

# Comparison of Alterations in the Surface Topographies of HyFlex CM and HyFlex EDM Nickel-titanium Files after Root Canal Preparation: A Three-dimensional Optical Profilometry Study

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## Abstract

**Aims:** The aims of the present study were to examine the surface topographies of intact HyFlex CM and HyFlex EDM nickel-titanium files and to compare alterations in the surface topographies of these files after root canal preparation of severely curved canals of molar teeth. **Methods:** Eight HyFlex CM (25/.08) and 8 HyFlex EDM (25/.08) files were included in the present study. In total, 64 severely curved canals of molar teeth, with curvature angles ranging between 50° and 70°, were prepared with HyFlex CM and EDM (n = 32 in each group). Quantitative and qualitative analyses of the files' surface deformation were performed by using three-dimensional optical profilometry before and after root canal preparation. The data were analyzed with the Student *t* test at the 5% significant level by using SPSS 21.0 software. **Results:** In the HyFlex EDM group, the qualitative evaluation revealed the presence of cracks and microcavities after use of the file for root canal preparation, whereas only minor surface deformation was observed in the HyFlex CM group. The average roughness, root mean square roughness, and peak to valley height values of the HyFlex EDM group were significantly higher than those of the HyFlex CM group before and after root canal preparation ( $P < .05$ ). The surface roughness values were statistically significantly increased in the HyFlex CM group after root canal preparation ( $P < .05$ ). In contrast, the increase in the HyFlex EDM group was not statistically significant ( $P > .5$ ). **Conclusions:** Within the limitations of the present study, the HyFlex CM files showed significantly higher surface alterations compared with the HyFlex EDM files after the preparation of severely curved root canals. (*J Endod* 2017; ■:1–5)

## Key Words

HyFlex CM, HyFlex EDM, NiTi, profilometry, surface deformation

The use of nickel-titanium (NiTi) rotary files in root canal preparation provided the reduction of frequency of procedural errors and the time required for chemomechanical preparation in proportion to manual files (1).

Despite all of the advantages of NiTi rotary files, the possibility of unexpected fracture of files within the canals because of cyclic or torsional fatigue distresses clinicians (2). Many developments including the new alloys and production methods improving the mechanical properties of NiTi files were used to increase the safety and efficiency of NiTi files (3). In recent years, many thermal treatments were used to optimize the microstructure of NiTi files (4).

HyFlex CM (Coltene Whaledent, Altstätten, Switzerland) is a NiTi rotary system that was manufactured in 2011 by using controlled memory (CM) alloy. The NiTi files made of CM alloy have no shape memory that traditional NiTi files have, and the HyFlex CM are manufactured in a special thermomechanical procedure that aims to increase the flexibility of traditional NiTi files (5). Many mechanical properties of HyFlex CM files were tested (6, 7), and superior cyclic fatigue resistance of HyFlex CM was reported (8, 9).

HyFlex EDM (Coltene Whaledent) is a new NiTi file system manufactured by using CM alloy via electrical discharge machining (EDM) technology. EDM technology is based on vaporizing and melting the small particles on the material via electric sparks and shaping the instrument (10). Although this is a method that is widely used in medical technology, HyFlex EDM file is the first endodontic file made with this method (11).

To date, many techniques including scanning electron microscope (SEM) (12) and atomic force microscope (AFM) were used to analyze the topographical properties of NiTi files (13). The noncontact three-dimensional (3-D) optical profilometry is a widely used method in dentistry in analyzing the teeth and composite surfaces (14, 15), but the method was first used by Ferreira et al (16) in examining the surface properties of NiTi files. Ferreira et al suggested the use of optical profilometry in analyzing the surface properties of endodontic files because this method makes it

## Significance

The surface property of the NiTi files is an important issue in files' mechanical behaviors. Thus it is important to know the intact and used NiTi files' surface properties to avoid unexpected file fractures.

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## Basic Research—Technology

possible to analyze wider surfaces when compared with AFM, and it offers reproducible measurements when compared with AFM and SEM. Moreover, the authors reported that the qualitative and quantitative information offered by 3-D optical profilometry has superiority to SEM.

The aims of the present study were to examine the surface topographies of intact HyFlex CM and HyFlex EDM NiTi rotary files and to compare alterations in the surface topographies of these files after root canal preparation of 4 severely curved canals of molar teeth. The null hypotheses tested were as follows:

1. There would be no difference between the surface topographies of HyFlex CM and HyFlex EDM files before root canal preparation;
2. There would be no difference between the surface topographies of HyFlex CM and HyFlex EDM files after root canal preparation; and
3. The root canal preparation would not affect the surface topographies of HyFlex CM and HyFlex EDM files.

### Materials and Methods

Eight HyFlex CM (lot no. F60212) and 8 HyFlex EDM (lot no. H22196) files were included in the present study. By using an ISO 014 diamond round bur (Strauss & Co, Industrial Diamonds Ltd, Ra'anana, Israel), all the files were marked on the shaft portion before the experiments. With the aid of these marks on the shaft, the same areas on the surfaces of the files were analyzed before and after the root canal preparation.

### Root Canal Instrumentation

Eight HyFlex EDM and eight HyFlex CM files were used *in vitro* in the present study. In the tests, 64 severely curved canals of molar teeth, with angles of curvature ranging between 50° and 70°, were used. To determine the root canal curvature, mesiodistal and buccolingual radiographs were taken according to the parallel technique (17). Only roots with a fully developed apex and no internal and external resorption were included in the present study. The working length (WL) was determined by measuring the length of #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) just visible at the apical foramen.

In the HyFlex CM group, a 25/.08 file was used to prepare the coronal third of the canal, followed by the use of 20/.06, 25/.06, and 25/.08 files in the WL. All the files were used to prepare 4 severely curved canals according to the manufacturer's recommendations at 500 rpm and 2.5 Ncm torque.

In the HyFlex EDM group, a 25/.12 file was used to prepare the orifice of the canal, and 10/.05 and 25/.08 files were then used in the WL. All the files were used to prepare 4 severely curved canals according to the manufacturer's recommendations at 500 rpm and 2.5 Ncm torque.

At each file change or pecking motion, the root canals were irrigated with 1 mL 2.5% sodium hypochlorite. A total of 20 mL 2.5% sodium hypochlorite was used in each sample. After the preparation of the root canals, the instruments were thoroughly rinsed with 5 mL distilled water. The files were then dried with a soft cotton swab. The used files were ultrasonically cleaned and sterilized by exposing them to 30 psi of pressure for 4 minutes at 134°C, followed by drying for 15 minutes (18). All procedures were performed by an endodontist with 5 years of experience.

### Surface Evaluation and Quantitative Analysis

The HyFlex CM 25/.08 and HyFlex EDM 25/.08 files were analyzed before and after the root canal preparation by using 3-D optical profilometry (NanoMap-1000WLI; AEP Technology, Santa Clara, CA). The surface evaluation of the files was adapted from Ferreira et al (16).

Briefly, the marked points on the shafts of the files were used as reference points. The scanning areas were located 3 mm coronal from the tip of each file. By using a  $\times 10$  objective lens, the scanning areas were obtained from the cutting blade and the adjacent portion of the flute. The dimensions of the scanning areas were  $210 \times 210 \mu\text{m}$ . Three amplitude parameters were evaluated in the quantitative analysis: the average roughness (Sa), root mean square roughness (Sq), and peak to valley height (Sz).

### Statistical Analysis

The data were first analyzed by using the Shapiro-Wilk test to verify the assumption of normality. For the statistical analysis of the data, the Student *t* test was performed by using SPSS 21.0 (IBM-SPSS Inc, Chicago, IL) software. The statistical significance level was set at 5%.

### Results

In the HyFlex CM group, the qualitative evaluation of the cutting blade and adjacent flute portion of the files showed minor surface deformations (Fig. 1C and D). In the HyFlex EDM group, the qualitative evaluation revealed the presence of cracks and microcavities after the root canal preparation (Fig. 1A and B).

The mean and standard deviations of the Sa, Sq, and Sz values are shown in Table 1. The Sa, Sq, and Sz values of the HyFlex EDM group were significantly higher than those of the HyFlex CM group before and after root canal preparation ( $P < .05$ ). In both groups, the tested amplitude parameters (Sa, Sq, and Sz) increased after root canal preparation. These parameters were statistically significantly increased in the HyFlex CM group after root canal preparation ( $P < .05$ ). In contrast, the increase in the HyFlex EDM group was not statistically significant ( $P > .5$ ).

### Discussion

Many of the files used in endodontics are manufactured via grinding procedure. Grinding procedure during the production of NiTi files causes the formation of irregular areas such as pit, fissure, and metal folds (19). It was reported that the irregular areas on the surfaces of files act as the starting point for the cracks, and these cracks might cause fracture because of cyclic fatigue by progressing (20). It has been reported that surface roughness of the files can affect the fatigue life of NiTi rotary files. It has been shown that files with less rough surface have higher resistance to cyclic fatigue (21). The increase in surface roughness increases the tendency of files toward fracture and causes decrease in cutting efficiency (22). For safe use of files in clinical practice, it is very important to know the post-production surface roughness values and the post-use change in these roughness values. In comprehensive literature review, no study examining the pre-use and post-use surface properties of HyFlex CM and HyFlex EDM NiTi rotary files via 3-D optical profilometry could be found. For this reason, in the present study it was aimed to analyze the intact surface properties of HyFlex CM and HyFlex EDM NiTi rotary file systems and the changes on the surface properties of files after severely curved root canal preparation.

SEM and AFM were used to examine the post-use surface changes of the NiTi files (23, 24). SEM could not provide either the 3-D images of samples being analyzed or the direct quantitative data regarding the surface roughness (25). It is very important that the samples have a flat surface for the reliability of results obtained in AFM analysis. Because the NiTi files have sloping and curved surfaces, the analysis via AFM is very difficult. Moreover, AFM can be used only in examining very small surfaces (16). Three-dimensional optical profilometry enables the qualitative and quantitative analysis of NiTi files regardless of the curved, flat,

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