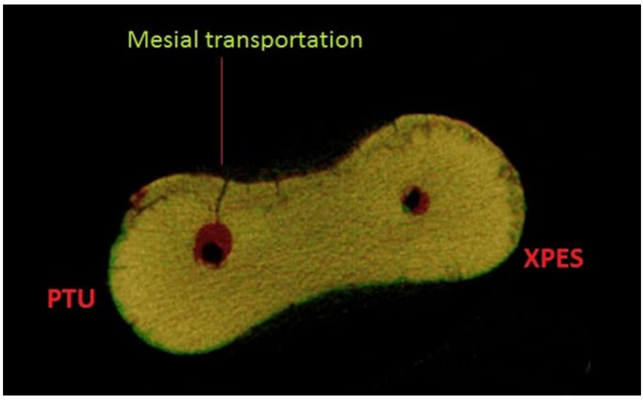

Figure 3. Micro-CT cross sectional image at 6 mm level; the pre-instrumentation image (red) superimposed the post-instrumentation image (green). The mesial transportation (arrow) value of the PTU group was significantly higher than that of the XPES group.

Discussion

Shaping ability is one of the most important features to be investigated for a new endodontic file, because root canal instrumentation is the most crucial aspect of root canal treatment [18, 19]. Therefore, we aimed to evaluate the shaping ability of the XPES file compared to PTU files in critical regions of the canal. Dimensions of 2, 4, and 6 mm were selected for evaluation, representing the apical and middle third, because those parts of the root are more critical to cleaning and shaping due to the curvatures and anatomical variations presented.

PTU was chosen as the file for the control group because it has been widely used in different studies as a gold standard to which new systems are compared [20]. It is made of conventional NiTi wire and has unique progressive taper design features that improve the flexibility and cutting efficiency [21 22]. Moreover, it is considered to be a safe instrument, which preserves the canal shape [23]. In our study, instrumentation with PTU was performed with size F3 files, corresponding to ISO size 30, to match the XPES, which is available in a single file that also provides a final preparation size similar to that of ISO 30.

It is claimed that XPES may alter its shape in response to variation in temperature and assume a predetermined form at body temperature inside the root canal. Therefore, instrumentation with both systems, XPES and PTU, was performed in a 37 °C water bath to mimic body temperature. Our results revealed that there were no statistically significant differences between the tested systems regarding change in cross-sectional area at all 3 dimensional levels (2, 4, and 6 mm) in mesial canals. The assessment of untouched dentine was beyond the objectives of the current study. However, our micro-CT images clearly demonstrated that neither of the systems prepared 100% of the root canal walls. This is consistent with previous studies, which found that none of the tested systems, including XPES, were able to instrument the canal walls completely[14,15].

The results of the transportation values revealed less mesial transportation in the XPES group. These findings are in agreement with previous studies; XPES is reported to have less transportation compared to Reciproc and Reciproc Blue[12], and its centering ability was superior to WaveOne Gold[13].

The sample size was small, which poses a limitation to the current study. Further studies with a larger sample size could lead to more conclusive results. Furthermore, the assessment of shaping ability was only performed on three levels (2, 4 and 6 mm). Nevertheless, the results revealed that XPES system had a superior shaping ability compared to PTU system. Therefore, we recommend the use of XPES in curved canals to minimize procedural errors and subsequently improve the clinical outcome of the root canal treatment. Clinical studies that evaluate the success rate of root canal treatment performed using these files is recommended.

Conclusions

Within the limitations of this study, there were no statistically significant differences between groups instrumented using XPES or PTU files regarding change in cross-sectional area. However, XPES instrumentation might reduce the magnitude of canal transportation in mesial canals of mandibular molars in the middle third region.

Acknowledgements

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Declaration of Interest

The authors report no conflict of interest.

References

1. Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod 2004;30(8):559-67.
2. De-Deus G, Belladonna FG, Silva EJ, et al. Micro-CT Evaluation of Non-instrumented Canal Areas with Different Enlargements Performed by NiTi Systems. Braz Dent J 2015;26(6):624-9.
3. Gergi R, Osta N, Bourbouze G, et al. Effects of three nickel titanium instrument systems on root canal geometry assessed by micro-computed tomography. Int Endod J 2015;48(2):162-70.
4. Burklein S, Jager PG, Schafer E. Apical transportation and canal straightening with different continuously tapered rotary file systems in severely curved root canals: F6 SkyTaper and OneShape versus Mtwo. Int Endod J 2017;50(10):983-90.
5. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. J Endod 1988;14(7):346-51.
6. Kansal R, Talwar S, Yadav S, Chaudhary S, R. N. Endodontics simplified. JIDMR 2013;6(3): 117-21.
7. Elnaghy AM, Elsaka SE. Torsional resistance of XP-endo Shaper at body temperature compared with several nickel-titanium rotary instruments. Int Endod J 2017.
8. Nielsen RB, Alyassin AM, Peters DD, Carnes DL, Lancaster J. Microcomputed tomography: an advanced system for detailed endodontic research. J Endod 1995;21(11):561-8.
9. Swain MV, Xue J. State of the art of Micro-CT applications in dental research. Int J Oral Sci 2009;1(4):177-88.
10. Dowker SE, Davis GR, Elliott JC. X-ray microtomography: nondestructive three-dimensional imaging for in vitro endodontic studies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83(4):510-6.
11. Silmi A, Asrianti D, Putranto AW, M. U. Micro-computed tomography evaluation of three-dimensional analysis of first mandibular and second maxillary premolars apical constrictions. JIDMR 2019;12(1):133-37.
12. Pacheco-Yanes J, Gazzaneo I, Perez AR, Armada L, Neves MAS. Transportation assessment in artificial curved canals after instrumentation with Reciproc, Reciproc Blue, and XP-endo Shaper Systems. J Investig Clin Dent 2019;10(3):e12417.
13. Poly A, AlMalki F, Marques F, Karabucak B. Canal transportation and centering ratio after preparation in severely curved canals: analysis by micro-computed tomography and double-digital radiography. Clin Oral Investig 2019.
14. Versiani MA, Carvalho KKT, Mazzi-Chaves JF, Sousa-Neto MD. Micro-computed Tomographic Evaluation of the Shaping Ability of XP-endo Shaper, iRaCe, and EdgeFile Systems in Long Oval-shaped Canals. J Endod 2018;44(3):489-95.
15. Lacerda M, Marceliano-Alves MF, Perez AR, et al. Cleaning and Shaping Oval Canals with 3 Instrumentation Systems: A Correlative Micro-computed Tomographic and Histologic Study. J Endod 2017;43(11):1878-84.
16. Zupanc J, Vahdat-Pajouh N, Schäfer E. New thermomechanically treated NiTi alloys–a review. Int Endod J 2018;51(10):1088-103.
17. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1971;32(2):271-5.
18. Griffiths IT, Bryant ST, Dummer PM. Canal shapes produced sequentially during instrumentation with Quantec LX rotary nickel-titanium instruments: a study in simulated canals. Int Endod J 2000;33(4):346-54.
19. Thompson SA, Dummer PM. Shaping ability of Hero 642 rotary nickel-titanium instruments in simulated root canals: Part 2. Int Endod J 2000;33(3):255-61.
20. Pérez-Higueras JJ, Arias A, José C, Peters OA. Differences in cyclic fatigue resistance between ProTaper Next and ProTaper Universal instruments at different levels. J Endod 2014;40(9):1477-81.
21. Ruddle CJ. The ProTaper endodontic system: geometries, features, and guidelines for use. Dent Today 2001;20(10):60-7.
22. Stavileci M, Hoxha V, Görduysus M Ö, et al. Effect of Endodontic Instrumentation Technique on Root Canal Geometry. JIDMR 2017;10(3):952-57.
23. Chen Y, Gao B, Yang JB, Liu Q. Micro-CT evaluation of root canal deviation after preparation. WCJS 2009;27(5):521-4.