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ORIGINAL ARTICLE

Apically extruded debris and irrigants during root canal instrumentation with TruNatomy and ProTaper Gold rotary file systems

ABSTRACT

Aim: *The objective of this study was to evaluate the amount of apically extruded debris and irrigants produced by TruNatomy and ProTaper Gold in mandibular incisor root canals.*
Methodology: *Forty mandibular incisors were instrumented using TruNatomy (Dentsply Sirona, Maillefer, Ballaigues, Switzerland) and ProTaper Gold (Dentsply Sirona, Maillefer, Ballaigues, Switzerland) rotary systems. Apically extruded debris and irrigants during instrumentation were collected into preweighed Eppendorf tubes and were assessed with an electronic scale. All the procedures were performed in a 35 °C hot water bath. The data were analyzed using the Shapiro-Wilk test and Mann-Whitney U test at a 5% significance level.*
Results: *Both NiTi file systems investigated extruded debris from the apical foramen. According to the data, the TruNatomy group extruded significantly less debris and irrigant from the apical foramen than the ProTaper Gold group ($p<0.05$).*
Conclusions: *All the instruments caused apical extrusion. The TruNatomy instruments extruded less debris and irrigants apically than the ProTaper Gold instruments.*

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Introduction

For long-term success in root canal treatment, canal cleaning and shaping are critical. During these procedures, it is essential to pay great attention; otherwise, complications - such as extrusion of dentin chips, pulpal residue, microorganisms, and irrigants into the periradicular tissue - may occur (1). Apical extrusion of debris and irrigants (AEDI) may cause postoperative pain, exacerbation and delayed periapical healing, creating an undesirable situation (2, 3). Studies show that all instrumentation techniques and instruments cause apical extrusion (4, 5).

The amount of extruded debris through the apex is related to the design (size and type) of the endodontic instruments used (6). Technological advances in rotary nickel-titanium (NiTi) instruments have led companies to develop new instruments with new design concepts. Recently, a novel heat-treated NiTi rotary system, TruNatomy (Dentsply Sirona, Maillefer, Ballaigues, Switzerland), has been developed with higher flexibility, allowing the file to be pre-curved when needed. According to the manufacturer, this system has an off-centered parallelogram cross-section design that is 0.8 mm of NiTi wire instead of the up to 1.2 mm found in most other variable tapered instruments (Dentsply Sirona, TruNatomy Brochure. Available at: https://www.dentsply-sirona.com/en/explore/endodontics/trunatomy.html. Accessed February 5, 2021). Van der Vyver et al. reported that TruNatomy instruments maintain their structural integrity via instrument geometry, regressive tapers, slim design and a heat-treated NiTi alloy (7). ProTaper Gold (Dentsply Sirona, Maillefer, Ballaigues, Switzerland) is made of "Gold-Wire" and has some characteristics similar to those of controlled memory wire (CM-wire) (8). This rotary system has a unique instrument design with a triangular cross-section and a variable progressive taper (9). To our knowledge, only one study has compared the apical extrusion effects of TruNatomy with ProTaper Gold and ProTaper Next rotary file systems (10).

The purpose of this investigation was to compare the AEDI associated with the use of TruNatomy and ProTaper Gold rotary file systems in mandibular incisor teeth with different methodology. The null hypothesis tested was that there would be no difference between TruNatomy and ProTaper Gold systems in terms of the amount of extruded debris and irrigants through the apex.

Materials and Methods

The Ethics Board approved the study protocol of Afyonkarahisar Health Sciences University (No: 2011-KAEK-2/2020/10). Based on the results of Tanalp et al. (11), a power calculation was performed using G*Power 3.1 software (Heinrich Heine University, Dusseldorf, Germany) with an alpha-type error of 0.05 and beta power of 0.80. The software indicated that the total sample size for the two groups must be a minimum of 40 teeth.

A total of 40 mandibular incisor teeth that had been extracted for periodontal reasons were included in the study. The inclusion criteria were as follows: mature apices with a single apical foramen without resorption/calcification or previous root canal treatment and roots with less than a 5° curvature (12). To increase the standardization, teeth that were abraded under water cooling to standardize their lengths to 20 mm, confirmed with a millimeter ruler, were included in the study. Soft and hard tissue debris on the external surfaces of all the teeth were mechanically removed.

The coronal access cavity was prepared using diamond burs. A #15 K-file (VDW GmbH, Munich, Germany) was advanced within the canal until the tip was seen through the major apical foramen, and the working length was determined by subtracting 1 mm from this length. The size of the apical foramen of the teeth was not greater than 0.15 mm.

The selected teeth were randomly divided into two groups (n=20) and numbered. The root surfaces of all teeth, except 1 mm of the apical part, were covered with a Teflon band. The weight of the samples was measured three times with an electronic scale of 10^{-4} g (Denver Instrument, New York, ABD), and

the mean value was calculated. Agar gel (3 mL, 1.5%) was injected into Eppendorf tubes, and the samples were then fixed in the tubes at the cementoenamel junction using cyanoacrylate adhesive (UHU Patafix; UHU GmbH & Co. KG, Baden, Germany) to prevent leakage of irrigating solution through the hole. After gelation of the agar, the weights of the tubes, including the agar solution, were measured three times again. The weight of each apparatus (tooth-free apparatus) was calculated by subtracting the first weight measurement of the samples from the second weight measurement value (14, 15). The Eppendorf tubes were positioned in a glass bottle filled with water. The equipment was placed in a 35 °C hot water bath (JSR Research Inc., Republic of Korea) (16).

Each instrument was used on four specimens, simulating a molar with four canals. All instruments were operated using an endodontic motor (VDW Gold, VDW, Munich, Germany). The root canal preparation was completed when the final instrument of each system had reached the working length. The canals were irrigated with 5 mL 2.5% NaOCl solution with a 30-G IrriFlex needle (Produits Dentaires SA, Switzerland). To standardize the irrigation protocol, the needle was attached to a device (Mindray BeneFusion SP1, Shenzhen, China) and inserted into the canal within 2 mm of the working length without binding and moved in an up-and-down motion. In all the groups, the flow rate of the irrigating solution was constant and equal to 2.5 ml/min. After completing the preparation, final irrigation was applied using 5 mL of 17% EDTA followed by 5 mL of 2.5% NaOCl.

All endodontic procedures were completed by a single operator.

Group 1 (n=20): the root canals were prepared using TruNatomy Glider (17.02), Small (20.04), Prime (26.04) and Medium (36.03) files at 500 rpm and 1.5 Ncm torque values.

Group 2 (n=20): the root canals were prepared using ProTaper Gold S1 (17.02), S2 (20.04), F1 (20.07), F2 (25.08) and F3 (30.09) files at 300 rpm and 2.0 Ncm torque values.

When the root canal preparation was completed, the Eppendorf tubes were removed from the glass bottles, and the teeth were removed from the tubes. After removal of the Teflon bands and the teeth from the Eppendorf tubes, each apparatus was weighed three times consecutively. The amount of extruded debris was calculated by subtracting the weight value of the tooth-free apparatus from the post-preparation weight value. The mean weight of each tube containing debris and irrigant was recorded. A second independent operator performed all the measurements of the AEDI.

Statistical Analysis

The median, minimum and maximum values were calculated for the two groups. To test for normality, the amount of extruded debris and irrigants were subjected Shapiro-Wilk test and were found to have a non-normal distribution. The data were analyzed via Mann-Whitney U test using SPSS 21.0 Software (IBM Corp, Armonk, NY). The alpha-type error was set at 0.05.

Results

The descriptive statistics in each group are listed in Table 1. All the groups extruded debris from the apical foramen. According to the data, the TruNatomy group extruded significantly less debris and irrigants from the apical foramen than the ProTaper Gold group ($p<0.05$).

Discussion

During cleaning and shaping of the root canals, microorganisms may pass to the periradicular tissues through the apical foramen, causing postoperative flare-up (16). This complication increases the need for the development of new root canal file designs that minimize debris extrusion. The instrument design, differences in instrument tapers and root canal anatomy are closely related to apical debris extrusion (1). This study assessed the weight of AEDI produced by TruNatomy and ProTaper Gold systems during root canal preparation.

In previous studies, distilled water was used during instrumentation to avoid crystallization of sodium hypochlorite, which could otherwise interfere with the weighing of the debris (5). However, sodium hypochlorite is

Table 1

The median, minimum and maximum values of AEDI according to groups in grams

Group (n=20)	Median (Min-Max)	U	p
TruNatomy	0.0104 (0.0019-0.0416)	108.5	0.013*
ProTaper Gold	0.0218 (0.0061-0.1774)		

**Mann-Whitney U test*

commonly used as an irrigation solution in root canal preparation. We used the same test apparatus to evaluate the amount of AEDI as that used by Uslu et al. (15). In this system, a 1.5% agar gel was used to simulate periapical tissue, and the weights of the tubes, including the agar solution, were measured; it was not necessary to vaporize the irrigant. Therefore, all samples were irrigated with 2.5% NaOCl and 17% EDTA solutions.

In all shaping procedures, many factors - such as the shape of the apical area, the instrumentation technique, the length of the irrigation needle, the penetration of the tip of the needle into the apical and the speed of the irrigant administration - can cause debris and irrigants extrusion (17, 18). To lower the irrigant extrusion achieved with regular needles (6), side-vented needles were used, and to standardize the irrigation protocol, the irrigant flow rate was provided with a device. Moreover, similar to other studies, in this study, a 30-G IrriFlex irrigation needle integrated into the syringe pump was set at a speed of 2.5 ml/min (19, 20).

Our study presents one variable data: the design (size and type) of the NiTi rotary endodontic instruments. The newly developed TruNatomy instruments are manufactured from a heat-treated NiTi alloy that exhibits higher fatigue resistance (21, 22). It has been reported that the TRN instruments preserve the structural dentine and tooth integrity due to instrument geometry, regressive tapers and the slim design, along with the heat treatment of the NiTi alloy (7). To the best of our knowledge, there has been only one study that compared TruNatomy and ProTaper Gold systems in terms of AEDI (10). Çırakoğlu et al. (10) compared the amount of extruded debris through the apex using ProTaper Next, ProTaper Gold, and TruNatomy systems. The ProTaper Gold system extruded more debris than the TruNatomy system with no significant difference. This result differs from those of the current study. The experimental set-up, design and type of teeth used might have led to different results.

The results of the present study show that the TruNatomy group extruded significantly less debris and irrigants from the apical foramen than the ProTaper Gold group. The null hypothesis was rejected because of AEDI with different amounts between the tested two instrumentation systems. Several studies reported that the larger tapers at the tips of instruments, resulting in more aggressive preparation of the root canals, might explain the increased amount of extruded debris through the apex (20, 23, 24). The design features of the ProTaper Gold system include progressive and regressive percentage tapers on a single file, but the TruNatomy System has variable regressive tapers on a single file. However, the TruNatomy Medium instrument has a 0.03 taper at the apical D0 point, whereas the ProTaper Gold F3 instrument has a 0.09 taper at the apical D0 point. The larger taper at the tip of the ProTaper Gold instrument might explain the increased amount of AEDI with this system. Moreover, the cross-sectional geometric design of the TruNatomy system is different from that of the ProTaper Gold system. TruNatomy instruments have an off-centered parallelogram cross- section design that incorporates a 0.8-mm NiTi wire instead of the up to 1.2 mm found in most other variable tapered instruments. All three shaping files offer a slim shape combined with a unique cross-section for better performance while providing more space for superior debris debridement (Dentsply Sirona, TruNatomy Brochure. Available at: https://www.dentsplysirona.com/en/explore/endodontics/trunatomy.html. Accessed February 5, 2021).

The elements of the file design, such as flute depth and cross-section, flexibility, alloy, are related to the amount of extruded debris through the apex (25). Koçak et al. (26) reported that the off-centered cross-sectional design might provide more space for debris

extrusion through the coronal direction. According to the authors of this article, TruNatomy's slim design with an off-centered parallelogram cross-section might be led to the debris removal coronally, which reduces apical compaction of debris within the root canal. This result is according to a previous study that also displayed lower debris extrusion associated with the TruNatomy system compared Reciproc Blue, HyFlex, HyFlex EDM, and ProTaper Next systems. In the present study, agar gel was used to simulate the periapical tissues because it has a similar density to periapical tissues (14). The presence of periapical tissues and changes in this tissue (e.g., lesions, periapical granulomas, or cysts) could affect the amount of AEDI under clinical conditions (28). In the use of real teeth, dentin microhardness also affects the amount of apically extruded debris (5). Moreover, because the mean temperature in the root canal is 35 °C (29), the experiment system was placed into a 35 °C hot water bath to mimic clinical conditions.

Conclusions

The design features and sizes of rotary systems have influenced the amount of AEDI during root canal preparation. Within the limitations of this study, the results show that although both tested systems extruded debris, TruNatomy instruments produced less AEDI than ProTaper Gold instruments.

Compliance with ethical standards

Ethical approval for the manipulation of human samples was obtained from the ethical committee of the University of Afyonkarahisar Health Sciences (No: 2011-KAEK-2/2020/10).

Clinical Relevance

Both NiTi file systems that TruNatomy and ProTaper Gold caused apical extrusion of debris and irrigants during canal shaping. The design of the NiTi rotary endodontic instruments are considered to be effective in the amount of apically extruded debris and irrigants.

Conflict of Interest

The authors declare that they have any conflict of interest.

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