NIU Journal of Health Sciences Copyright©2026
Nexus International University ISSN: 3136-6449; 12(2) 23-29

A comparative Study on the Canal Transportation of Two Heat Treated Rotary NiTi Instruments; Orodeka Plex-V and AF F-One Files in Sever Curved Simulated Canals (A comparative *in vitro* Study)

Saad A. Ramadhan MSc., Ph.D., Conservative Dentistry, University of Misan, Iraq
Hamid Kasim MSc., Ph.D., Sawa University, Samawa, Iraq
Corresponding Author: *Dr. Hamid Kasim*, e-*mail: hamidkasim100@yahoo.com.*

Abstract
Aim: to evaluate the shaping ability Orodeka Plex-V and Fanta AF F-One rotary nickle-titanium systems in simulated curved canals.
Materials and Methods: twenty artificial curved resin canals were divided into two groups according to the instruments used for canal preparation. All canals were instrumented to master apical file of 25/04. Outer and inner transportation were evaluated. Measurements were carried out at five different levels. Pre-and postoperative images of the canals were taken at 40X magnification. An assessment of the canal shape was determined using Photoshop CS2 software.
Results: Plex-V caused greater transportation of the outer walls of the canals than F-One files, with a statistically significant difference at all five levels examined. Similar results were observed on the inner canal walls, without statistical significance, except at the apical level, where the difference was significant. In general, the transportation on the outer walls was greater than on the inner walls along the canals.
Conclusions: Within the limitations of the study, F-One instruments maintained the original curvature significantly better than Plex-V.

Keywords: Transportation, Fanta AF F-One, Orodeka Plex-V.

1. Introduction

Root canal treatment involves several steps; canal shaping is one of the most important (1). A fundamental aspect of biomechanical preparation is shaping the canal into a tapering form without altering the original shape (2). This phase is crucial for successful canal preparation, especially in the apical third, as uneven cutting of the canal walls may lead to ledge formation or even perforation. Therefore, instruments must be used to cut the dentin evenly from all sides (3).
Glossary of Endodontic Terms defined the transportation as "an excessive removal of the outer wall of the apical half of the canal due to the instrument's tendency to return to its original straight shape during instrumentation, which may end with the ledge formation and possibly perforation" (4). Teeth with narrow and curved canals are more prone to these aberrations (5). Hence, degree of transportation of root canal can be used to measure the performance of various endodontic instruments and techniques used for canal preparation (6).

The introduction of NiTi to the world of endodontics, significant advancements occurred in root canal instruments, positively impacting the time required to complete the treatment, enhancing dentist comfort, and reducing the error rate (7). Since these tools were introduced to the market, updates have been ongoing in terms of engineering design and heat treatment (8).
One of the new NiTi rotary systems that was introduced to the field of root canal treatment is the Orodeka Plex-V files. These instruments are manufactured using a special thermal process called CM wire, which aims to increase flexibility and high resistance to cyclic fatigue. These files feature a triangular cross-section to minimize the friction with canal walls and a non-cutting tip used for canal searching and negotiation (8).

Recently, Fanta introduced a new type of files termed AF F-One system using a special heat treatment called AF Wire. A notable feature of this design is the flat surface along the cutting edge of the file, which makes the file more flexible and reduces friction with the canal walls, thus increasing the file's resistance to breakage and providing a larger space for evacuation debris coronally. In addition, the cross-section is S-shaped, which increases the cutting performance of the file (8).
According to the investigation oversaw on scientific websites, there is no research comparing these modern endodontic rotary systems in terms of their ability to prepare canals without deviating from the original paths of the canals. Therefore, this research was conducted in this experiment to find out which of these files is more capable of preparing the sever curved simulated canals while preserving the original shape of the canals in term of transportation.

2. Materials and Methods

2.1 Artificial Root Canals

Twenty artificial curved root canals (Dentspiy Maillefer, Ballaigues, Switzerland) were used in this study. These canals were identical to the geometry of ISO K-file #10. The straight part was 11 mm long, while the curved part was 5 mm long, making the total length of the canal 16 mm. the angle of curvature was 45° according to Schneider (9), and radius with 5.5mm along with Pruett et al., (10).

2.2. Canals Photography

Before starting the instrumentation, and to increase the contrast of the images, each artificial canal was filled with writing ink (Hero, China) using a 27-gauge syringe (Seoul, Korea). Each sample was magnified 40 times by a stereomicroscope (Keyence VH8000, Osaka, OSK, Japan), and the image was taken under this magnification by a digital camera (Cyber-shot, Sony, Japan). The camera was mounted on the microscope lens in a way that allowed the model to be repositioned in the exact same location to take before-and-after photos of sample preparation. After the photography, the simulated canals were washed of ink residue with tap water.

2.3. Instrumentation of Simulated Root Canals

The samples were randomly divided into two groups (n=10) based on the type of rotary system used in the preparation. Canals patency was verified by ISO K file #10 (Dentsply, Maillefer, Ballaigues, Switzerland). The canals were prepared by a root canal specialist experienced with these rotary systems. The rotary files were operated with X-Smart Plus iQ electric motor (Dentsply, maillefer, Ballaigues, Switzerland).

Group 1:
In this group, the Orodeka Plex-V system (Shandong Province, China) was used by X-Smart motor, according to the manufacturer's recommendations for this system in terms of speed and torque as follow:
Orifice Opener (15/08), WL:5mm, speed:300rpm, torque: 2.5N.
Glide Path (15/03), WL:15mm, speed:300rpm, torque:1.5N.
Shaping file (yellow ring, 20/04), WL:15mm, speed:500rpm, torque:2.5N.
Shaping file (red ring, 25/04), WL:15mm, speed:500 rpm, torque: 2.5N.

Group 2:

AF F-One (Fanta, Shanghai, China) files were used in preparing the models in this group using X-Smart Plus electronic motor, according to the program designed for this system as follow:
Orifice Opener (17/12), WL: 5mm, speed:500 rpm, torque: 2.5 N.
Path finder (16/04), WL: 15 mm, speed: 500 rpm, torque: 2 N.
Shaping file (yellow ring, 20/04), WL: 15 mm, speed: 500 rpm, torque: 2.5 N.
Finishing file (red ring, 25/04), WL: 15 mm, speed: 500 rpm, torque: 2.5 N.

The movement of the files during preparation was slow in and out pecking motion. Distilled water (Baghdad, Iraq) was used as the irrigating fluid using endodontic irrigating syringes (Ultradent Products, Inc., South Jordan, UT, USA) with NaviTip 21 mm (yellow) 30 gauge. The canal was rinsed with 2 ml of distilled water before preparation, and after each file, the canal was rinsed with another 2 ml, resulting in a total of 10 ml of irrigating fluid per canal. Once the file reaches the length of the canal and rotates freely, it is withdrawn. This process takes no more than 5 seconds. The file was used to prepare only 5 canals. After each use, the file was inspected to ensure it was free of cracks and distortion. If these defects were found, the file would be replaced immediately.

2.4. Assessment of Canal Transportation

After completing the canal preparation process, ink is injected into the canal, and the canal was imaged in the same way it was imaged before preparation. Digital images of the canals before and after preparation were superimposed and measured. Here, canal transportation was determined by comparing the digital image before and after preparation and was done by measuring the change from the original canal boundaries from the inner and outer sides of the canal at 5 reference points using Adobe Photoshop CS2 software program (fig.1). The measurements were at right angles to the canals (fig.2).

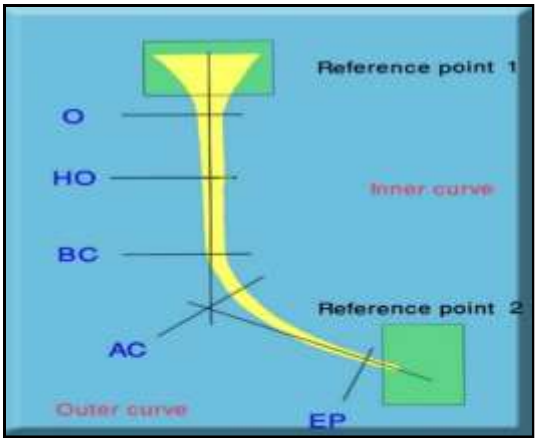

Fig. (1): *The five levels of measurement.*

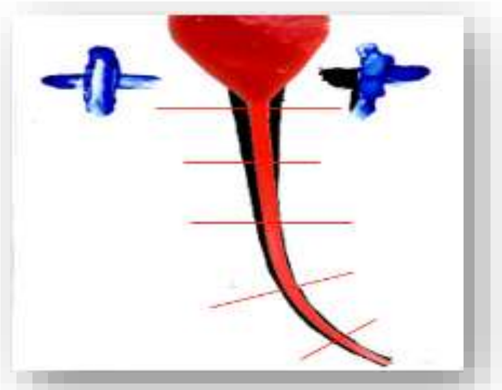

Fig. (2): *superimposed and treated images of unprepared and prepared canal with computerized program Adobe Photoshop (C).*

Level 1 (O): canal orifice.
Level 2 (HO): the point mid-way from the beginning of the curvature to the orifice.
Level 3 (BC): the point where the canal departs from the long axis of its coronal portion (beginning of the curvature).
Level 4 (AC): the point where the long axes of the coronal and the apical portions of the canal intersect (apex of the curve).
Level 5 (EP): the end point of preparation.

3. Results

3.1. Outer Transportation.

The mean values and the standard deviations of outer canal transportation after instrumentation at the five measuring levels are given in Table 1.

Table 1: Mean and standard deviation of outer transportation (mm) for the two groups.

System		O	HO	BC	AC	EP
Plex-V	*Mean*	7.08	6.69	5.80	3.94	2.37
	SD±	0.47796	0.57629	0.71181	0.51467	0.27101
F-One	*Mean*	6.52	5.24	4.27	2.90	1.64
	SD±	0.53914	1.13940	1.34582	0.86923	0.38064
t-test		2.458	3.591	3.178	3.256	4.940
P-value		0.004 *S*	0.002 *S*	0.005 *S*	0.004 *S*	0.000 *S*

Based on the table above, it can be observed that Plex-V removed more material from the outer surface than F-One at all levels. Statistical analysis by using the student t-test showed significant differences between the two systems at all levels.

3.2. Inner Transportation

The mean values and the standard deviations of inner transportation after instrumentation at the five different levels examined are listed in Table 2.

Table 2: Mean and standard deviation of inner transportation (mm) for the two groups.

System		O	HO	BC	AC	EP
Plex-V	*Mean*	5.780	5.080	3.640	2.390	1.590
	SD ±	0.70679	1.00973	0.57194	0.53009	0.37253
F-One	*Mean*	6.180	4.740	3.920	2.250	1.200
	SD ±	0.65963	1.08341	1.18584	0.51045	0.24944
t-test		1.308	0.726	0.673	0.602	2.751
P-value		0.207 *NS*	0.477 *NS*	0.510 *NS*	0.555 *NS*	0.013 *S*

At the orifice of the canals F-One showed the higher means of inner transportation (6.180) than Plex-V (5.780). Next to the second measuring level, Plex-V got the maximum inner transportation (5.080) and F-One showed the minimum mean (4.740). On the third level the results were as follows: F-One (3.920), Plex-V (3.640). On the fourth plane the view was completely inversed as the higher means of inner transportation was with Plex-V (2.390) than F-One (2.250). By the side of the end level of preparation, Plex-V removed more resin from the inner sides (1.590) followed by F-One (1.200). By using Student t-Test (Table 2), in inner transportation, showed no significant difference between the two systems at all levels, but not at the apical level where the difference was significant.

4. Discussion

Canal preparation aims to create a conical shape—with the smallest diameter at the apex and the largest towards the crown—while strictly maintaining the original shape of the canal. One of the most common problems encountered during canal instrumentation is the straightening of the canal; this classically occurs in curved roots, specifically affecting the outer wall in the apical third (11).

According to the American Association of Endodontists (2016), the term "transportation" is defined as the cutting away of the outer wall of the root canal—specifically in the apical half—caused by the instrument's tendency to straighten within the canal during instrumentation; this leads to complications such as root perforation or ledge formation (4).

The degree of transportation is measured by the distance between the edge of the unprepared canal and the corresponding edge after canal preparation (12). The closer the transportation value is to zero, the better the performance of the instruments in canal preparation (13).

Apical transportation plays a crucial role in ensuring the feat of root canal treatment; the degree of curvature throughout preparation affects the seal of the filling materials, thereby determining the success or failure of the root canal management (14).

Several researchers stated that an apical transportation of 0.15 mm is acceptable; however, if it exceeds 0.30 mm, it compromises the apical seal, allowing bacteria or their byproducts to enter the root canal and leading to endodontic treatment failure. Excessive apical transportation leads to several complications; it may cause zipping and the subsequent elbow formation —which hinders the smooth insertion of accessory points of gutta-percha. This prevents a tight apical seal, ultimately resulting in endodontic treatment failure (14, 15).

Reviewing the results of this study reveals that neither of the systems used was able to produce an exact replica of the canal shapes present prior to preparation; in other words, all the instruments caused the original canals to transport to varying degrees. Under conditions of the study, no system exhibited apical transportation exceeding than 0.3 mm, indicating that preparation with these two systems falls within the ideal standards for root canal preparation.

The research by hand was conducted using transparent resin blocks that simulate natural root canals, ensuring standardized dimensional parameters—such as length, diameter, taper, and curvature—while also facilitating imaging before and after preparation. Artificial canals do not replicate the actual anatomy of root canals, but they allow for comparisons regarding canal preparation using various rotary root canal preparation systems. At the same time, it must be noted that the cutting process in these resin blocks differs from that of natural dentin; cutting these canals with rotary systems causes the resin temperature to rise and leads to the accumulation of resin debris in the instrument flutes, which can ultimately result in file breakage (11).

Thus, the results derived from using these blocks must be interpreted with caution when evaluating the performance of preparation systems (16). In the same context, Adobe Photoshop was utilized to analyze images of the canals taken before and after preparation, aided by ink injected into the artificial canals; the software allowed for image enhancement and colorization, facilitating computer-based measurements (11).

Curved canals are ideally used to evaluate root canal instrumentation, as they reflect instrument efficiency—unlike straight canals (17). Hence, rotary instruments are evaluated using curved artificial canals, regardless of whether they maintain the original curvature of the prepared canals or cause them to transport (11).

It is important to note that when comparing rotary root canal systems, the standardization of master apical files size and taper must be considered; in this study, the instruments used were size 25 with a taper of 04. Furthermore, all samples were prepared by a single operator to eliminate operator-related variables (8).

4. 1. Outer Transportation

Regarding the outer canal wall, Table (1) clearly shows that, across all five canal levels, group Plex-V instruments removed significantly more resin than group F-One files. Accordingly, the canals prepared using F-One instruments were closer to the original shape, as these instruments removed less of the outer canal wall; consequently, there was less transportation, straightening, and distortion of the canals across the five examined levels. These results can be explained by once recognizing that the mechanical and geometric properties of the files significantly influence their performance during rotation within the canals (18, 19).

Tasdemir et al. (2005) stated that several factors directly influence the degree of canal transportation; foremost among these are the flexibility of the instrument used for preparation (20). As well as the cross section of the instrument (21). In the same context, other studies have stated that the flexibility of instruments may be the main factor that allows the instruments to plane the canal walls rather than engaging and screwing into them and to cut of dentin evenly along the canal wall (22).

According to the conclusions of a study conducted by Saad and Hamed in 2026, the F-One type files are more flexible than the Plex-V files. This high flexibility is due to the unique engineering design of the F-One files, which feature flat side surface; this reduces stress on the file as it rotates and contacts the outer surface of the canal (8).

The cross-section of the file is an important factor in determining the instrument's flexibility. According to the manufacturer, the cross-section of the F system is S-shaped, whereas it is a triangular shape for Plex-V system (8). Some studies have stated that the lower metal mass of S-shaped cross section file gives them greater flexibility (23, 19).

As stated by Di Nardo (2020), the core of a file determines its flexibility. A file with an S-shaped cross-section is more flexible than a triangular cross-section file due to its lower core. Consequently, file F-one is more flexible compared to file Plex-V (24).

Another factor that could explain the results of this study is the cutting efficiency of the file. The unique geometric design of F-one file—featuring a flat side and an S-shaped cross-section— This means there are fewer spaces along the file, causing them to fill up quickly with debris, thereby reducing its cutting efficiency (8).

4. 2. Inner Transportation

Tables (1, 2) show that the direction of transportation was toward the outer wall of the canals; that is, the amount of material removed was greater on the outer aspect compared to the inner aspect of the root canals. This outward transportation has also been confirmed in other studies (25, 26).

These results are attributed to the forces tending to restore the file to its straight shape within the curved canal; this causes friction and cutting against the outer canal wall—with less force exerted on the inner wall—resulting in greater outward transportation compared to inner one (27).

The results of inner transportations indicate that instruments Plex-V removed a greater amount of resin from the inner canal walls compared to instruments F-One; however, the difference was not statistically significant along the length of the canal, except at the apical level. Concerning the original root curvatures, the results of this study reveal that F-One systems obtained better canal geometry, demonstrated less canal transportation and straightening at the five tested levels of the simulated canals and better maintained the original shape of the curved canals compared with Plex-V instruments. Once again, these results can be explained by the differences between the two systems in terms of flexibility and cutting efficiency (8).

It is worth noting a crucial factor determining the shaping capability of root canal instruments: the heat treatment of the metal from which they are manufactured; however, this topic lies beyond the scope of the current study.

5. Conclusions

Despite the limitations of this *in vitro* study, both systems caused some transportation in the root canals along the working length, but these transportations were within acceptable limits and did not cause problems with root canal sealing. Considering that system Plex-V caused a greater deviation than F-One system.

Conflict of interest

Authors have nothing to declare.

Funding
Nothing apart from personal funds.

References

Peters OA (2004) Current challenges and concepts in the preparation of root canal systems: A Review. *Journal of Endodontics 30,* 559–67.
Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974; 18: 269-96.
Hulsmann, M. Peters, O.A.; Dummer, P.M. Mechanical preparation of root canals: Shaping goals, techniques and means. Endod. Top. 2005, 10, 30–76.
Glossary of Endodontic Terms. American Association of Endodontists 9th Edn. Chicago, American Association of Endodontists. 2016. Available at https://www.aae.org/specialty/clinical-resources/glossary-endodontic-terms/.
Weine FS, Kelly RF, Lio PJ (1975) The effect of preparation procedures on original canal shape and on apical foramen shape. J Endod 1, 255-262. doi: 10.1016/ S0099-2399(75)80037-9
Gluskin AH, Brown DC, Buchanan LS. A reconstructed computerized tomographic comparison of Ni–Ti rotary GT™ files versus traditional instruments in canals shaped by novice operators. *Int Endod J.* 2001; 34(6): 476-84.
Ferraz CC, Gomes NV, Gomes BP, Zaia AA, Teixeira FB, Souza-Filho FJ (2001) Apical extrusion of debris and irrigants using two hand and three engine-driven instrumentation techniques. International Endodontic Journal 34, 354–8.
Ramadhan SA, Kasim H. A study of fracture resistance and deformation of two heat treated rotary NiTi instruments; Orodeka Plex V files and AF F-One files in sever curved simulated canals (a comparative *in vitro* study). *International Journal of Advanced Research in Medicine.* 2026;8(2):12-16.
Schneider S. A comparison of canal preparations in straight and curved canals. Oral Surgery 1971, 32 (2). 271-5.
Pruett J, Clement D, Garnes D. Cyclic fatigue testing of nickel-titanium endodontic instruments. *Journal of Endodontics 1997, 23,* 77-85.
Hamid Kasim and A. K. J. Al-Azzawi. The shaping effects of three rotary Nickel-Titanium systems in simulated curved canals. *J Bagh College Dentistry Vol. 24(3),* 2012

Song Y, Bian Z, Fan B, Fan M, Gutmann J, Peng B. A comparison of instrument-centering ability within the root canal for three contemporary instrumentation techniques. *International Endodontic Journal 2004, 37(4),* 265-271.
Gambill et al. (1996): "Comparison of nickel-titanium and stainless-steel hand instruments in the preparation of simulated curved root canals." *Journal of Endodontics.*
Wu MK, Fan B, Wesselink PR (2000) Leakage along apical root fillings in curved root canals. Part I: effects of apical transportation on seal of root fillings. *J Endod 26,* 210-216.
Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod 2004; 30: 559–67.
Bitter K, Gruner D, Wolf O, Schwendicke F. Artificial versus natural teeth for preclinical endodontic training: A randomized controlled trial. J Endod 2016; 42:1212-7.
Berutti E, Chiandussi G, Paolino D, Scotti N, Cantatore G, Castellucci A, et al. Canal shaping with Wave one primary reciprocating files and ProTaper system: A comparative study. J Endod 2012; 38:505-9.
Martins JN, Martins RF, Braz Fernandes FM, Silva EJ. What meaningful information are the instruments mechanical testing giving us? A comprehensive review. J Endod. 2022; 48:985-1004.
Silva EJ, Martins JN, Ajuz N, Vieira VT, Pinto R, Marques D, et al. Multimethod analysis of a novel multi-coloured heat-treated nickel-titanium rotary system: Design, metallurgy, mechanical properties, and shaping ability. J Endod. 2024; 50:1622-1633.
Tasdemir T, Aydemir H, Inan U, Ünal O. Canal preparation with Hero 642 rotary NiTi instruments compared with Stainless steel hand K-instrument assessed using computed tomography. *International Endodontic Journal 2005,38 (2),*402-8.
Yoshimine Y, Ono M, Akamine A. The shaping effects of three nickel-titanium rotary instruments in simulated S-shaped canals. J Endod 2005; 31:373-5.
Tepel J, Schafer E. Endodontic hand instruments: cutting efficiency, instrumentation of curved canals, bending and torsional properties. Endod Dent Traumatol 1997,13,201-210
Bürklein S, Zupanc L, Donnermeyer D, Tegtmeyer K, Schäfer E. Effect of core mass and alloy on cyclic fatigue resistance of different nickel-titanium endodontic instruments in matching artificial canals. Materials (Basel). 2021; 14:5734.
Di Nardo D, Miccoli G, Mazzoni A, Seracchiani M, Gambarini G, Testarelli L. Centering ability of a new nickel-titanium rotary instruments with a peculiar flat-side design: An in vitro study. J Contemp Dent Pract. 2020; 21:539-542.
Schafer E, Schlingemann R. Efficiency of rotary nickel titanium K3 instruments compared with stainless steel hand K-Flexofile. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. *International Endodontic Journal 2003, 36,* 208-217.
Guelzow A, Stamm O, Martus P, Kielbassa A. Comparative study of six rotary nickel-titanium systems and hand instrumentation for root canal preparation. *International Endodontic Journal 2005, 38 (10),* 743-752.
Schafer E. Relationship between designs features of endodontic instruments and their properties part I, cutting efficiency. *Journal of Endodontics 1999, 25 (1),* 52-55.