

Shaping ability of ProTaper Gold and ProTaper Universal files by using cone-beam computed tomography

Amr M Elnaghy, Shaymaa E Elsaka^{1,2}

Departments of Endodontics, Faculty of Dentistry, ¹Dental Biomaterials, Faculty of Dentistry, Mansoura University, Mansoura, Egypt, ²Department of Restorative Dental Sciences, Al-Farabi College of Dentistry and Nursing, Jeddah, Kingdom of Saudi Arabia

ABSTRACT

Context: This study evaluated and compared the shaping ability of ProTaper Gold (PG) (PG; Dentsply, Tulsa Dental Specialties, Tulsa, OK, USA) system with ProTaper Universal (PU) (PU; Dentsply Maillefer, Ballaigues, Switzerland) using cone-beam computed tomography (CBCT) imaging.

Materials and Methods: Forty mesiobuccal canals of mandibular first molars with curvatures of 25–30° were divided into two experimental groups ($n = 20$) according to the rotary nickel–titanium (NiTi) file system used in canal instrumentation as follows: Group PG and group PU. Canals were scanned before and after instrumentation using CBCT scanner to evaluate root canal transportation and centering ratio at 3, 5, and 7 mm from the apex and volumetric changes. Data were statistically analyzed using independent *t*-tests and the significance level was set at $P < 0.05$.

Results: There was no significant difference between PG and PU systems in the mean volume of removed dentine, canal transportation, and centering ratio ($P > 0.05$).

Conclusions: The PG and PU NiTi rotary systems showed similar root canal shaping abilities in the preparation of mesial canals of mandibular first molars.

Key words: Centering ratio, cone-beam computed tomography, ProTaper Gold, ProTaper Universal, root canal volume, transportation

Received : 01-12-15
Review completed : 17-01-16
Accepted : 29-02-16

Root canal shaping is a crucial procedure in endodontic treatment that influences the subsequent steps of root canal disinfection and obturation.^[1] The principles of root canal shaping are to form a continuously tapering funnel from the coronal access cavity to the root apex, preserving the original canal shape, and sustaining the integrity and location of the apical canal anatomy.^[2] However, procedural errors during instrumentation such as ledging, zipping, perforations, root canal transportation, and instrument separation can happen, especially when preparing curved canals.^[1,3]

In recent years, there have been considerable improvements in the design and the raw materials of nickel–titanium (NiTi)

rotary instruments to improve their clinical performance.^[3–5] The superelasticity of NiTi alloy provides enhanced flexibility and facilitates the NiTi rotary instruments to efficiently follow the original path of the root canal. Accordingly, NiTi rotary instruments have become an imperative adjunct for root canal shaping.^[6] On the other hand, it has been reported that the method of manufacturing and the design features could considerably affect the clinical performance of NiTi rotary instruments.^[3,7,8] Consequently, the development of new materials and methods of manufacturing NiTi rotary instruments are needed to obtain better performance while shaping the root canal.^[7]

Recently, ProTaper Gold (PG) (PG; Dentsply, Tulsa Dental Specialties, Tulsa, OK, USA) NiTi rotary system was introduced. PG was developed with proprietary advanced

Address for correspondence:

Dr. Amr M Elnaghy
E-mail: aelnaghy@mans.edu.eg

Access this article online

Quick Response Code:



Website:

www.ijdr.in

DOI:

10.4103/0970-9290.179812

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Elnaghy AM, Elsaka SE. Shaping ability of ProTaper Gold and ProTaper Universal files by using cone-beam computed tomography. Indian J Dent Res 2016;27:37–41.

metallurgy. It features a progressively tapered design that claimed to improve the cutting efficiency and safety. PG rotary files feature the same exact geometries as ProTaper Universal (PU) (PU; Dentsply Maillefer, Ballaigues, Switzerland), but it may appear slightly curved when removed from the package due to their metallurgy. This is not a defect, but rather, an advantage as supposed by the manufacturer. PG system has been metallurgically enhanced through heat treatment technology.^[9] PG files exhibit a convex triangular cross-section and progressive taper. PG files 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).^[10]

Several approaches have been used to assess the shaping ability of different NiTi rotary systems, including histological sections, plastic models, serial sectioning, scanning electron microscopy, radiographic comparisons, silicone impressions of instrumented canals, and micro-computed tomography (μ CT).^[7,11-14] Cone-beam CT (CBCT) has been used to evaluate root canal instrumentation.^[7,15-17] Through this method, it is possible to get before and after instrumentation images with no need to cut into tooth before the process.^[7,8,15,16] In addition, the quality of the three-dimensional images attained by this method is superior to other techniques, and therefore, approving its use for geometric analysis of root canal area.^[7,15,17-19]

The aim of this study was to evaluate and compare the effect of using PG and PU NiTi rotary systems on the volume of removed dentine, the transportation, and the centering ability using CBCT imaging.

MATERIALS AND METHODS

Forty extracted human mandibular first molars with two separate mesial canals and apical foramina were selected for this study. Sample size was calculated with 85% power to detect differences among groups at $\alpha = 0.05$ using statistical software (G * Power 3.1.9.2; Erdfelder, Faul, and Buchner). Teeth were accessed using an Endo-Access bur (Dentsply Maillefer) in a high-speed handpiece. Size 10 K-files (Dentsply Maillefer) were inserted through the mesiobuccal canals (MB), and the canal curvature was evaluated according to Schneider's method.^[20] Only canals with curvatures of 25–30° were included in this study. The distal roots with the respective part of the crown were sectioned at the furcation level using a low-speed diamond saw (Isomet 1000, Buehler Ltd., Lake Bluff, IL, USA) under water and discarded. The determination of the working length was established at $\times 10$ magnification using a surgical microscope (Global Surgical, St. Louis, MO, USA) by inserting size 10 K-file to root canal terminus

and subtracting 1 mm from this measurement.^[6,7,17,21] The teeth were numbered from 1 to 40 and randomly assigned to two groups ($n = 20$ each) using specific software (Random Allocation Software 2.0, Microsoft Corporation, WA, USA). The program was run by setting the sample size ($n = 40$), the number of groups ($n = 2$), and the name of each group according to the tested rotary systems. The "simple method" was chosen and a randomized list of numeric unique identifiers was produced by the software, thus obtaining the following study groups: Group PG and group PU.

Root canal shaping

Canals were instrumented by a single operator (Elnaghy AM) according to the manufacturers' instructions for each system. The files were operated using an electric motor (X-Smart; Dentsply Maillefer) with a 16:1 reduction handpiece. Glyde (Dentsply Maillefer) was used as a lubricant during instrumentation. A glide path was performed using ProGlider (Dentsply Maillefer; size 16, 0.02 taper) file to the working length. Apical preparation was completed with a size 25 file using the file order specified by the manufacturer. In both groups, the root canals were instrumented to the working length using the following sequence: SX, S1, S2, F1, and F2. In both systems, the first three shaping files were used with a brushing action, and the last two finishing files were used with a nonbrushing action until the working length was reached. During instrumentation, the canals were irrigated with 2 mL 5.25% NaOCl. After instrumentation, 1 mL of 17% ethylenediaminetetraacetic acid (Sigma-Aldrich, Riedel-de Haën, Switzerland) was applied for 3 min followed by final irrigation with 3 mL of NaOCl. Each instrument was used to prepare three canals and then discarded.^[8]

Image analysis

The roots were placed in a custom-made specimen holder in which each root could be positioned in the same place before and after instrumentation.^[1] The roots were aligned perpendicularly to the beam and they were scanned before and after instrumentation using the CBCT scanner (Veraviewepocs 3D; J. Morita, Kyoto, Japan) operating at 120 kV and 3–7 mA. The field of view was 8 cm in diameter and 8 cm in height. Slices were 800 $\times$ 800 pixels, with a pixel size of 0.125 mm.^[8]

Cone-beam computed tomography measurements

Pre- and post-instrumentation measurements of MB canals were achieved using the OnDemand 3D software (Cybermed Inc., Irvine, CA, USA). The volume of removed dentine was measured in mm³ for each root canal by subtracting the uninstrumented canal volume from the instrumented canal volume.^[7] Canal transportation and centering ratio were calculated at three cross-section levels, i.e., 3, 5, and 7 mm from the apical end of the root using the following equation:^[22]

Degree of canal transportation = $(m_1 - m_2) - (d_1 - d_2)$

Canal centering ratio = $(m_1 - m_2) / (d_1 - d_2)$ or $(d_1 - d_2) / (m_1 - m_2)$

where m_1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, m_2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, d_1 is the shortest distance from the distal edge of the root to the distal edge of the uninstrumented canal, and d_2 is the shortest distance from the distal edge of the root to the distal edge of the instrumented canal [Figure 1].^[2,7,8,22]

Statistical analysis

A statistical analysis (SPSS 15.0; SPSS Inc., Chicago, IL, USA) of the data was performed using independent *t*-test. Statistical significance level was set at $P < 0.05$.

RESULTS

Volume of removed dentine

The mean and standard deviation values of the volume of removed dentin for each group are shown in Table 1. There was no significant difference between PG and PU systems in the mean volume of removed dentine ($P > 0.05$).

Canal transportation and centering ratio

The mean and standard deviation values of the canal transportation and centering ratio at the three studied levels (3, 5, and 7 mm) for each group are shown in Table 2. At 3, 5, and 7 mm levels, there was no significant difference between PG and PU systems in canal transportation and centering ratio ($P > 0.05$).

DISCUSSION

Root canal shaping is one of the most significant procedures in root canal treatment.^[3] It is essential in determining the efficiency of all subsequent procedures, including chemical disinfection and root canal obturation.^[23,24] Previous studies have reported that maintaining the original canal shape with a less invasive method decreases the possibility of

canal transportation with a subsequently lower incidence of canal curvature straightening, the formation of ledges, and irregular apical enlargement.^[23,25,26]

The purpose of this study was to assess and compare the shaping ability of the recently introduced PG system with the PU rotary system, which has been used over the years as a reference technique for comparison.^[27] The assessment of alterations in canal shape after instrumentation is a reliable method to evaluate the susceptibility of a shaping technique to preserve the original canal anatomy or to straighten the curves.^[28,29] The CBCT imaging technique was used to assess the shaping ability of the tested files as it provides a precise, reproducible, three-dimensional assessment of alterations in dentine thickness and root canal volume before and after preparation without the damage of the specimens.^[7,18,30] However, the CBCT provides lower resolution compared with the μ CT tool. Instead, CBCT could be used in patients and *in vivo* studies despite its lower resolution due to the lower radiation level of exposure compared with μ CT. In addition, the μ CT imaging technique is time-consuming, and therefore, not suitable for the dental office.^[31]

Three levels were chosen including 3, 5, and 7 mm, which represent the apical, middle, and coronal thirds of the root canals, respectively, where curvatures with high susceptibility to iatrogenic mishaps usually exist. Crowns corresponding to the mesial roots were maintained to mimic the clinical conditions where the interference of cervical dentine projections would produce tensions on the files during canal instrumentation.^[7] The angle of curvature at 20–30° was chosen as it is considered as moderate curvature according to American Association of Endodontists (AAE) Endodontic Case Difficulty Assessment to obtain results that cover a large scale of cases.

In this study, regarding the volume of removed dentine, there was no significant difference between PG and PU systems. This finding could be attributed to the same

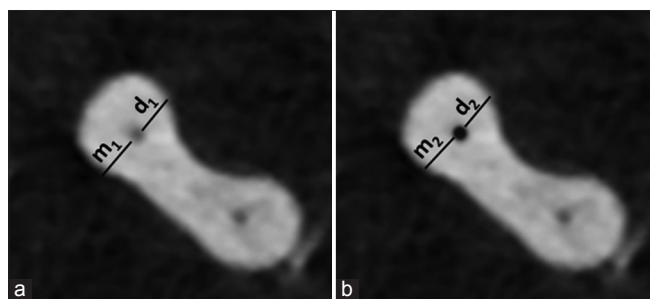


Figure 1: Representative cone-beam computed tomography image of tooth sections revealing how transportation and centering ratios were derived. (a) Uninstrumented image and (b) instrumented image

Table 1: Mean±standard deviation of volume of removed dentine (mm³) for tested groups and statistical analysis

Group	Mean±SD	P
PG	3.81±1.93	0.669
PU	4.07±2.01	

PG=ProTaper Gold, PU=ProTaper Universal, SD=Standard deviation

Table 2: Mean±standard deviation of transportation (mm), centering ratio values for tested groups, and statistical analysis

Level (mm)	Assessment	PG	PU	P
3	Transportation	0.11±0.02	0.12±0.02	0.06
	Centering ratio	0.55±0.19	0.54±0.17	0.76
5	Transportation	0.13±0.03	0.14±0.02	0.51
	Centering ratio	0.62±0.13	0.60±0.12	0.59
7	Transportation	0.16±0.02	0.17±0.03	0.100
	Centering ratio	0.68±0.16	0.65±0.15	0.56

PG=ProTaper Gold, PU=ProTaper Universal, SD=Standard deviation

geometrical and cross-section design of PG and PU files. Both systems have convex triangular cross-sectional design combined with the flute design with its progressive tapers sequence along the shaft.^[7,10]

The results of canal transportation and centering ratio revealed that there were no significant differences between PG and PU systems in canal transportation and centering ratio at the three studied levels. These findings could be due to the noncutting tip design that PG and PU possess, which functions only as a guide to allow easy penetration with minimal apical pressure.^[7,10] It has been reported that the apical transportation >0.3 mm reduces the quality of the apical seal.^[32] The results of this study showed that none of the instrumented specimens reached the above-mentioned critical level of transportation on all studied levels. In addition, the maximum root canal transportation in tested groups was less than the shortest distances from the outside of the curved root to the periphery of the uninstrumented canal. Consequently, the tested rotary systems with size 25 and taper 0.08 could be used in curved canals due to minimal transportation. This finding is in agreement with previous studies.^[6,27,33] On the other hand, counter to our findings, some previous studies reported that NiTi files with tapers >0.04 for apical enlargement of curved canals should not be used as reported for Profile (Dentsply Maillefer)^[34] and conventional ProTaper rotary files;^[35] otherwise, transportation would happen. These inconsistent findings could be due to the use of PU and PG files which have a rounded safe tip,^[10,36] instead of conventional ProTaper files and because of new proprietary advanced metallurgy processing of PG files.^[10]

The PG and PU NiTi rotary systems revealed comparable volume of removed dentine, canal transportation, and centering ratio. Further investigations to the metallurgy and mechanical properties of the new PG system are required to gain insight on how the proprietary advanced metallurgy processing of PG affect its properties. In addition, evaluations of the clinical performance of the tested brands *in vivo* are needed to give reliable recommendations for endodontists.

CONCLUSIONS

Within the limitations of this study, the following conclusion was drawn:

The PG and PU NiTi rotary systems showed similar root canal shaping abilities in the preparation of mesial canals of mandibular first molars *in vitro*.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. You SY, Kim HC, Bae KS, Baek SH, Kum KY, Lee W. Shaping ability of reciprocating motion in curved root canals: A comparative study with micro-computed tomography. *J Endod* 2011;37:1296-300.
2. Yamamura B, Cox TC, Heddaya B, Flake NM, Johnson JD, Paranjpe A. Comparing canal transportation and centering ability of endosequence and vortex rotary files by using micro-computed tomography. *J Endod* 2012;38:1121-5.
3. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. *J Endod* 2004;30:559-67.
4. Gao Y, Gutmann JL, Wilkinson K, Maxwell R, Ammon D. Evaluation of the impact of raw materials on the fatigue and mechanical properties of ProFile Vortex rotary instruments. *J Endod* 2012;38:398-401.
5. Lopes HP, Gambarra-Soares T, Elias CN, Siqueira JF Jr., Inojosa IF, Lopes WS, *et al.* Comparison of the mechanical properties of rotary instruments made of conventional nickel-titanium wire, M-wire, or nickel-titanium alloy in R-phase. *J Endod* 2013;39:516-20.
6. Zhao D, Shen Y, Peng B, Haapasalo M. Micro-computed tomography evaluation of the preparation of mesiobuccal root canals in maxillary first molars with hyflex CM, twisted files, and K3 instruments. *J Endod* 2013;39:385-8.
7. Hashem AA, Ghoneim AG, Lutfy RA, Foda MY, Omar GA. Geometric analysis of root canals prepared by four rotary NiTi shaping systems. *J Endod* 2012;38:996-1000.
8. Elnaghy AM, Elsaka SE. Evaluation of root canal transportation, centering ratio, and remaining dentin thickness associated with ProTaper next instruments with and without glide path. *J Endod* 2014;40:2053-6.
9. Ruddle CJ. Shaping complex canals: Clinical strategy and technique. *Dent Today* 2014;33:88-95.
10. Dentsply Tulsa. The ProTaper Gold Brochure; 2014. Available from: http://www.tulsadentalspecialties.com/Libraries/Tab_Content_-_Endo_Access/Shaping/Brochure_for_ProTaper_Gold.sflb.aslx. [Last accessed on 2015 Aug].
11. Backman CA, Oswald RJ, Pitts DL. A radiographic comparison of two root canal instrumentation techniques. *J Endod* 1992;18:19-24.
12. Campos JM, del Rio C. Comparison of mechanical and standard hand instrumentation techniques in curved root canals. *J Endod* 1990;16:230-4.
13. Reynolds MA, Madison S, Walton RE, Krell KV, Rittman BR. An *in vitro* histological comparison of the step-back, sonic, and ultrasonic instrumentation techniques in small, curved root canals. *J Endod* 1987;13:307-14.
14. Peters OA, Peters CI, Schönenberger K, Barbakow F. ProTaper rotary root canal preparation: Effects of canal anatomy on final shape analysed by micro CT. *Int Endod J* 2003;36:86-92.
15. Bernardes RA, Rocha EA, Duarte MA, Vivan RR, de Moraes IG, Bramante AS, *et al.* Root canal area increase promoted by the EndoSequence and ProTaper systems: Comparison by computed tomography. *J Endod* 2010;36:1179-82.
16. Pasternak-Júnior B, Sousa-Neto MD, Silva RG. Canal transportation and centering ability of RaCe rotary instruments. *Int Endod J* 2009;42:499-506.
17. Marzouk AM, Ghoneim AG. Computed tomographic evaluation of canal shape instrumented by different kinematics rotary nickel-titanium systems. *J Endod* 2013;39:906-9.
18. Hartmann MS, Barletta FB, Camargo Fontanella VR, Vanni JR. Canal transportation after root canal instrumentation: A comparative study with computed tomography. *J Endod* 2007;33:962-5.
19. Saber Sel D, Abu El Sadat SM. Effect of altering the reciprocation range on the fatigue life and the shaping ability of WaveOne nickel-titanium instruments. *J Endod* 2013;39:685-8.
20. Schneider SW. A comparison of canal preparations in straight and curved root canals. *Oral Surg Oral Med Oral Pathol* 1971;32:271-5.

21. Sanfelice CM, da Costa FB, Reis SÓ MV, Vier-Pelisser F, Souza Bier CA, Grecca FS. Effects of four instruments on coronal pre-enlargement by using cone beam computed tomography. *J Endod* 2010;36:858-61.
22. Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. *J Endod* 1996;22:369-75.
23. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, *et al.* Canal shaping with WaveOne primary reciprocating files and ProTaper system: A comparative study. *J Endod* 2012;38:505-9.
24. Hülsmann M, Peters OA, Dummer PM. Mechanical preparation of root canals: Shaping goals, techniques and means. *Endod Topics* 2005;10:30-76.
25. Loizides AL, Kakavetsos VD, Tzanetakis GN, Kontakiotis EG, Eliades G. A comparative study of the effects of two nickel-titanium preparation techniques on root canal geometry assessed by microcomputed tomography. *J Endod* 2007;33:1455-9.
26. Jafarzadeh H, Abbott PV. Ledge formation: Review of a great challenge in endodontics. *J Endod* 2007;33:1155-62.
27. Capar ID, Ertas H, Ok E, Arslan H, Ertas ET. Comparative study of different novel nickel-titanium rotary systems for root canal preparation in severely curved root canals. *J Endod* 2014;40:852-6.
28. Berutti E, Paolino DS, Chiandussi G, Alovisei M, Cantatore G, Castellucci A, *et al.* Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. *J Endod* 2012;38:101-4.
29. Merrett SJ, Bryant ST, Dummer PM. Comparison of the shaping ability of RaCe and FlexMaster rotary nickel-titanium systems in simulated canals. *J Endod* 2006;32:960-2.
30. Zanette F, Graziotin-Soares R, Flores ME, Camargo Fontanella VR, Gavini G, Barletta FB. Apical root canal transportation and remaining dentin thickness associated with ProTaper Universal with and without PathFile. *J Endod* 2014;40:688-93.
31. Michetti J, Maret D, Mallet JP, Diemer F. Validation of cone beam computed tomography as a tool to explore root canal anatomy. *J Endod* 2010;36:1187-90.
32. Wu MK, Fan B, Wesselink PR. Leakage along apical root fillings in curved root canals. Part I: Effects of apical transportation on seal of root fillings. *J Endod* 2000;26:210-6.
33. Bürklein S, Benten S, Schäfer E. Shaping ability of different single-file systems in severely curved root canals of extracted teeth. *Int Endod J* 2013;46:590-7.
34. Kum KY, Spångberg L, Cha BY, Il-Young J, Seung-Jong L, Chan-Young L. Shaping ability of three ProFile rotary instrumentation techniques in simulated resin root canals. *J Endod* 2000;26:719-23.
35. Schäfer E, Vlassis M. Comparative investigation of two rotary nickel-titanium instruments: ProTaper versus RaCe. Part 1. Shaping ability in simulated curved canals. *Int Endod J* 2004;37:229-38.
36. Câmara AS, de Castro Martins R, Viana AC, de Toledo Leonardo R, Bueno VT, de Azevedo Bahia MG. Flexibility and torsional strength of ProTaper and ProTaper universal rotary instruments assessed by mechanical tests. *J Endod* 2009;35:113-6.

