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Cone-beam computed tomography analysis of centering ability and root canal transportation of ProTaper gold and v taper blue files in mandibular molar root canal preparation

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Abstract
Introduction: To maintain the original shape of root canals using instruments with minimum effects on canal location is considered an important step in root canal preparation. Canal transportation is a common procedural mistake in the instrumentation of curved canals. This *in vitro* study aimed to evaluate the central ability and root canal transportation of two types of rotary files in curved canals using cone-beam computed tomography (CBCT).
Method and Material: A total of 40 mesiobuccal root canals of human mandibular first molars with an angle of curvature of 25-35 degrees and radius curvature of 5 millimeters were randomly divided into two groups of 20 canals each. Group A was prepared with Pro Taper Gold and Group B with V Taper Blue. Pre- and post-instrument CBCT scans were recorded. Images were reconstructed and cross-sections were detected corresponding to distances 3, 6, and 9 mm from the anatomic apex using Gambill's method. Statistical analysis was performed with T-test and repeated measure ANOVA. P-value was set at 0.05.
Results: No significant difference was observed among Pro Taper Gold and V Taper Blue in terms of centering ability from mesiodistal (P=0.304) and buccolingual (0.632) directions. Also, there was no statistical difference across two different instruments in considering to canal transportation from mesiodistal (P=0.581) and buccolingual (P=0.259) directions. However, in centering ability evaluation, each of the two groups showed significant differences in various levels of coronal, middle, and apical root level (P=0.000).
Conclusion: The two instruments were similar in terms of centering ability and canal transportation in mandibular curved canal preparation.

Keywords: canal transportation, centering ability, cone-beam computed tomography, protaper gold, V taper blue

Introduction
During the last decades, considerable progress in endodontics has been done. Root canal preparation as a critical procedure influencing the subsequent steps of disinfection and obturation plays an important role in endodontic treatment. During root canal instrumentation, developing a continuous tapering canal with the original canal shape preservation and keeping the instruments centered without teeth structure weakness are some key factors to final success, however, canal curvatures make the process difficult [1]. Nickel–titanium (NiTi) rotary instruments provide faster treatment meanwhile lesser iatrogenic mistakes. Comparison between NiTi and stainless steel in previous studies has shown that NiTi instruments have higher central ability and less canal transportation than stainless steel files [2, 3]. Despite the advantages, NiTi instruments seem to be vulnerable to separation by cyclic fatigue or torsional stress [4]. The ProTaper Gold (PTG) (Dentsply Maillefer, Ballaigues, Switzerland) rotary system is a common thermally treated rotary instrument with the same features as the ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) but advanced thermal treatment, named gold treatment [5]. Complex heating-cooling treatment of these files contributes to a

visible titanium oxide layer on the instrument surface, with shape memory alloy, higher flexibility, fatigue resistance, cutting efficiency, and canal centering ability [3, 4, 6-9].

The heat-treated AF-wire of FANTA company is an advancement of NiTi files with enhanced mechanical characteristics and efficient flexibility to prevent dislocation in root canals. Also, it has enough hardness to effective cut. The company introduces three types of flexible wires according to their crystalized phase of alloy which are ordered from higher to lower flexibility; AF-H, AF-R, and AF-L. Normal NiTi is less flexible than AF-L.

Recently, a new generation of rotary instruments was launched on the market, V Taper Blue (VTB) (Fanta Dental Material, Shanghai, China) which is especially consisted of AF-R alloy. According to the manufacturer, the V-Taper™ Rotary System is a series of three variable tapers NiTi rotary files which allow you to complete most molar and premolar root canals using 2-3 files and anterior root canals using 1-2 files. They claimed that this performance-enhanced system is easier, safer, more efficient, and less expensive than any other NiTi rotary file system [10].

Up to our knowledge, no studies have investigated the central ability and root canal transportation of VTB files. Therefore, this *in vitro* study was designed to compare the two aforementioned characteristics of PTG and VTB files employing cone-beam computed tomography (CBCT). The null hypothesis was that there would be no difference between the two systems concerning central ability and root canal transportation.

Methods and Materials

Tooth Selection

Forty extracted human mandibular first molars without any crowns or posts, defects, root canal calcification, internal or external root resorption, prior endodontic treatment, and aberrant canal morphology, extracted for periodontal reasons, were included. Ethical approval was granted by the ethics committee of Azad University, Dental Branch, Tehran, Iran. Using buccolingual and mesiodistal periapical radiographs, teeth with calcification or internal resorption were excluded. Teeth were stored in 5.25% sodium hypochlorite for one hour to disinfection, then stored in normal saline until use. To gain standardization, crowns were cut using a diamond disc and roots measuring 16±1 mm were included in this *in vitro* study. The first CBCT (NewTom VGi, QR SRL Company, Verona, Italy) was carried out to detect the canal morphology and curvature before instrumentation. Teeth with angles of curvature within 25°–35° in mesiodistal (MD) and buccolingual (BL) dimensions and 5-mm radius curvature were selected according to Pruett's method [11].

Tooth Preparation

A #10 K-file (0.02) (Mani Inc, Utsunomiya, Tochigi, Japan) was used to initial patency of working length (WL), visible at the apical foramen, and the WL was determined 0.5 mm short of this length. The teeth were embedded in molding wax with upright roots in rows of 20.

Forty MB canals of these 40 samples were randomly divided into two groups of A and B, and prepared by an expert operator in both rotary systems.

In group A (n = 20), the root canals were prepared using ProTaper Gold (Tulsa Dental Specialties, Dentsply, Tulsa, USA) with the speed of 300-350 rpm and 2N Torque. The following sequence of rotary files was applied in preparation; SX (0.04), S1 (0.02), and S2 (0.04) files to flare and shape the orifice, coronal, and middle thirds of the mesiobuccal canals with brushing movements to reach straight-line access. Then, preparation continued by F1 (0.07) and F2 (0.08) files with non-brushing movements to WL. Each file was used to prepare four channels and then discarded.

In group B (n = 20), V Taper Blue (Fanta Dental Material, Shanghai, China) rotary files with the speed of 300-350 rpm and 2N Torque were used for root canal preparation. Three files of Vx (#20), V1 (#25), and V2 (#30) were applied with the crown-down technique according to the manufacturer's instructions (10). Each file was used to prepare four channels and then discarded.

After the application of each file in both systems, recapitulation was carried out using a #10 K-file and the canals were rinsed with 2ml of 2.25% NaOCl. Each file was used in the preparation of four canals.

Scans Assessment

The samples underwent CBCT with the same exposure settings as those applied before instrumentation; fov 6*6, 110 KVP, 5.52 mA. The OnDemand 3D Dental software (Cybermed, Seoul, South Korea) was used to evaluate root canal transportation and the centering ratio at 3, 6, and 9 mm distance from the apex from Mb and BL directions. The three levels including 3, 6, and 9 mm from the root apex showed the apical, middle, and coronal thirds of the root canals, respectively, before and after preparation. The shortest distance between the canal wall and the external root surface in the mesial, distal, buccal and lingual was assessed and recorded. The measurements were made on CBCT scans as follows;

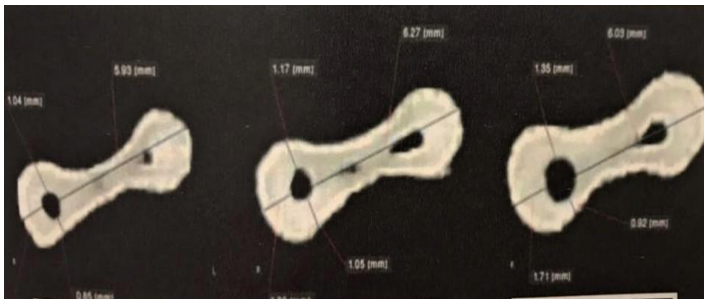

Fig 1: CBCT of root canals after preparation with V Taper Blue file in 3, 6, and 9 mm level

Canal Transportation: The amount of canal transportation was measured according to the formula by Gambill *et al*. (12); canal transportation (mm): (a1–a2) – (b1–b2)

a1: The shortest distance from the root mesial edge to the mesial edge of the uninstrumented canal.

b1: The shortest distance from the root distal edge to the distal edge of the uninstrumented canal.

a2: The shortest distance from the root mesial edge to the mesial edge of the instrumented canal

b2: The shortest distance from the root distal edge to the distal edge of the instrumented canal.

The result of "0" declared no canal transportation and other than "0" showed that transportation has occurred.

Canal Centering Ability: It was calculated by the following formula;

(a1–a2)/(b1–b2) or (b1–b2)/(a1–a2)

A result of "1" showed perfect centering, and the higher figure was considered as more deviation. The root dentinal thickness (RDT) was detected by subtracting the uninstrumented canal from the instrumented canal.

Statistical Analysis

Data of centering ability and root canal transportation of the two different rotary systems were analyzed using ANOVA test to compare systems during different times. To pairwise comparison, Kai-2 and the independent t-test were used. SPSS statistics version 20.0 (SPSS Inc., Chicago, IL, USA) was utilized for statistical analysis.

P-value was set at 0.05. α=0.50 and β=0.2 were considered.

Results

Centering Ability: The Mean (SD) values of centering ability of the two groups are illustrated in Table 1and fig 2. As it can be realized, in both MD and BL directions;

- No significant difference was showed between two groups of PTG and VTB ($P \geq 0.05$). However, there was significant difference in various distances of 3, 6, and 9 mm from the apex ($P \leq 0.05$) in both groups of PTG and VTB and the centering ratio became higher from apical to coronal.

Table 1: Mean (SD) values for centering ability (%) in root canals from mesiodistal (MD) and buccolingual (BL) directions following preparation with different files.

Direction		Root Level						Anova Test
		3mm		6mm		9mm		
		Mean (SD)	Coefficient of Variation	Mean (SD)	Coefficient of Variation	Mean (SD)	Coefficient of Variation	
MD€	ProTaper Gold (Control)	0.648 (0.126)	0.194	0.717 (0.168)	0.234	0.882 (0.228)	0.258	0.000
	V Taper Blue (Case)	0.533 (0.168)	0.315	0.640 (0.174)	0.271	0.879 (0.114)	0.129	
	P-Value	0.304						
BL¥	ProTaper Gold (Control)	0.690 (0.115)	0.166	0.849 (0.132)	0.155	0.995 (0.127)	0.127	0.000
	V Taper Blue (Case)	0.604 (0.152)	0.251	0.699 (0.114)	0.163	0.766 (0.161)	0.210	
	P-Value	0.632						
P<0.05, T Test, as appropriate. MD€: Mesiodistal, BL¥: Buccolingual								

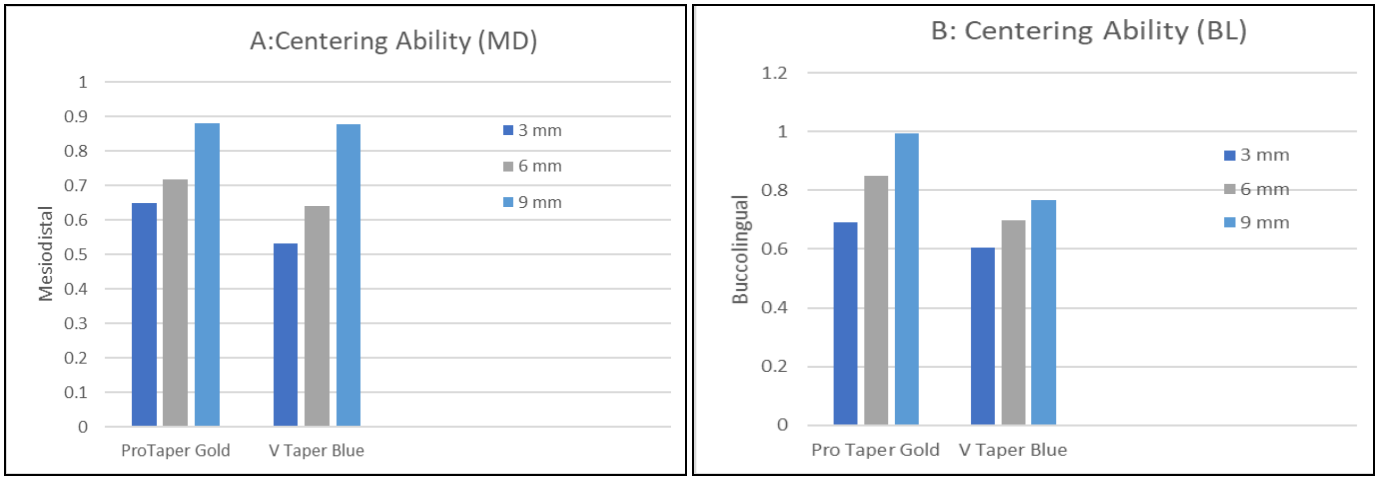

Fig 2: Centering ability in root canals following preparation with different files from A) mesiodistal (MD) and B) buccolingual (BL) directions

Root Canal Transportation: The Mean (SD) values of root canal transportation in two groups are shown in Table 2 and fig 3. In analysis of both MD and BL directions;

The difference between the two groups was not significant ($P \geq 0.05$). Also, there was no significant difference in none of the 3, 6, and 9 mm-sections ($P \geq 0.05$).

Table 2: Mean (SD) values for centering ability (%) in root canals from mesiodistal (MD) and buccolingual (BL) directions following preparation with different files.

Direction		Root Level						Anova Test
		3mm		6mm		9mm		
		Mean (SD)	Coefficient of Variation	Mean (SD)	Coefficient of Variation	Mean (SD)	Coefficient of Variation	
MD€	ProTaper Gold (Control)	0.017 (0.01)	0.588	0.016 (0.011)	0.687	0.005 (0.011)	2.2	0.427
	V Taper Blue (Case)	0.032 (0.219)	6.843	0.019 (0.13)	0.684	0.044 (0.225)	5.11	
	P-Value	0.581						
BL¥	ProTaper Gold	0.016	0.5	0.01	0.9	0.049	4.612	0.187

	(Control)	(0.08)		(0.009)		(0.226)		
	V Taper Blue (Case)	0.019 (0.006)	0.315	0.016 (0.009)	0.562	0.014 (0.009)	0.642	
	P-Value	0.259						
$P<0.05$, T Test, as appropriate. MD€: Mesiodistal, BL¥: Buccolingual								

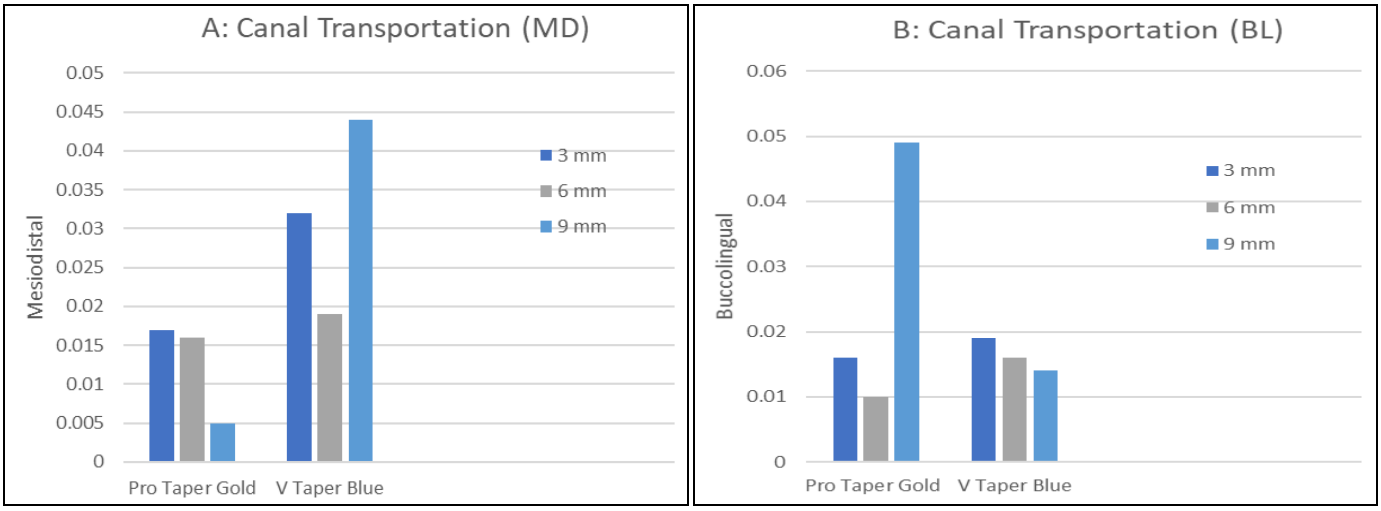

Fig 3: Canal transportation in root canals following preparation with different files from A) mesiodistal (MD) and B) buccolingual (BL) directions

Discussion

The MB canal of first mandibular molars with 25-35 curvature and 5-mm radius curvature were selected according to Prueet's method due to the more probable risk of ledge formation, canal transportation, and perforation in such as these curved canals [13]. The aim of this *in vitro* study was a comparative evaluation of centering ability and canal transportation of PTG and VTB systems using CBCT. The current study was based on the hypothesis that various instruments of different brands would not affect root canal transportation or centering ability in mandibular molars. The obtained results were statistically similar for the tested instruments, confirming the null hypothesis. This may be due to the same manufacturing process of both PTG and VTB instruments from metallurgical point.

Different techniques have been used in evaluation of centering ability of NiTi files such as radiography [14], Bramante latitudinal sectioning [15], Longitudinal clarification of teeth [16], high resolution computed tomography (hr CT) [17, 18], micro tomography (μCT) [18, 19] and CBCT [20]. Among these techniques, CBCT with its high resolution is a good choice to assess root canal morphology, fractures and changes of root canal systems after preparation because of its advantages; non-invasive, reproducible and measurable method for three-dimensional assessment prior and after instrumentation with high accuracy and resolution [21, 22].

Some previous studies have assessed PTG files with other instruments in terms of centering ability and root canal transportation [23-27], although there has been no assessment on VTB instruments up to now. Higher mechanical properties of PTG are related to the innovative metallurgy, which demonstrates two-stage specific transformation behavior and high AF temperatures. PTG involves two categories of shaping instruments with a progressively tapered design (SX, S1, S2) and finishing files (F1, F2, F3, F4, F5) with fixed tapers between D1 and D3, which decrease progressively from D4 to D14 [28].

Silva *et al.* [29] showed no significant differences between PTG and Reciproc Blue System in degree of canal transportation and centering ability of the cervical and middle thirds of mandibular molars using (μCT) ($P>0.05$). However, significant difference in the centering ability of the apical third of MB canals noted and PTG was less effective in centralization ($P<0.05$). They hypostasized that thermomechanical blue treatment of Reciproc Blue contributed to an increased flexibility of the instruments, therefore, the probability of more centralization and less shape memory effect.

According to Antony SDP *et al.* [27], three systems of Profit S3 (PS3), One Curve (OC), and PTG showed no significant difference in terms of canal transportation and canal centering ratio. Although PTG system had more dentin removal in comparison to the other systems.

In a comparison of PTG, Reciproc, and Pro Taper Universal by Arsalan H *et al.* [30], they claimed that root canal transportation and centering ratio were similar among the three groups at 3, 5, and 7-mm levels.

Elnaghy AM *et al.* [31] showed no significant difference between PTG and Pro Taper Universal NiTi rotary systems in root canal shaping abilities of mesial canals of mandibular first molars at three levels of 3-, 5-, and 7 mm.

In an evaluation of different NiTi files by Mamede-Neto l *et al.* [32], PTG showed the lowest canal transportation with the highest centering ability values, however, there was no significant difference between all tested groups.

In assessment of shaping ability by using CBCT, Sing S *et al.* [33] reported that two-shape (2S) files showed minimal canal transportation when compared to PTG. They observed that PTG removed dentin more aggressively than that of S2.

Sing S *et al.* [34] declared that PTG had a greater significant difference in apical transportation and centering ability values when compared to two-shape (2S) and Wave One Gold.

According to Jain A *et al.* [35], Wave One single reciprocation file system showed better canal anatomy better than Pro Taper. Pro Taper individually had better centering ability at 3 mm (apical third) and 9 mm (coronal 3rd) levels than 6 mm level (middle third).

In the present study, it should be considered that in both PTG

and VTB groups, no canal transportation value was over the critical point of 0.300 mm, which the apical filling ability of the root canal sealer may be compromised above this point [36]. The acceptable value of root canal transportation is reported up to 0.15 mm [37].

Conclusion

PTG and VTP instruments were similar in terms of centering ability and canal transportation in mandibular curved canal preparation. In centering ability evaluation, both groups showed significant difference at various levels of coronal, middle, and apical root level. Centering ability values became higher when it came from apical to coronal level. In summary, this *in vitro* study showed that the two systems were safe to use, however, further studies are suggested to evaluate these findings in real clinical situations.

Conflict of Interest

The authors deny any conflict of interest.

Acknowledgement

Declared none.

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