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Comparative Evaluation of The Shaping Ability of The Three Nickel-Titanium Rotary Instruments Using Cone-Beam Computed Tomography.

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ABSTRACT

The aim of this in vitro study was to compare the canal transportationand centering ability of three nickel-titanium rotary systems HyFlex EDM, Protaper NEXT and Mtwo, using cone-beam computed tomography (CBCT).A total of 45 extracted maxillary first molars with completely formed apices that were extracted due to severe periodontal problems were selected for this study and distributed into 3 groups (*n*=15). The samples were prepared with HyFlex EDM, Protaper NEXT and Mtwofiles. The centering ability and amount of canal transportation were assessed by a comparison of the pre- and post-instrumentation micro-CT scans. The ANOVA test was used for statistical analysis. The level of significance was set at 0.05. Canals prepared with HyFlex EDM showed minimum values for root canal transportation at all the three levels which may be attributed to its unique cross section design. Maximum canal transportation was observed with MTwo in the coronal and middle thirds.

Keywords: Micro-Computed Tomography, HyFlex EDM, Protaper NEXT, Mtwo, apical transportation, centering ability.

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INTRODUCTION

The goal of root canal treatment is to remove infected and necrotic pulpal remnants and eliminate microorganisms. Preserving the radicular anatomy while cleaning and shaping of the root canal is an important phase of a successful endodontic treatment [1]. Although several preparation techniques have been developed to overcome procedural errors such as apical transportation, there are still some difficulties with endodontic treatment of curved root canals. Since the introduction of nickel-titanium (NiTi) rotary instruments in the 1990s, studies have shown that these instruments maintain original canal shape and therefore allow for a safer, more rapid, more centered and easier preparation of severely curved root canals [2-5].

The new HyFlex EDM files constitute the 5th generation root canal files. HyFlex EDM NiTi files have completely new properties due to their innovative manufacturing process using electric discharge machining. Workpieces are machined in the EDM manufacturing process by generating a potential between the workpiece and the tool [6]. The sparks generated in this process cause the surface of the material to melt and evaporate. This creates the unique surface of the new Niti files and makes the HyFlex EDM files stronger and more fracture resistant (Fig.4). This entirely unique combination of flexibility and fracture resistance makes it possible to reduce the number of files required for cleaning and shaping during root canal treatments without having to compromise preservation of the root canal anatomy. Just like HyFlex CM files, HyFlex EDM files have the already familiar controlled memory effect (CM). This results in very similar properties in terms of material flexibility and regeneration.

HyFlex files are manufactured utilising a unique process in which the crystallographic phase transitions from austenite to martensite at room temperature in contrast to conventional NiTi files, making the files extremely flexible and fracture resistant [6]. Due to the controlled memory, the files always follow the anatomy of the canal, thus significantly reducing the risk of ledging, transportation or perforation of a canal. Like stainless steel files, the HyFlex files can be pre-bent.

In a starter set, the HyFlex EDM Introkit Compact offers 4 file sizes with which treatments, particularly of straight canals, can be performed very simply to ISO size 40 (table 1).Step-by-step instruction for use of HyFlex EDM files is showed in Fig. 2 and Fig. 6 .All HyFlex EDM NiTi files can be used at 400 rpm and at a torque of up to 2.5 Ncm excepted the Glidepath files which can be used with 300 rpm and at a torque up to 1.8 Ncm.The HyFlex Glide Path file 10/.05 ensure optimal shaping of the glide path due to the controlled memory (Fig. 5).The aim of this study was to evaluate the apical transportation and centering ability of the rotary nickel-titanium instruments by using the cone-beam computed tomography (CBCT). Three groups of the instruments were included in the investigation: HyFlex EDM (Coltene, Switzerland), ProTaper Next (Dentsply, Switzerland) and Mtwo (VDW,Germany).

Table 1: HyFlex EDM Files

Size	Taper
25	~
40	04
50	03
60	02

MATERIALS AND METHODS

A total of 45 extracted maxillary first molars with completely formed apices that were extracted due to severe periodontal problems were selected for this study. The teeth were inspected for absence of resorption, root fractures, root caries. The presence of second mesiobuccal canal was assessed using stereomicroscope (Leica M320, Germany) at 40× magnification and was a criterion for tooth exclusion. The curvature angle of the canals was determined according to the Schneider's method. Canals with curvatures between 25°and 35° were included in the study. After disinfection with 5.25% sodium hypochlorite (NaOCl), samples were stored in 10% formalin solution before experiment. Access cavities were prepared using a #4 high speed round carbide bur (Dentsply Maillefer, Ballaigues, Switzerland) in a high-speed handpiece under copious irrigation. For establishing the working length (WL), a size 10 K-file (Dentsply, Maillefer, Ballaigues,

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Switzerland) was placed into the canal until it was visible at the apical foramen. The working length (WL) was determined 1 mm short of this length.

Fig 1: HyFlex EDM external surface

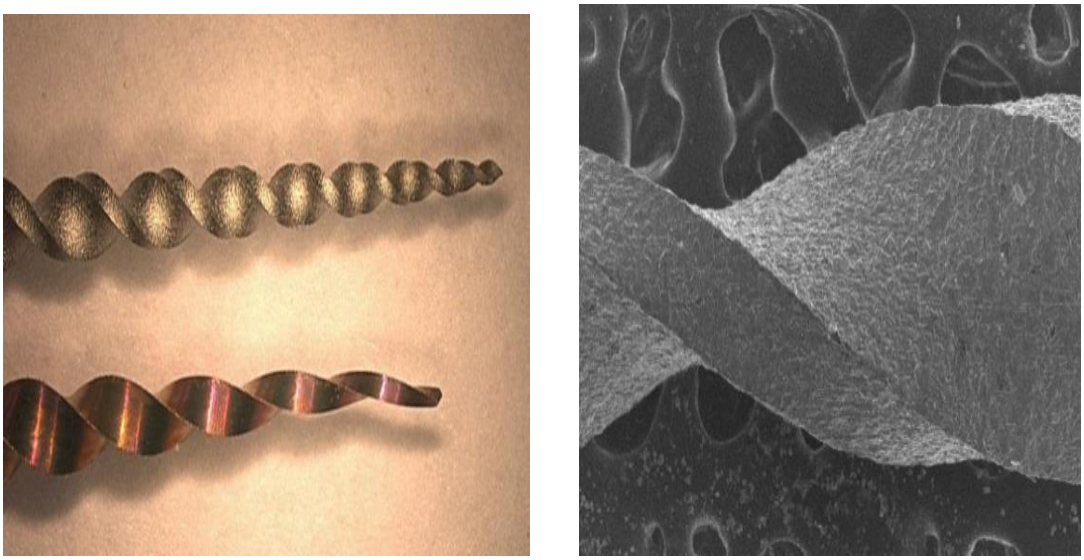

Fig 2: Step-by-step instruction for use of HyFlex EDM files

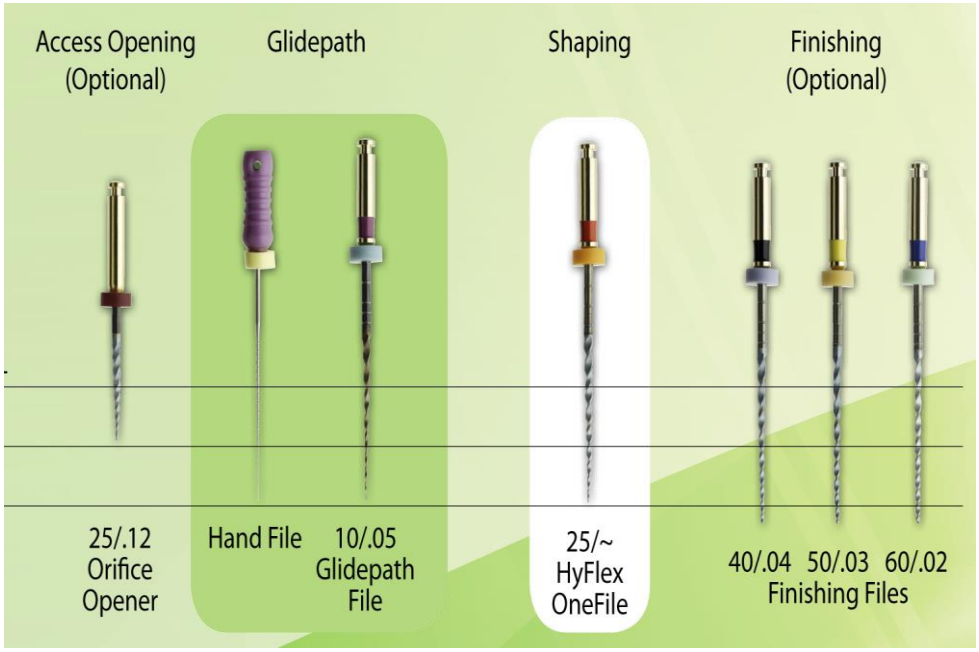

Fig 3: HyFlex 25/~ One File

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Fig 4: Cross section of a size 40/.04 HyFlex EDM file

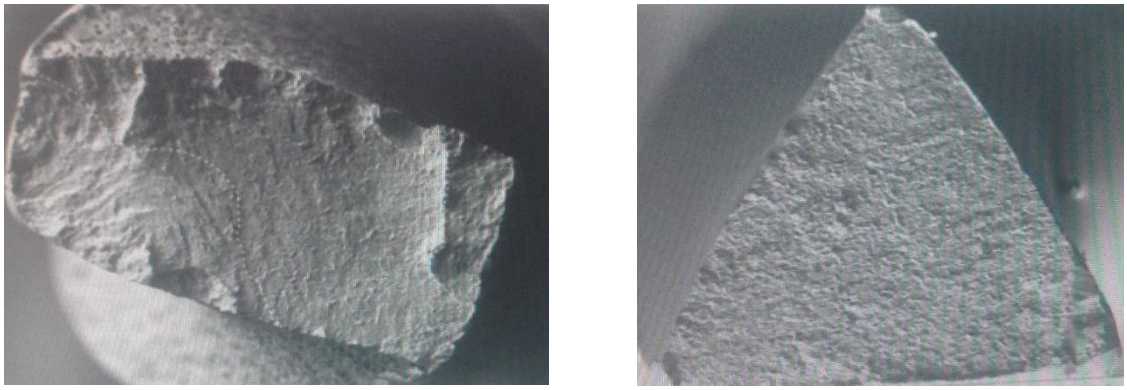
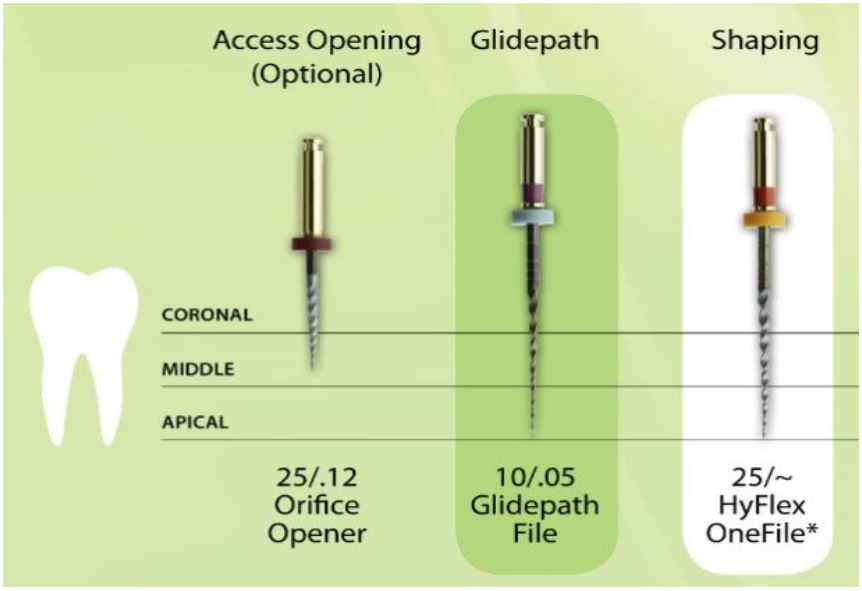


Fig 5: The HyFlex Glide Path file 10/.05

Fig 6: Step-by-step instruction for use of HyFlex EDM files and HyFlex CM files
a) standard clinical situation ;



b) complicated clinical situation with curved canals.

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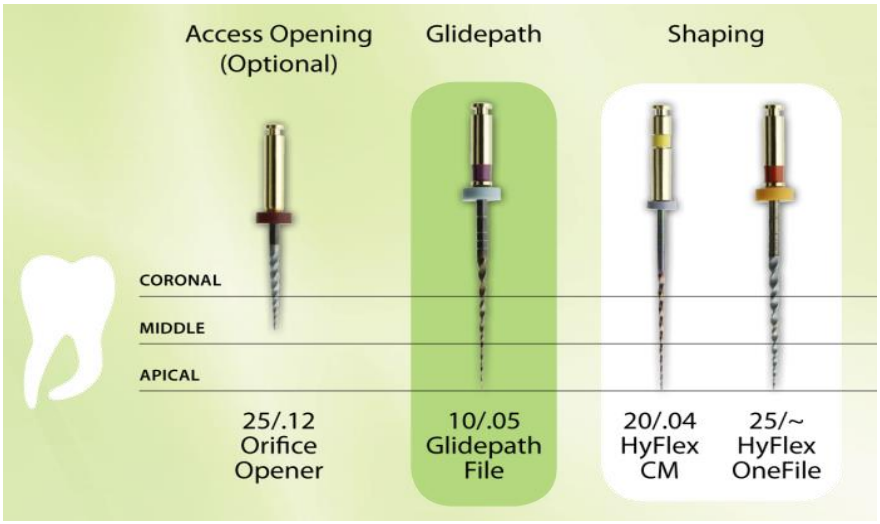
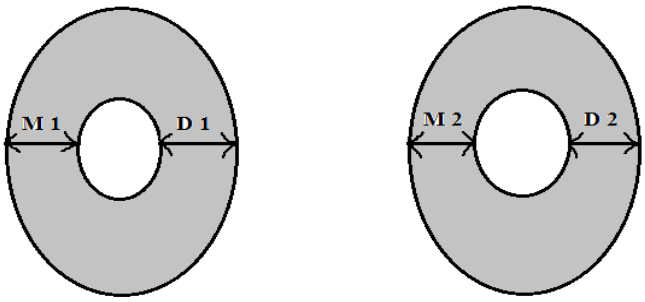


Fig 7: Schematic view of measurements for evaluation of apical transportation and centering ability



Samples were fitted in the desired position by using a silicon-based impression material (Speedex, Coltene/Whaledent, Altstätten, Switzerland) and the plastic mode. The teeth were inserted in parallel positions to the wall of the plastic mold so that the most apical point of the roots touched the base of the mold. CBCT images were captured, both before and after instrumentation, in the same position. The three-dimensional CBCT machine (PointNix 3D Combi 500, Korea) was used to prepare each series of pre- and post-instrumentation radiographs with a background of 8×8 cm, 40-90 kVp, 4-16 mA.

The selected teeth were randomly assigned into 3 experimental groups (Groups 1-3) with 15 teeth in each group. The rotary file systems were performed with an electrical motor (X-Smart, Dentsply Maillefer, Ballaigues, Switzerland). For each file, the individual torque limit and rotational speed were used according to the manufacturers' instructions. All the preparations were made by a single operator.

The preparation sequences are as follows:

Group 1. HyFlex EDM files (Coltene, Switzerland) were used in the following sequence to prepare the samples: HyFlex CM 25/.12 Orifice Opener, HyFlex Glidepath file 10/.05, HyFlex EDM 25/~ OneFile. Preparation was made using single-length technique.
Group 2. ProTaperNext files (Dentsply, Switzerland) were used in the following sequence to prepare the samples: Protaper Universal SX, ProTaper Next X1, ProTaper Next X2. Preparation was made using single-length technique.
Group 3: Mtwo files (VDW, Munich, Germany) were used in the following sequence: 10/.04; 15/0.05; 20/.06; 25/.06; 30/.05; 35/.04; and 40/.04. Preparation was made using single-length technique.
The following formula were used to evaluate apical transportation and the centering ability of the instrument at 3, 5, and 7 mm from apical foramen:

Apical transportation = (M1 – M2) – (D1 – D2).

Centering ability = (M1 – M2) / (D1 – D2) или (D1 – D2) / (M1 – M2),

where M1 is the shortest distance from the mesial edge of the root to the mesial edge of the un-instrumented canal, M2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, D1 is the shortest distance from distal edge of the root to the distal edge of the un-instrumented, and D2 is the shortest distance from distal edge of the root to the distal edge of the instrumented canal (Fig. 7).Statistical analysis was performed with Statistica, 8 (StatSoft Inc.). The distribution of teeth among the three groups for pre-instrumentation canal curvature was assessed by using analysis of variance (ANOVA). The significance level was set at p = 0.05.

Table 2 shows the apical transportation (mm) and the centering ability values for all studied groups.

Table 2: Apical transportation and the centering ability of the studied instruments

Groups	The distance from the apical foramen	Studied value	Mean (SD)	Median	p
HyFlex EDM	3 мм	Apical transportation	0,052 ±0,009	0,05	0,073
ProTaper Next			0,076 ±0,007	0,08	
Mtwo			0,077 ±0,01	0,08	
HyFlex EDM	5 mm	Apical transportation	0,079 ±0,006	0,08	0,092
ProTaper Next			0,093 ±0,006	0,09	
Mtwo			0,095 ±0,011	0,1	
HyFlex EDM	7 mm	Apical transportation	0,151 ±0,008	0,15	0,169.
ProTaper Next			0,171 ±0,012	0,17	
Mtwo			0,173 ±0,012	0,17	
HyFlex EDM	3 mm	Centering ability	0,517 ±0,097	0,5	0,515
ProTaper Next			0,518 ±0,027	0,5	
Mtwo			0,452 ±0,016	0,46	
HyFlex EDM	5 mm	Centering ability	0,494 ±0,049	0,5	0,479
ProTaper Next			0,484 ±0,028	0,5	
Mtwo			0,414 ±0,027	0,42	
HyFlex EDM	7 mm	Centering ability	0,372 ±0,028	0,38	0,368
ProTaper Next			0,363 ±0,016	0,38	
Mtwo			0,352 ±0,011	0,36	

RESULTS

The first studied group, instrumented by the HyFlex EDM system, showed less apical transportation at all studied levels from apical foramen than other groups (3 mm – 0,052±0,009 mm; 5 mm – 0,079 ±0,006 mm; 7 мм – 0,151±0,008 mm); second group, instrumented by the ProTaper Next system, showed the following results: 3 mm – 0,076±0,007 mm; 5 mm – 0,093±0,006 mm; 7 mm – 0,171±0,012 mm. The highest apical transportation measurements were observed in the third group of the teeth, instrumented by the Mtwo system (3 mm – 0,077± 0,01 mm; 5 mm – 0,095±0,011 mm; 7 mm – 0,173±0,012 mm).

During the analysis of the centering ability, the HyFlex EDM system showed the highest values (3 mm – 0,517±0,097; 5 mm – 0,494±0,049; 7 mm – 0,372±0,028). The second group of the instruments showed the following values of the centering ability: 3 mm – 0,518±0,027; 5 mm – 0,484±0,028; 7 mm – 0,363±0,016. The third group of the instruments (Mtwo files) showed the following results: 0,452±0,016; 5 mm – 0,414±0,027; 7 mm – 0,352±0,011.

The main objective of the instrumentation phase of root canal therapy is to remove all pulpal tissue and debris from the canal and to prepare the canal three dimensionally for the desired filling material. Sufficient enlargement to remove contaminated dentin while preparing the apical portion should be round in cross-section and a smooth tapering preparation is a must for close adaptation of the master cone to the canal walls is recommended [7].

This study used extracted human teeth to better simulate the clinical conditions with regard to the morphological changes caused by the file systems used for instrumentation. The MB canals of upper molars were chosen given their high incidence of abrupt curvature in the apical third [8], which can adversely influence the canal preparation [9]. However, MB canals tend to vary considerably in their anatomy [10], which represents a challenge in terms of sample standardization [11]. The incidence of a second canal in the MB root of upper molars can vary between 18.6 to 100%, [10, 12], making the selection of single MB root canals of upper molars a critical point in research.

DISCUSSION

Cone-beam computed tomography (CBCT), a nondestructive high-resolution scanning system, has been used for evaluation of the exact location and anatomy of the root canal system, quality of root canal preparation, and to take measurements of root canal system before and after instrumentation [13].

However, shaping of curved canals has been offset by a tendency for all preparation techniques to deviate the prepared canal from its original axis. Deviation from the original curvature can lead to excessive or inappropriate dentine removal, straightening of the canal and creation of a ledge in the dentinal wall, a biomechanical defect known as elbow, which forms the coronal to the elliptical-shaped apical seal, canals with hourglass appearance in cross-section, which requires stripping and over-preparation that weakens the tooth, resulting in fracture of the root [14].

In the present study, canals prepared with HyFlex EDM showed minimum values for root canal transportation at all the three levels which may be attributed to its unique cross section design. HyFlex EDM NiTi files have completely new properties due to their innovative manufacturing process using electric discharge machining. Maximum canal transportation was observed with MTwo in the coronal and middle thirds.

In the analysis of centering ability, canals prepared with HyFlex EDM and Protaper Next system showed maximum values at all three levels compared with Mtwo files.

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