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Comparison of canal transportations and centering ability of rotary instrument systems with different heat-treated NiTi alloys: An in vitro CBCT study.

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ABSTRACT

One of the most important stages in root canal treatment is shaping. Manufacturers have developed various equipment and techniques to achieve better shaping abilities This study aims to evaluate the effects of 3 different rotary file systems, produced with the different heat-treated NiTi alloys technology on root canal transportation and centering ability via CBCT. A total of 36, Vertucci Type IV mesiobuccal (MB) root canals of mandibular molars were used. After pre-instrumented CBCT images were taken, the samples were randomized according to initial canal curvature angles into three groups (n=12). Root canal instrumentation was completed according to the manufacturer's instructions in all groups (VDW.Rotate, K3XF, Hyflex EDM). Post-instrumented CBCT images were taken. The root canal transportation and centering ability was calculated according to the Gambill et al described before (1996). Statistical analysis was performed using the IBM Statistics SPSS 20.01 program. One-way ANAVO and post-hoc Tukey tests were used for evaluating the differences among the groups. The significance level was set at P=0.05. There were no statistical differences at any level on canal transportation and centering ability according to groups. However, the tendency to transportation changed according to differences in horizontal levels. In conclusion, all systems produced similar canal transports in the mandibular molar canals and these systems were all clinically acceptable limits.

Key Words: canal transportation, centering ability, VDW.Rotate, Hyflex EDM.

INTRODUCTION

One of the most important stages in root canal treatment is root canal shaping, which will determine the fate of other stages (1). The manufacturing of endodontic instruments from straight metals causes root canal transportation during the shaping of curved canals, and most of the root canals are curved (2). This situation will result in untouched areas in the root canals after shaping or many endodontic errors (3). With the introduction of NiTi rotary instruments into the market, root canal shaping has started to take place with fewer errors, but defects such as root canal transports (4), which occur due to the unique characteristics of these files, have also started to be discussed in the literature.

Manufacturers have developed patented manufacturing techniques to achieve better mechanical properties such as fracture resistance, cutting efficiency, and flexibility in NiTi rotary tools. VDW Rotate, which is the latest marketed by VDW company, produces different files with many different metals and cutting properties. VDW.Rotate is an s-shaped cross-sectioned file with rotation movement, offering files in many different taper for different cases ((15/.04), (20/.05), (25/.04), (25/.06), (30/.04), (35/.04), (40/.04), (50/.04), (60/.04), (30/.06), (35/.06), and (40/.06))(5).

HyFlex EDM (Coltene Whaledent) files are produced by an electro discharge machining (EDM) process

(While EDM technology was previously used to produce miniature components for use in medical technologies (6), it was used for the first time in endodontic files via Hyflex EDM (7). While grinding metal in traditional metal production techniques, EDM method is a non-contact method that allows the removal of unwanted parts on the material by evaporation with electric sparks and shaping the tool to its desired final state (8). K3XF (SybronEndo, Orange, CA) is a file produced from R-phase wire. Provides R-phase, shape memory and good superelasticity effects; It has a lower Young's modulus than the austenite phase. This means that a file made from R-phase wire will have lower hardness (9). Today, CBCT has taken its place as an undisputed technology in the field of endodontic imaging. It is used to reconstruct the anatomy of the tooth in axial, sagittal and coronal directions with the help of computer in detail, according to 2D imaging. CBCT provides the clinician with uniquely detailed information on teeth and related pathologies (10). This study aims to evaluate the effects of 3 different rotary file systems on root canal transport using CBCT imaging.

2. MATERIALS AND METHODS

Pre-posttest experimental study design was preferred. G*Power 3.1.2 software (SPSS version 0.17; SPSS Inc., Chicago, IL, USA) was used for appropriate sample size estimation. As a reference study of Razcha et al (2020), the study sample size was calculated as 12 specimens/group with the parameters of a test power of 80%, with a type I error probability of 0.05, and for an effect size above 0.46 as Cohen (1988) described before (11,12).

A total of 30 mesio-buccal (MB) root canals of extracted (not related to this study) mandibular molars with fully formed apices were used. The canals in Vertucci Type IV (2 starts and continue separately and end in 2 separete canals) was selected for study. The teeth with no comparable root length, root canal calcification or internal/ external root resorption are excluded from study with a radiographically examination in both bucco-lingual and mesio-distal directions. Teeth were cleaned, disinfected and stored in 0.9% saline solution. Then, the teeth were fixed in a silicone impression (Zhermack Elite HD+ Putty, Badia Polesine, Italy) for providing constant position for CBCT. Pre-instrumented, CBCT (Newton FP, Quantitative Radiology, Verona, Italy) images were taken whereby the constant exposure parameters of 110kv tube potential and 0.02 mAs tube current and 6*8 cm field of view were preferred. Axial slice thickness was 0.10mm with a 0.10 mm pixel size.

After the standardized access cavities were opened under water-cooling, glide path was performed via #10 K-files (Dentsply Maillefer, Ballaigues, Sweden).

Mimics 15.01 software (Materalise HQ, Levven, Belgium) were used to interpret the pre and post CBCT images. The measurement slice was determined in 2,5 and 8 mm from the apex according to the CBCT images horizontal slices.

MB canals curvature angles were calculated according to Estrela et al (2008) (13). Canals with severe curvatures (20° to 45°) were selected for the study.

The samples were randomly divided into three groups according to their angles (n = 12). Glide file was inserted into the root canal and passively pushed forward till it had been visible from the apical foramen and the length of root canal was measured. And working length was calculated by 1mm minus from that length. Root canal instrumentation was completed according to the manufacturer rinstructions in all groups (VDW.Rotate, K3XF, Hyflex EDM). As irrigation procedure, 2 ml of 2.5% sodium hypochlorite solution was used after each instrument change. Each instrument was used in 4 canals. Instrumentation was completed by an expert with The Vdw.Gold Reciproc Motor (GRM) (VDW GmbH, Munich, Germany) as the procedures defined below;

Group 1, VDW.Rotate; The instruction of manufacturer's was followed. Glide path was

performed with the file size 15, 0.4 taper by brushing motion. And then, the file size 20, 0.6 taper and the file size 25,0.4 taper were used and the files were used with 350-400 rpm and 1.3-2Ncm, respectively.

Group 2; HyFlex EDM; As recommendations of manufacturer, the instruments were used at a rotational speed of 400 rpm and a torque of 2.5 Ncm. And also the shaping procedure for the canals with severe curvature was followed. For 2/3 coronal part of the root canal the file with the size 25, .12 taper was used and then for glide path #10 K type file was used in working length. And the file size 25 were used respectively.

Group 3 K3XF; As recommendations of manufacturer, the instruments were used at a rotational speed of 400 rpm and a torque of 2 Ncm. The file size 15, .04 taper, file size 20, .04 taper and file size 25,.04 taper were used respectively.

The root canals were sectioned horizontally at 2,5,8 mm from the apex. 2mm level was set as apical portion, 5 mm level was set as midroot and 8mm level was set as coronal portion of the root. And the shortest length from the root canal to the outer surface of root were measured in the mesial and distal part as Gambill et al. described before (14). Canal transportation and centering ratio was calculated according to the formula as; The following formulas for transportation was used in determining the amount of transportation; | (xinitial-x2) - (yinitial-y2) |, | (xinitial-x5) - (yinitial-y5) |, | (xinitial-x8) - (yinitial-y8) | and the following formula for centering ratio; (xinitial –x2) / (yinitial-y2), (xinitial-x5) / (yinitial-y5), (xinitial-x8) / (yinitial-y8) (Gambill et al 1996). “x” represents mesial and “y” represent distal measurements at related levels. According to this formula; “0” means there is no canal transportation, and positive values means there is a transportation through the mesial region and negative values means there is a transportation through the distal zone. And also, for centering ratio the values which are closer to 1 mean to better centering ability whereas 0 indicates worse centering ability (Figure 1).

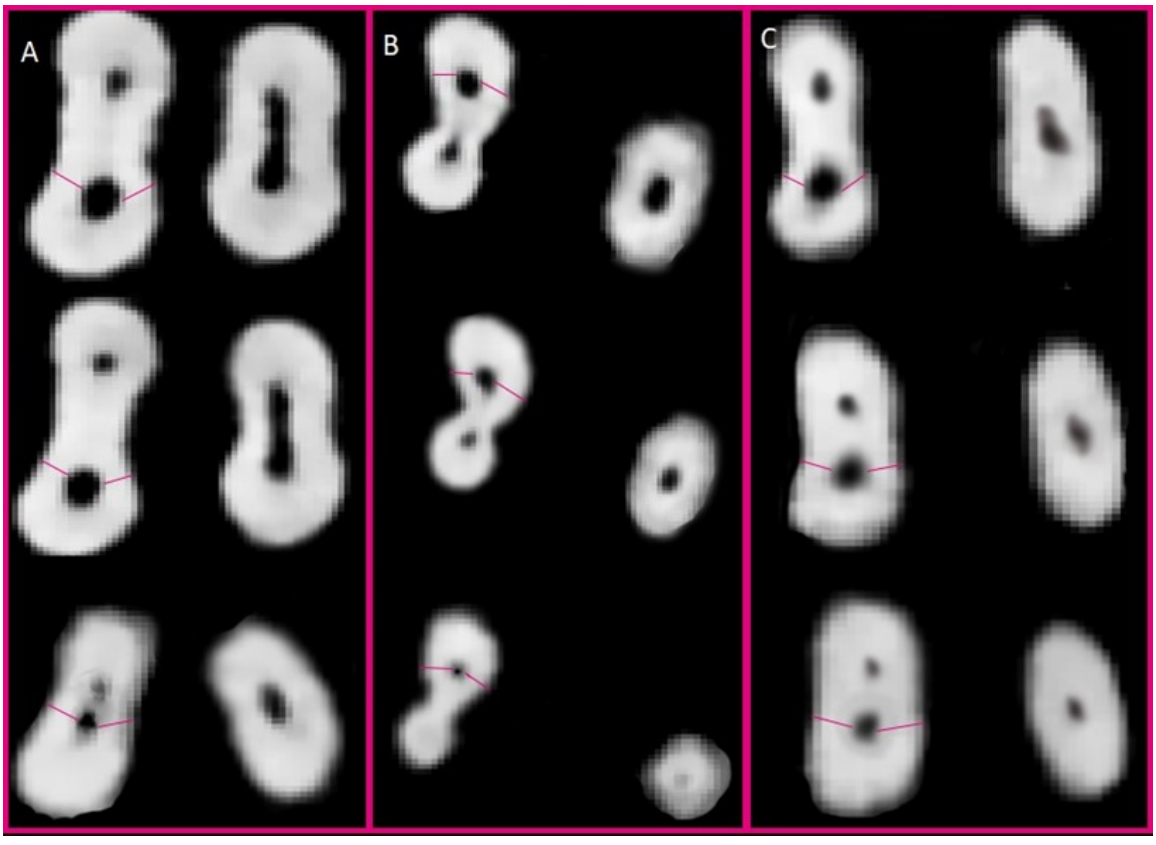

Figure 1. Calculation the canal transportation according to Gambill et al (1996) at three different level of 2mm, 5mm, and 8 mm, from apex in three experimental groups.

Statistical analysis was performed using the IBM Statistics SPSS 20.01 program. Normality distributions for variables was carried out by The Kolmogorov-Smirnov test. One-way Anova and post hoc Tukey tests were used for evaluating the differences among the groups. The significance level was set at P=0.05.

Table 1. The variables of mean and standard deviations of initial canal curvatures (°)

Group	Initial Curvature (±SD)°
VDW.Rotate	34,28 6,45
K3XF	33,76 6,45
Hyflex EDM	31,9 5,86
P value	0,627
One-way ANOVA	

3. RESULT AND DISCUSSION

3.1. Results

The mean and standard deviations of initial canal curvatures was shown in Table 1.

The statistical analysis of the mean (±SD) canal transportation and centering ability values in mm and canal transportation tendencies according to groups were shown in Table 2.

Table2 . The statistical analysis of the mean (±SD) canal transportation and centering ability values in mm and canal transportation tendencies according to groups.

Group	Canal Transportation (±SD)	*P value*	Centering Ratio (±SD)	*P value*	Canal transportation tendency (%)	
					Mesial	***Distal***
2mm from the apex		**0,378**		***0,108***		
VDW.Rotate	0,14 (±0,24)		0,51 (±0,21)		60	40
K3XF	0,06 (±0,05		0,63 (±0,30)		70	30
Hyflex EDM	0,06 (±0,08)		0,73 (±0,17)		70	30
5 mm from the apex		**0,691**		**0,722**		
VDW.Rotate	0,07 (±0,06)		0,89 (±0,40)		40	60
K3XF	0,05 (±0,03)		0,72 (±0,14)		10	90
Hyflex EDM	0,06 (±0,04)		0,74 (±0,21)		50	50
8mm from the apex		**0,55**		**0,130**		
VDW.Rotate	0,79 (±0,03)		0,73 (±0,18)		50	50
K3XF	0,11 (±0,07)		0,58 (±0,22)		40	60
Hyflex EDM	0,10 (±0,06)		0,58 (±0,21)		40	60

According to the results, there were no statistical differences at any level on canal transportation according to groups. However, at the apical portion of the root canals (2 mm from the apex all systems showed a tendency to transport the canal mesial side with the percentage of 60%,70% and 70% respectively. At midroot level (5 mm from the apex, set as the curvature degree) VDW.Rotate and K3XF showed a tendency to transport the canals to distal side 60% and 90% respectively, although Hyflex EDM showed equal tendency to both side (50%). At the coronal part of the root canals (8mm from the apex), although VDW Rotate showed an equal tendency of canal transportation to both side (50%), K3XF and Hyflex EDM showed a tendency to transport the root canals towards the distal side 60% and 60% respectively.

3.2. Discussion

One of the most important goals of root canal shaping is to ensure that the root canal takes a conical shape from the apical to the coronal and preserve the original canal tract of the root canal (15). Root canal transport, according to the definition of the American Society of Endodontics, is defined as "the removal of more material from the outer wall of the tooth by the file, which tends to flatten in the apical third of the curvature canals" (16). Once root canal transport has occurred in a curved canal, it is impossible to reverse it (17). Evaluation of root canal transportation and centering ratio are effective methods to analyze the preparation quality of root canals prepared with different techniques and instruments (18). In this study, we preferred severe curved mesio-buccal (MB) root canals of extracted mandibular molars because the frequency of root canal transportation and perforation is higher in this type of canals (15). In this study, we aimed to evaluate the canal transportation of 3 different brands (Hyflex EDM, K3FX, VDW.Rotate) made of different NiTi materials in extracted teeth via CBCT.

Although CBCT has its limitations when evaluating apical transport, it is not invasive among the currently available techniques, allowing imaging before and after instrumentation, being cross-sectional, and having high accuracy and resolution of its 3D image makes CBCT useful in these studies (19,20).

In the canal transportation part of their study that they made with CBCT Prasanthi at all., they found that K3FX performed statistically significantly less canal transpostation than ProTaper Universal (21). The researchers attributed this to the Proteaper Universal's triangular cross-section, the taper varying with the length of the cutting section and positive rake angle without radial lands (21).

In the literature, no canal transportation studies have been found with VDW.Rotate before. In the study of Pit et al. in 2020, they reported that VDW.Rotate and TruNatomy created the least increased root canal area in a similar way, while Reciproc Blue and ProTaper Gold systems created more increased root canal area (22). The other two studies in the literature related to VDW.Rotate were related to cyclic fatique resistance. According to literature, VDW.Rotate is more resistant to TruNatomy, while Reciproc Blue is more resistant than VDW.Rotate in both rotation and reciprocating motion (23,24).

The Hyflex EDM system was found to be better than the other systems via cyclic fatique resistance (25). In previous studies, it has been reported that Hyflex EDM preserves the original canal shape of the root canal and does not cause significant defects in the root canal (11). These findings are also consistent with our study. In the study made by Razcha et al., the canal transportation rate of Hyflex EDM was higher than the TruNatomy system and less than the ProTaper Gold system (11). In our study the canal transportation of Hyflex EDM is not statistically significant different than VDW.Rotate and K3XF.

4. CONCLUSION

In conclusion, all systems produced similar canal transports in the mandibular molar canals and all amount of canal transportations are within clinically acceptable limits. All systems used in this study can be used safely in the clinic and any errors that may occur are clinically acceptable.

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REFERENCES

1. Fidler A, Plotino G, Kuralt M. A Critical Review of Methods for Quantitative Evaluation of Root Canal Transportation. J Endod, (47), (2021), 721–31.
2. Peters OA. Current challenges and concepts in the preparation of root canal systems: A review. Journal of Endodontics, (30), (2004), 559–67.
3. Hulsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endodontic Topics, 10(1), (2005), 30–76.
4. Short JA. A comparison of canal centering ability of four instrumentation techniques. Journal of Endodontics, 23(8), (1997), 503–7.
5. VDW. VDW.Rotate Product Brochure, (2022). Available from: https://www.vdw-dental.com/en/products/detail/vdwrotate/#download
6. Sabyrov N, Jahan MP, Bilal A, Perveen A. Ultrasonic vibration assisted electro-discharge machining (EDM)-An overview. Materials. Materials (Basel), (12), (2019).
7. Iacono F, Pirani C, Generali L, Bolelli G, Sassatelli P, Lusvarghi L, Gandolfi, M. G. Giorgini, L.& Prati, C. Structural analysis of HyFlex EDM instruments. International Endodontic Journal, 50 (3), (2017), 303–13.
8. Daneshmand S, Kahrizi EF, Abedi E, Mir Abdolhosseini M. Influence of machining parameters on electro discharge machining of NiTi shape memory alloys. International Journal of Electrochemical Science. 8(3), (2013), 3095–104.
9. Cheung GSP, Shen Y, Darvell BW. Does Electropolishing Improve the Low-cycle Fatigue Behavior of a Nickel-Titanium Rotary Instrument in Hypochlorite? Journal of Endodontics, 33 (10), (2007), 1217–21.
10. Scarfe WC, Levin MD, Gane D, Farman AG. Use of Cone Beam Computed Tomography in Endodontics. International Journal of Dentistry. 12, (2009), 1–20.
11. Razcha C, Zacharopoulos A, Anestis D, Mikrogeorgis G, Zacharakis G, Lyroudia K. Micro-Computed Tomographic Evaluation of Canal Transportation and Centering Ability of 4 Heat-Treated Nickel-Titanium Systems. Journal of Endodontics. 46(5), (2020), 675–81.
12. Cohen J. (2013): Statistical power analysis for the behavioral sciences. Routledge.
13. Estrela C, Bueno MR, Sousa-Neto MD, Pécora JD. Method for determination of root curvature radius using cone-beam computed tomography images. Brazilian Dental Journal, 19(2), (2008), 114–8.
14. Del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. Journal of Endodontics, 22(7), (1996), 369–75.
15. Karkehabadi H, Siahvashi Z, Shokri A, Haji Hasani N. Cone-beam computed tomographic analysis of apical transportation and centering ratio of ProTaper and XP-endo Shaper NiTi rotary systems in curved canals: an in vitro study. BMC Oral Health, 21, (2021), 211-19.
16. American Association of endodontists Special Committe. Glossary of Endodontic Terms 2016. Glossary of Endodontic Terms, 10(4), (2020)
17. Weine F (2003): Endodontic therapy. CV Mosby.
18. Shah DY, Wadekar SI, Dadpe AM, Jadhav GR, Choudhary LJ, Kalra DD. Canal transportation and centering ability of protaper and self-adjusting file system in long oval canals: An ex-vivo cone-beam computed tomography analysis. Journal of Conservative Dentistry, 20(2), (2017), 105–9.
19. Shokri A, Shakibaei Z, Langaroodi AJ, Safaei M. Evaluation of the mandibular canal visibility on cone-beam computed tomography images of the mandible. Journal of Craniofacial Surgery, 25(3), (2014), 56-68.
20. Eskandarloo A, Mirshekari A, Poorolajal J, Mohammadi Z, Shokri A. Comparison of cone-beam computed tomography with intraoral photostimulable phosphor imaging plate for diagnosis of endodontic complications: A simulation study. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology, 114(6). (2012), 54-61.
21. Prasanthi NNVD, Rambabu T, Sajjan GS, Varma KM, Satish RK, Padmaja M. A comparative evaluation of the increase in root canal surface area and canal transportation in curved root canals by three rotary systems: A cone-beam computed tomographic study. Journal of Conservative Dentistry, 19(5), (2016), 434–9.
22. Pit A-B, Borcean I-A, Vargatu I-A, Mai A, Shyblak M, Mokdad S. Evaluation of the time and efficiency of TruNatomy, VDW.ROTATE, Protaper Gold and Reciproc Blue in shaping root canals - an in vitro study. Romanian Journal of Oral Rehabilitation. 12(3), (2020), 250–6.
23. Gündoğar M, Uslu G, Özyürek T, Plotino G. Comparison of the cyclic fatigue resistance of VDW.ROTATE, TruNatomy, 2Shape, and HyFlex CM nickel-titanium rotary files at body temperature. Restorative Dentistry & Endodontics, 45(3), (2020).
24. Uygun AD. Cyclic fatigue resistance of VDW.ROTATE and Reciproc Blue nickel-titanium files at root canal temperature. Journal of Dental Research, Dental Clinics, Dental Prospects, 14(3), (2020), 177–80.
25. Yılmaz K, Uslu G, Özyürek T. Effect of multiple autoclave cycles on the surface roughness of HyFlex CM and HyFlex EDM files: an atomic force microscopy study. Clinical Oral Investigations, 22(9), (2018), 2975–80.