Original Article

Comparative evaluation of remaining dentin thickness using single file, two file, and multiple rotary file system – An *in vitro* CBCT study

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Abstract

Context: Endodontic success hinges on a multifactorial interplay, with meticulous canal shaping, proper disinfection, and three-dimensional obturation being paramount. Among these factors, the amount of dentin remaining after instrumentation directly influences the biomechanical resilience and longevity of the tooth.

Aims: This study aims to evaluate the impact of various rotary instrumentation systems, including single-file, two-file, and multiple-file configurations, on the remaining dentin thickness (RDT) following canal preparation.

Settings and Design: This was an *in vitro* study, original research article.

Materials and Methods: Sixty mandibular premolar human extracted teeth were decoronated at the cementoenamel junction with a diamond disc. Samples were randomly assigned to three groups using a simple random sampling technique ($n = 60$). Group I – Single-file system (One Curve, MicroMega) ($n = 20$), Group II – Two-file systems (2Shape, MicroMega) ($n = 20$), and Group III – Multiple-file system (Hero Gold, MicroMega) ($n = 20$). Preoperative cone-beam computed tomography (CBCT) scans were obtained after the sample was mounted on a modeling wax sheet. The biomechanical preparation of canals followed the manufacturer's protocols for every system. Postoperative CBCT scans were obtained. Pre- and postoperative scans were compared at standardized depths (4 mm, 7 mm, and 11 mm) within the canals (coronal, middle, and apical thirds), allowing for a comprehensive assessment of RDT throughout the canal.

Statistical Analysis and Results: According to one-way ANOVA, the highest mean was seen in Group I, followed by Group II and Group III. Hence, a statistically significant difference was found between all the groups. *Post hoc* Tukey's test was done for intergroup comparison.

Conclusions: A single-file system preserved more dentin with less aggressive cutting compared to two-file and multiple-file systems.

Keywords: Dentin thickness; hero gold; One Curve; 2 shape

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INTRODUCTION

Endodontic success is dependent on various elements,

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including canal preparation, disinfection, and three-dimensional obturation. The remaining thickness of dentin after instrumentation has a direct impact on the root's resistance to fracture. As most dentin is removed during canal instrumentation, preserving residual dentin thickness is crucial for the longevity and strength of an endodontically treated tooth.[1] Conventionally, hand files were used for endodontic instrumentation, which had limitations such as breakage and inflexibility. Nickel-titanium (NiTi) instruments were introduced to address these constraints. However, excessive dentin removal remained a significant issue in achieving an acceptable canal taper. Recently, single-file systems have been introduced, simplifying multistep rotary instrumentation. One Curve is a one-time-use rotary file that can shape a complete length of the canal, including the apex. It is made of heat-treated NiTi alloy with Micro-Mega's patented C-wire technology. 2Shape is a series of two shaping files that are constantly rotated and heat-treated with T-wire technology. The instruments are flexible, allowing for greater user comfort, and superior curvature negotiation. The instruments revert to their original shape after each use.[2] The HERO Shaper® file system uses multiple files. Its pronounced tapers are intended to gradually remove limitations and flare the canal using the crown-down approach. The coronal third uses. 06 taper HERO Shaper® files, while the apical third uses. 04 taper HERO Shaper® files. The varying helical pitch and length of the cutting part of the files give a remarkable mix of efficiency and flexibility.[3] Hence, selecting an appropriate file system is critical. Therefore, this study aimed to compare the cutting efficiency of three different file systems, One Curve, Two Shape, and Hero Gold, in terms of remaining dentin thickness (RDT). The null hypothesis stated that there is no statistically significant difference between the groups.

MATERIALS AND METHODS

Sixty mandibular premolar teeth, extracted and free of caries, were collected and underwent sterilization. They were then stored in 0.9% normal saline. Following confirmation of single, patent canals, the teeth were decoronated at the cementoenamel junction (CEJ) using a diamond disc. The specimens were then randomly allocated to three groups for a root canal preparation experiment ($n = 60$).

- Group I: Single-file system utilized with a torque-controlled endodontic motor ($n = 20$)
- Group II: Two-file system (two-curve) employed ($n = 20$)
- Group III: Multi-file system implemented ($n = 20$).

A standardized decoronation procedure was performed at the CEJ level using a diamond disc. A size 10 K-file established the glide path, and the working length was determined by subtracting 0.5 mm from the measurement obtained with a size 15 K-file. For stability during subsequent procedures, all specimens were mounted on a modeling wax base. Preinstrumentation cone-beam computed tomography (CBCT) scans were acquired for all samples to serve as a baseline for calculating postpreparation dentin thickness. Each group underwent root canal preparation using a distinct instrumentation system, following the manufacturer's instructions:

Irrigation with standardized volumes of 3% sodium hypochlorite and 17% EDTA solutions (2 mL each, 1 min dwell time) and final irrigation consisting of 5 mL saline solution was performed between each file change in all groups. Postinstrumentation CBCT scans were acquired at three predetermined apical levels (4 mm, 7 mm, and 11 mm) to evaluate the RDT after preparation. These scans were compared to the baseline scans for definitive measurement. The RDT among all three groups was calculated and statistically evaluated by one-way ANOVA and intergroup comparison between groups done using *post hoc* – Tukey's test with SPSS 24.0 software (IBM SPSS, Chicago, IL, USA). The significance level was set at $P < 0.05$.

RESULTS

A comparison was made between the amount of RDT at 4 mm on all four sides-buccal, lingual, mesial, and distal-between Groups I, II, and III [Figures 1 and 2]. It was found that there was no significant difference between Group I and Group II. However, there was a significant difference when comparing Groups I and III and Groups II and III. At 7 mm, there was a significant difference in the RDT between all three groups. The same was observed at 11 mm, indicating that multiple file systems removed more dentin at the apical third. According to the one-way ANOVA, Group I had the highest mean, followed by Group II and Group III had the lowest mean. This indicates a statistically significant difference between all three groups [Graphs 1-3].

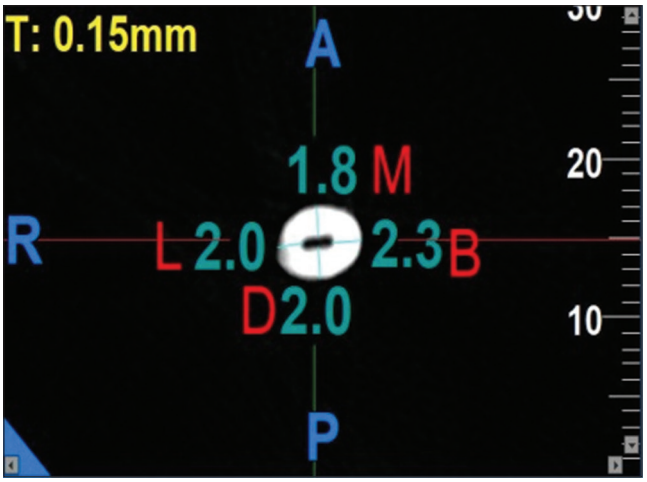


Figure 1: Baseline radicular dentin thickness (4 mm from radiographic apex)

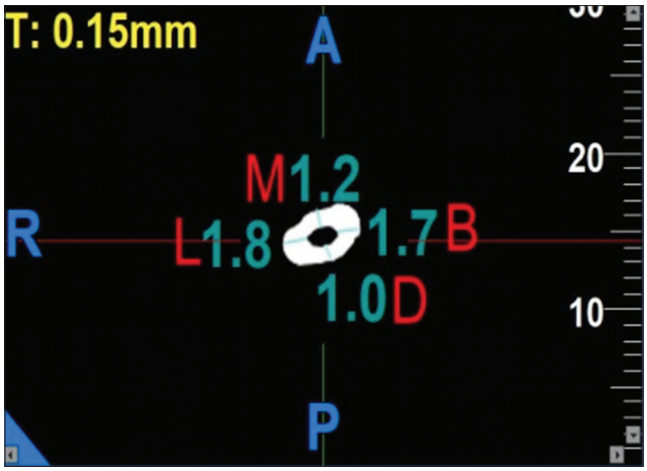
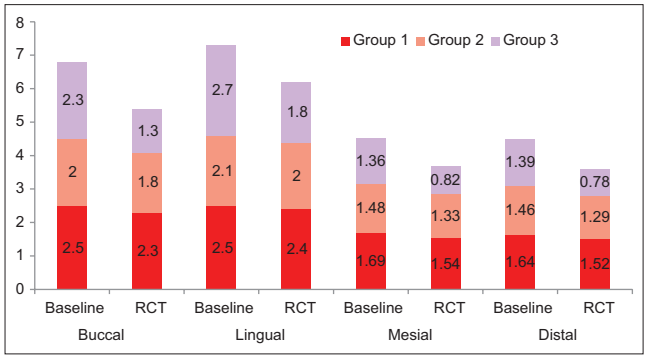
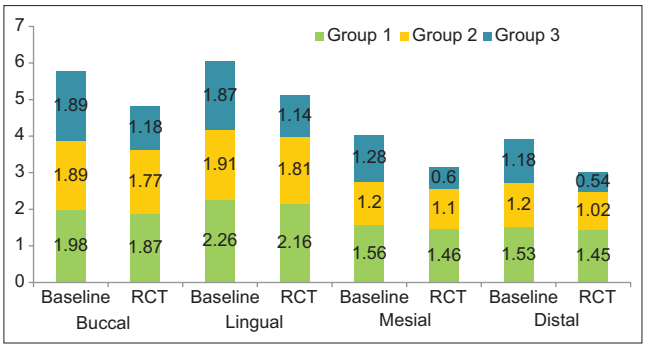


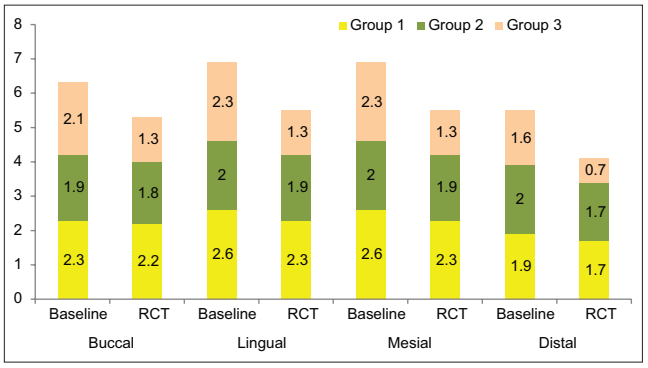
Figure 2: Remaining dentin thickness after cleaning and shaping (4 mm from radiographic apex)



Graph 2: Mean comparison of remaining dentin thickness between groups at 7 mm. RCT: After root canal treatment



Graph 1: Mean comparison of remaining dentin thickness between groups at 4 mm. RCT: After root canal treatment



Graph 3: Mean comparison of RDT within groups at 11mm, RDT: Remaining dentin thickness, RCT: after root canal treatment

DISCUSSION

The root canal space requires an appropriate taper to allow for proper irrigation and obturation, but excessive enlargement can damage the root structure. Therefore, selecting suitable equipment for instrumentation is crucial to the success of root canal therapy. The RDT after instrumentation is a crucial factor that can influence the tooth's fracture resistance, strength, and durability of a tooth that has had root canal treatment. Researchers have found that at least 0.3 mm of residual dentin should remain after root canal preparation to provide the necessary resistance against lateral stresses. Compared to multifile NiTi systems, single-file NiTi systems offer several advantages in shaping curved canals. Single-file systems minimize instrument usage, reducing the risk of cyclic fatigue and potential instrument breakage within the canal, lowering the possibility of cross-contamination between patients, shorter chair time for both patients and dentists, and cost effectiveness.[4,5] In this study, CBCT was used because it allows for three-dimensional views of the root canal space (transverse, axial, and coronal). CBCT scans provide a noninvasive deep view of the root canal system, making it possible to scan the teeth before and after instrumentation and compare the resulting images.[6] Recent advances in imaging technology and software have led to using CBCT in endodontic research. A single imaging approach allows us to observe images in a variety of planes. The study evaluated three sections of the root canal system: 4 mm, 7 mm, and 11 mm, which roughly reflect the apical, middle, and coronal thirds of the root canal, where there is significant susceptibility.[7-9] The One Curve file system is a rotary file made of heat-treated NiTi alloy, constructed using C-wire technology that provides shape memory. It is a single-use instrument capable of shaping the entire canal. The changing cross-section throughout the blade results in improved centering and flexibility. Studies have shown that using more flexible instruments during root canal preparation can increase centralization and minimize cutting and transportation. The current study's findings were consistent with those of Gomaa *et al*., 2021,[10] who found that One Curve maintained more dentin than Hyflex EDM and ProTaper Next. The One Curve file's alloy is created using electropolishing and heat treatment processes. The file has a triple-helix cross-section in the 4-mm apical part and an S-shaped cross-section with two blades across the blade for apical third centering and efficient debris removal up to the middle and coronal regions.[11,12] The C-wire heat treatment is an exclusive

proprietary feature that offers controlled NiTi memory and the ability to prebend the file for better root canal access and reduction of limitations. The single-file one-curve system is associated with drawbacks, including apical extrusion, transportation, canal binding, and reduced centering ability when compared to reciprocation files.[13] This study found that 2Shape performed better than Hero Gold due to its NiTi-alloy metallurgy known as T-wire, which provides improved resilience to cycle fatigue (+40%) and better curvature negotiation. A new generation of cross-sections with a triple helix consisting of two primary cutting edges and one secondary cutting edge helps achieve an optimal balance between cutting efficiency and debris clearance. These findings are in line with a previous study by Singh S *et al.*, (2019)[14] who compared dentinal removal using ProTaper gold (PTG) and 2Shape, and found that 2Shape performed better. The design of the 2Shape file differs from the One Curve file in the distribution of its triple-helix cross-section. While the One Curve file reserves this design for the apical region, the 2Shape incorporates it throughout the cutting instrument. This variation may result in the 2Shape system conforming more closely to the anatomy of the root canals, potentially leading to enhanced shaping efficiency. However, a potential drawback of this tighter contact could be the hindered removal of debris generated during the shaping process through the opening of the root canal. The 2Shape file's usage involves a three-wave motion (three up-and-down movements) accompanied by an upward circumferential filing action. The nonsymmetrical profile minimizes the risk of instrument breakage while optimizing the effectiveness of circumferential brushing for targeted cleaning.[14] The 2Shape file has a triple-helix cross-sectional design that runs across the cutting region, whereas the One Curve file has this design only at the tip. This difference may help the 2Shape system to get closer to the root canals, improving its shaping abilities.[15] However, the tight contact may hinder the removal of created material through the root canal opening. According to a recent investigation, the use of Hero Gold results in the removal of a significant amount of dentin. This is potentially due to the file's multiple sequences and circumferential brushing action, as well as its three cutting edges and positive rake angle. The positive rake angle increases the interaction between the file edges and the walls of the canal.[16,17]

CONCLUSIONS

Based on the limitations of this study, it can be concluded that the single-file system is better at preserving dentin and is less aggressive at cutting dentin when compared to the 2-file and multiple-file systems. Further research is necessary to confirm these findings in a clinical setting with a broader patient pool. This would provide stronger evidence for the impact of NiTi instruments on dentin preservation and long-term success rates. In addition, ongoing advancements in design and material science for NiTi instruments hold promise for minimizing dentin removal during root canal procedures, potentially leading to improved clinical outcomes.

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Conflicts of interest
There are no conflicts of interest.

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