

An *in vitro* comparative evaluation of efficiency of three rotary nickel–titanium file systems in terms of remaining dentin thickness using cone-beam computed tomography

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Abstract

Aim: The objective of the present research was to assess and compare the residual dentin thickness after biomechanical preparation of teeth using three distinct rotary nickel–titanium (Ni-Ti) file systems.

Materials and Methods: In the current experimental study, a total of 45 single-rooted teeth were selected for the analysis. The cements/enamel junction of each tooth was decoronated using a diamond disc. The teeth were randomly allocated to three groups, with each group representing a different rotary file system: Group 1: Hero GOLD (Micro Mega), Group 2: One Curve (Micro Mega), and Group 3: HyFlex electro-discharge machining (EDM) (Coltene-Whaledent, Altstätten, Switzerland). To evaluate the initial condition of the teeth, cone-beam computed tomography (CBCT) scans were conducted before the biomechanical preparation. The teeth were positioned on a modeling wax sheet, and the CBCT scans provided baseline measurements. The biomechanical preparation of the root canals followed the manufacturer’s recommended guidelines for each file system. After the completion of the canal preparation, follow-up CBCT scans were conducted. The postprocedure CBCT scans were then compared with the initial scans to assess any changes in the residual thickness of dentin in the teeth.

Statistical Analysis: *Post hoc* Tukey analysis of variance tests was utilized to examine differences between the groups. A statistically significant result was defined as $P = 0.05$ or less for every test.

Results: The comparison of preinstrumentation and postinstrumentation CBCT images showed that the HyFlex EDM group removed less dentin clinically compared to the other two groups, i.e., Hero GOLD and One Curve. No significant statistical difference was found between Hero GOLD versus One Curve, One Curve versus HyFlex EDM, and Hero GOLD versus HyFlex EDM.

Conclusion: Based on the results of this study, the HyFlex EDM file system exhibited superior cutting efficiency at various levels. Nonetheless, additional investigations are required to comprehensively assess the influence of Ni-Ti rotary file systems on the remaining dentin thickness.

Keywords: Cone-beam computed tomography; Hero GOLD; HyFlex electro-discharge machining; One Curve

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INTRODUCTION

The efficacy of endodontic treatment hinges up on three fundamental elements: disinfection, shaping and cleaning,

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and three-dimensional (3D) obturation of the root canal system.^[1,2] While determining the most influential factor among these three is challenging, it is noteworthy that the removal of necrotic debris from the root canal holds greater significance than the materials subsequently introduced into it.^[2] Consequently, the cleaning and shaping process assumes paramount importance as it precedes all other factors. Disregarding this initial step can jeopardize the entire procedure.^[1-3] Therefore, meticulous shaping and cleaning of the root canal system play a pivotal role in preventing and eradicating bacterial presence.^[4]

During the instrumentation of root canals, several procedural errors may occur, including apical blockage, elbow formation, apical perforation, strip perforation, canal zipping or straightening, ledge formation, and instrument fracture.^[5,6] These errors are particularly prevalent in long, thin, and calcified canals. Such errors can lead to inadequate debris removal from the root canal system, which lowers the endodontic therapy success rates. It is significant to highlight that the majority of dentin removal occurs during root canal instrumentation.^[7] Therefore, preserving the remaining dentin thickness during this process is crucial for enhancing the strength and durability of teeth that have undergone endodontic treatment.^[8] Several studies have highlighted the necessity of retaining a minimum dentin thickness of 0.3 mm following root canal preparation to ensure adequate resistance to lateral stresses.^[8]

In recent years, nondestructive technology has gained popularity in the pre- and postinstrumentation assessment of the root canal. Cone-beam computed tomography (CBCT) is a highly accurate and quantifiable imaging technique that can provide both 3D images and cross-sectional (cut plane) of the root canal system.^[9] The present analysis aims to assess the remaining dentin thickness of the root canal before as well as after instrumentation using three different rotary nickel–titanium (Ni-Ti) file systems, namely HyFlex electro-discharge machining (EDM) (Coltene), Hero GOLD (Micro Mega), and One Curve (Micro Mega).

MATERIALS AND METHODS

The institutional ethical committee accepted the study's protocol, and it was given the ethical clearance number TDC/EC/25/2020. This study is an analytical *in vitro* investigation conducted on extracted human premolars. A total of 45 single-rooted teeth [Figure 1] with a single canal and no visible caries or cracks on the root surface were selected for this study. The samples were stored in a normal saline solution until they were used. They were randomly divided into three groups, each consisting of 15 specimens. Buccal and proximal radiographs were taken to confirm that each tooth had only one canal.

Premolars with a single root, no internal or external pathological root resorption, and apical closure were chosen for the study. Premolars with an open apex and those with cracks or fractures were excluded from the study. The study was divided into three groups on the basis of the rotary file system used: Group I: instrumentation using Hero GOLD (Micro Mega), Group II: instrumentation using One Curve (Micro Mega), and Group III: instrumentation using HyFlex EDM (Coltene). To standardize the procedure and minimize errors, the teeth were decoronated at the “cementoenamel junction.” Modeling wax was used to create occlusal rims that were the same size as the CBCT bite plane. A preoperative CBCT scan was considered, and the remaining dentin thickness was determined at 3, 6, and 9 mm from the root apex, respectively.

The apical foramen was located using a patency K-file size #10 after a standard endodontic access cavity had been created. This point was established to be 0.5 mm short of the working length. The canals were shaped and cleaned using rotary Ni-Ti files with a 6% taper and up to International Organization for Standardization (ISO) size 25, following the manufacturers' instructions for the respective file systems. Following instrumentation, 17% Ethylenediamine tetraacetic acid (EDTA) and 5.25% sodium hypochlorite were used to irrigate each sample, and a final saline rinse was performed. In the same position, a postoperative CBCT was conducted, and the recorded results were reported.

Statistical analysis

The data were examined using descriptive and comparative statistics. Differences among the groups were measured with “analysis of variance” and *post hoc* Tukey tests. At a significance level of $P = 0.05$, every test was deemed statistically significant. Means and standard deviation were used to express the results.

RESULTS

The current research was designed to assess and compare remaining dentin thickness before and after instrumentation with Hero GOLD, One Curve, and HyFlex EDM using CBCT, which represented Groups 1, 2, and 3, respectively. Forty-five extracted single-rooted premolars were randomly allotted to the three groups. The difference between the pre- and postoperative CBCT scans was calculated for the three groups, and a comparison was made between them.

Table 1 compares the mean amount of dentin removed in the mesiodistal dimension (in millimeters) for three different groups (Hero GOLD, One Curve, and HyFlex EDM) at three different levels (3 mm, 6 mm, and 9 mm). The values

for the mesial and distal sides are provided separately. It appears that the HyFlex EDM group generally removed the least dentin, while the Hero GOLD group removed the most dentin. However, the differences between the groups and levels are not large, and there is some variability within each group.

Table 2 compares the mean removed dentin in the buccal and lingual dimensions in three different groups at three different levels of the canal (3 mm, 6 mm, and 9 mm). The groups tested were Hero GOLD, One Curve, and HyFlex EDM. The results show that the amount of dentin removed varied between the groups and between the dimensions and levels tested. Overall, HyFlex EDM removed the most dentin in both the buccal and lingual dimensions at all levels, while One Curve removed the least amount of dentin.

DISCUSSION

Apical periodontitis, characterized by inflammation and infection around the root of a tooth, is primarily attributed to persistent microorganisms within the root canal.^[10-12] In addition, periapical inflammation or pain can arise from the presence of residual necrotic tissue or bacteria.^[13,14] Root canal treatment serves as a viable approach to address these concerns by treating the tooth through the root canal system.^[15] The main aim of root canal treatment is the eradication of microorganisms, and various techniques and materials have been developed for this purpose.^[13-16]

To evaluate the amount of remaining dentin following root canal treatment, several assessment methods are available, including radiographs, longitudinal root sectioning for microscopic analysis, stereomicroscopic study of transparent teeth, microcomputed tomography, “scanning electron microscopy,” and CBCT. These methods provide valuable insights into the efficiency of root canal treatment and the degree of dentin preservation, as seen in Figure 2.^[17-19]

The success of endodontic treatment relies on the biomechanical preparation of the root canal system.^[19] Various techniques have been developed to achieve the desired tapered preparation. In traditional endodontic practice, hand files have been extensively utilized for shaping the root canal system, playing a crucial role in negotiation, initial shaping, and preventing iatrogenic events.^[19] These hand files were commonly manufactured from materials such as carbon steel or stainless steel, which provided adequate strength and flexibility for the intended purposes.^[19]

Ni-Ti alloys have emerged as a significant advancement in endodontic instrumentation due to their remarkable mechanical properties.^[20] These alloys possess unique metallurgical characteristics that make them highly suitable for root canal shaping procedures. The shape memory property of Ni-Ti alloys allows them to undergo reversible phase transformations between two distinct crystal structures, namely martensite and austenite, based on temperature variations.^[20]



Figure 1: Decoronation of teeth, occlusal plane for CBCT imaging

Table 1: Comparison of mean removed dentin in mesiodistal dimension in three groups

	3 mm		6 mm		9 mm	
	Mesial	Distal	Mesial	Distal	Mesial	Distal
Hero gold	0.53±0.57	0.48±0.38	0.57±0.44	0.50±0.32	0.44±0.45	0.52±0.36
One Curve	0.51±0.36	0.56±0.41	0.42±0.39	0.43±0.25	0.51±0.37	0.59±0.40
HyFlex EDM	0.44±0.33	0.50±0.38	0.37±0.39	0.45±0.29	0.44±0.30	0.41±0.34

EDM: Electro-discharge machining

Table 2: Comparison of mean removed dentin in buccolingual dimension in three groups

	3 mm		6 mm		9 mm	
	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
Hero gold	0.98±0.92	0.78±0.56	0.70±0.60	0.70±0.47	0.68±0.56	0.56±0.45
One Curve	0.54±0.40	0.64±0.44	0.45±0.42	0.62±0.60	0.51±0.31	0.61±0.42
HyFlex EDM	0.88±0.54	0.56±0.42	0.62±0.56	0.39±0.34	0.69±0.56	0.40±0.41

EDM: Electro-discharge machining

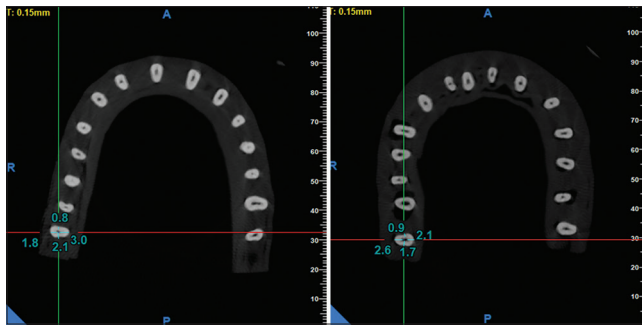


Figure 2: Preoperative and postoperative measurement of remaining dentin thickness of CBCT imaging

Recent research studies have shown promising results regarding the effectiveness of techniques employed in root canal treatments.^[20] However, there remains a significant concern regarding the effect of these techniques on the “residual dentin thickness” (RDT) within the root canals.^[20] The RDT plays a crucial role in the overall success of root canal treatment, as it provides essential structural support to the tooth and helps preserve its integrity. Moreover, the effectiveness of root canal instrumentation is influenced by the anatomical complexities of the root canal system, which can present challenges in terms of instrument accessibility to all areas of the canal and complete removal of debris.^[20]

The importance of RDT and root canal anatomy in the success of root canal treatments utilizing rotary Ni-Ti systems has gained recognition within the field. However, the existing literature on this specific topic is limited, necessitating further investigation. In response, this *in vitro* analysis was performed to assess the amount of RDT remaining after root canal treatment with three various rotary Ni-Ti systems: Hero Gold, One Curve, and HyFlex EDM.

Table 1 presented in the study shows that the amount of canal preparation achieved varies based on the type of file system used, tooth thickness, and point. Hero GOLD and One Curve achieved similar amounts of canal preparation, while HyFlex EDM achieved less. All three instruments had low scores of dentin removed, indicating their effectiveness in maintaining tooth integrity. However, there were variations between the instruments, and dentin was removed in different directions. HyFlex EDM had the lowest score for dentin removal in the mesial direction at 3 mm, while One Curve had the lowest amount of dentin removal in the distal direction. Hero GOLD had the lowest amount of dentin removal in the mesial direction at 6 mm, while One Curve had the lowest dentin removal in the distal direction. At 9 mm, there were no significant variations between the instruments in terms of removed dentin.

The findings in Table 2 display that Hero GOLD resulted in the highest amount of dentin removal on both buccal and

lingual surfaces compared to One Curve and HyFlex EDM at all three measurement distances. One Curve generally resulted in less dentin removal than Hero GOLD, but more than HyFlex EDM, particularly on the lingual surface. HyFlex EDM resulted in the least amount of dentin removal on both surfaces, particularly on the lingual surface at the 6 mm and 9 mm measurement distances.

The current study’s results are consistent with previous studies indicating that the HyFlex EDM system removed less dentin compared to other file systems. The One Curve group removed more dentin than HyFlex EDM but less than Hero GOLD. A study by Biasillo *et al.*^[21] also found that Reciproc Blue was better than One Curve in the apical part of canal curvatures. The Hero GOLD group in this study removed the highest amount of dentin, consistent with a previous study comparing Hero Gold and Nitiflex by Kaptan *et al.*^[22] However, Hero Gold also removed dentin from the inner aspect of the curvature, leading to an overall increase in enlargement. It is important to remember that root canal instruments often straighten inside of canals.^[21,22]

CONCLUSION

In the present study, CBCT was utilized to assess and compare the RDT after teeth were biomechanically prepared using different rotary file methods. The results demonstrated varying cutting efficiencies among all the tested file systems at 3 mm, 6 mm, and 9 mm levels within the root canals. Notably, the HyFlex EDM file system exhibited superior performance overall. However, further investigations are warranted to comprehensively assess the efficacy of Ni-Ti rotary file systems in relation to the preservation of dentin thickness.

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Conflicts of interest

There are no conflicts of interest.

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