

Original Research

Apical transportation with different root canal preparation techniques using edgEEvolve rotary instruments

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ABSTRACT

Background: This study aimed to investigate the extent of apical transportation following instrumentation with EdgeEvolve rotary instruments applying single-length and crown-down techniques.

Materials and Methods: In this experimental *in-vitro* study, 60 mandibular molars with mesiobuccal curvatures of 20°–40° were selected, and digital radiographic images were taken. Teeth were randomly assigned into two groups of single-length and crown-down preparation techniques. In both mentioned groups, EdgeEvolve rotary system was used. After preparation, the same as the previous ones, digital radiographic images were taken from the canals. The data were analyzed using Student's *t*-test and Shapiro-Wilk normality test ($P = 0.05$).

Results: The mean standard deviation (SD) for apical transportation in the single-length and the crown-down group was 4.42 (2.9) and 7.48 (3.9) degrees, respectively ($P < 0.05$). The mean SD of the preparation time in the single-length and crown-down group was 135.07 (30.8) and 109.07 (20.8), respectively ($P < 0.05$). The apical transportation and the time of preparation between the two groups were significant.

Conclusion: Using EdgeEvolve rotary instruments canal preparation with both single-length and crown-down techniques led to some degrees of apical transportation.

Key Words: Apical foramen, endodontics, root canal preparation, root canal therapy

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INTRODUCTION

The ideal goal for nonsurgical root canal treatment is to cure or prevent apical periodontitis.^[1] The process of chemo-mechanical debridement reduces the number of microorganisms and irritants from the root canal system. While clinicians use several canal preparation techniques during root canal treatment, crown-down and single-length techniques are the two most recommended ones by nickel-titanium (NiTi) rotary file manufacturers. Cleaning and shaping curved root

canals may result in several procedural errors, for instance, apical transportation, ledge formation, canal blockage, and subsequently, perforations.^[2]

The Glossary of Endodontic Terms of the American Association of Endodontists (2015)^[3] defines transportation as “Removal of canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their

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original linear shape during canal preparation; may lead to ledge formation and possible perforation.”

Several methods have been introduced for the measurement of apical transportation, such as digital radiography, cone beam computed tomography (CBCT), and micro-computed tomography (micro-CT), to name a few.^[4-6] However, an established gold standard for evaluating apical transportation is still missing.^[6]

In the periapical radiographic technique, the radiographs obtained before and after root canal instrumentation are superimposed to measure the degree of apical transportation. The advantages of this method are being straightforward to perform, inexpensive, and capable of revealing if any canal transportation has occurred.^[6]

Studies have demonstrated that NiTi rotary instruments have a more centered root canal preparation than stainless steel hand files.^[7] Besides, the apical transportation of different NiTi rotary instruments has been reported. Hu *et al.*,^[8] compared ProFile ISO, ProFile Vortex, and Vortex blue in terms of apical transportation, and found no significant difference between the three groups. In another study, three systems of rotary files, F6SkyTaper, Mtwo, and OneShape, were compared, and no significant difference was observed. Besides, the authors concluded that files maintained the original shape of the root canals.^[9]

The EdgeEvolve rotary instruments (EdgeEndo, Albuquerque, NM, USA) are made of heat-treated NiTi alloy called Firewire.^[4] This system consists of files #17 to #40 with 0.04, 0.06, 0.08, and 0.10 tapers. The diversity in size and taper of files allows clinicians to choose a specific preparation technique based on canal shape and size, degree of curvature, and skills. A previous study demonstrated improved cyclic fatigue resistance of the instrument due to the heat treatment.^[10]

Based on our review of the literature, using different root canal preparation techniques with a NiTi rotary system has not yet been thoroughly explored. In addition, using different preparation techniques may result in disparate treatment outcomes. The present study aims to fill this gap by comparing the apical transportation of single-length and crown-down techniques using the EdgeEvolve rotary system.

MATERIALS AND METHODS

This *in vitro* study was approved in research and ethics committee of Isfahan (NO:396883). The present study

was approved by the Regional Bioethics Committee affiliated to Isfahan University of Medical Sciences, Isfahan, Iran (396883). In this experimental *in-vitro* study, 60 extracted human mandibular molars were selected for this study. The selection criteria for this study were a complete root formation, 20°–40° canal curvature (according to Pruett’s method),^[11] a 2.2–11.1 cm radius of curvature, and 2 separated mesial canals [Figure 1].

The access cavities were prepared with round diamond burs. The teeth were mounted in impression putty to provide a reproducible position for the digital dental X-ray sensor and cone alignment. A #10 K-file (Mani, Tochigi, Japan) was inserted into the mesiobuccal canal of each tooth to ensure a patent canal from orifice to apex. The working length was established by inserting a #15 K-file (Mani, Tochigi, Japan) into the root canal until the file tip became invisible through the apical foramen under a dental loup (HEINE, Herrsching, Germany) at $\times 2.5$, then subtracting 0.5 mm. A digital radiograph (DURR Dental SE, Bissingen, Germany) was obtained in a buccolingual view to register the initial apical curvature. The root canal curvature angle and radius were measured according to Pruett *et al.*’s^[11] method using the AutoCAD 2008 program (Autodesk Inc., San Rafael, CA, USA). The teeth were divided into two groups ($n = 30$) with similar angles and radius of curvature. The curvature angles ranged from 20° to 40°.

An endodontist performed root canal preparation in all samples. In both groups, the glide path was verified with a K-file #15. In the single-length

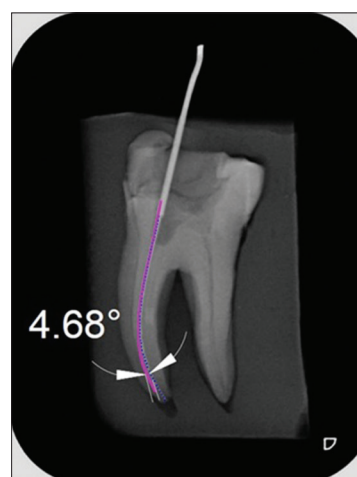


Figure 1: Measuring the apical transportation after instrumentation of canals.

group, the following sequences of the EdgeEvolve rotary NiTi instrument were used in the working length: #20/0.04, #20/0.06, #20/0.08, #20/0.10, and #25/0.08. In the crown-down group, rotary instruments were introduced to the canal up to the binding point: 20/0.10, 20/0.08, 20/0.06, 20/0.04, and 25/0.08. Between each file, the canals were irrigated with 2 mL of 2.5% NaOCl. After completing the preparation procedure, a K-file #15 was placed into the root canal at the working length. Further, the teeth were remounted on the impression putty, and a post instrumentation radiograph was obtained. AutoCAD 2008 program was used to superimpose pre- and post-instrumentation radiographs. The angles between the tip of the initial and final files were measured [Figure 2]. The time of canal preparation was also recorded. The data were analyzed by a blind computer operator using the Student's *t*-test and Shapiro-Wilk normality test with SPSS software version 22 (IBM Inc., Armonk, NY, USA).

RESULTS

The box plot illustrated the absence of any outliers in the data, and the Shapiro-Wilk test revealed that the observations are normally distributed. Besides, there was no incidence of instrument separation in any of the cases. No statistically significant difference was observed between the radius of curvature and curvature angle of the selected root canals for each group (*t*-test, $P > 0.05$).

The mean standard deviation (SD) for apical transportation in the single-length and crown-down group was 4.42 (2.95) and 7.48 (3.89) degrees,

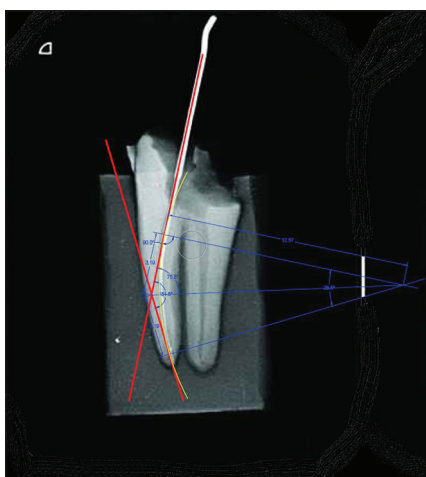


Figure 2: Measuring the curvature of the root canal according to Pruet's method.

respectively. The Student's *t*-test showed a significant difference between the two groups concerning apical transportation ($P < 0.05$). The mean SD of the time of preparation in the single-length and the crown-down group was 135.07 (30.83) and 109.07 (20.83), respectively. Furthermore, there was a significant difference between the two groups regarding the preparation time ($P < 0.05$) [Table 1].

DISCUSSION

Preparing the root canals without deviating from the original canal morphology is one of the most substantial cleaning and shaping goals. However, all instruments and preparation techniques tend to cause root canal transportation.^[12] Apical transportation means the deviation of the canal's physiological path to the iatrogenic path, mainly located on the outer surface of the curvature. Different types of apical transportation can occur as Type I (mild form) to Type III (severe form). However, type I transportation is the only manageable type by nonsurgical endodontics.^[4] It can also cause improper debridement of the canal in the apical and the coronal region, and even excessive removal of dentin, especially in the concave root canal area. Insisting on continuing the incorrect pathway can also lead to the apical foramen's zipping or perforation.^[13]

In general, several factors influence the occurrence of accidents during treatment, such as complex canal anatomy, instrument design, operator experience, rotation speed, not maintaining canal patency, and inadequate irrigation.^[11,13]

Extracted teeth or resin blocks can be used to evaluate the quality of cleaning and shaping endodontic instruments. As resin blocks differ in the degree of hardness and shape of the 3-dimensional (3D) canal compared to regular teeth, extracted teeth were used to simulate clinical conditions.^[14] In the present study, the mesiobuccal root canals of mandibular molars were selected. This selection is because they are often narrow and curved in both buccolingual and mesiodistal planes,^[15] making the preparation more difficult.^[15,16]

EdgeEvolve rotary instruments are made of heated NiTi alloy called Fire-Wire. The use of this alloy has been shown to increase cyclic fatigue and torque resistance of the instrument.^[17] Dosanjh *et al.*,^[10] investigated the effect of temperature changes on the periodic fatigue of EdgeFile, Vortex Blue, and

Table 1: Mean degree (°) and standard deviation of canal curvature, radius of curvature, apical transportation, and time (s) of preparation with different techniques

Technique	Mean (SD)				
	Number of canals	Degree of curvature (°)	Radius of curvature (cm)	Apical transportation (°)	Time (s)
Single-length	30	28.4 (8.71)	5.97 (2.27)	4.42 (2.95)	135.07 (30.83)
Crown-down	30	28.6 (8.4)	5.79 (1.91)	7.48 (3.89)	109.07 (20.83)

SD: Standard deviation

ESX NiTi Instruments. In this study, EdgeFile files were found to have a higher number of instrument separation cycles than other files supporting the manufacturer's claim.

The quality of canal preparation is typically assessed using either 2D, X-rays, or 3D imaging techniques such as CBCT or micro-CT. In the 2D radiographic methods, digital radiographic images are compared before and after treatment by calculating the level of canal transportation through overlapping the images using commercial software.^[18] However, in this procedure, the actual canal displacement values cannot be accurately measured. Nevertheless, overlapping radiographic images (the method used in the present study) is one of the most popular methods for calculating canal displacement.^[6,19,20] Despite its inability to perform volumetric calculations, this method is relatively inexpensive, easy to implement, and reliable. Cross-sectional cutting is also a method, in which the shape and position of root canals are directly observed. However, the actual path of the canal cannot be determined before preparation.^[21] The use of micro-CT scanners is now routinely used in the evaluation of new endodontic systems because of their practicality and nondestructive nature.^[22,23]

In this study, no significant differences were found in the amount of root canal curvature and radius of the curvature in the single-length and crown-down groups. Consequently, the roles of the interfering factor in the canal curvature in the apical displacement of the canals are probably controlled. According to the present study results, the amount of apical transportation of root canals in single-length and crown-down groups was measured at 4.42° and 7.48°, respectively. The difference in apical transportation values was statistically significant in single-length and crown-down techniques. The results obtained in the present study can be related to factors such as the type of NiTi alloy used in the EdgeEvolve file structure, file design factors such as cross-section and noncutting tip as well as operator's skill. Furthermore, using a sequence of files in both techniques and the

Glide Path preparation procedure will impact these results.

Most studies investigating apical transportation of the root canal have used limited types of rotary systems.^[24-26] Besides, comparisons between studies are limited due to differences in study designs such as differences in operator, root canal lengths, final apical size, and measurement methods.^[27]

Based on a review of studies published to date, only one study has examined the effect of preparation technique on canal apical displacement with a rotary system. Hamze *et al.*^[13] investigated the apical transportation of Mtwo rotary files in single length and crown-down techniques. They found no significant difference between these methods when preparing the canal curvature's apical and middle sections. However, according to the present study results, the difference between the apical transportation values in the single-length and crown-down techniques was statistically significant.

A review of the literature reveals a dearth of studies on the apical displacement of root canals following EdgeEvolve files' use. Only one research has examined the EdgeFile rotary system's ability to be manufactured by another EdgeEvolve manufacturer with a similar alloy to this rotary file with two other methods. Versiani *et al.*,^[28] investigated the shaping ability of various files, including XP-endo Shaper, iRaCe, and EdgeFile, using micro-CT techniques. Based on the results of this study, all three systems had similar canal formation capabilities.

In the present study, the average canal preparation time in the single-length and crown-down groups was 135.07 and 109.07 s, respectively. Preparation time in the crown-down technique can be due to the removal of coronal interference and the more efficient irrigation of debris created during preparation, thus a better performance of rotary files. Lack of sufficient clinical experience to work with new endodontic devices can also lead to increased canal preparation time. Therefore, increasing the skill of the clinicians is expected to reduce the preparation time of the canal.

CONCLUSION

Using of EdgeEvolve rotary instruments in the preparation of canals with single-length and crown-down techniques led to different degrees of apical transportation. However, the single-length technique was associated with less apical transportation.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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