Acta Odontologica Turcica
The official journal of Gazi University Faculty of Dentistry

DOI: https://doi.org/10.17214/gaziaot.1143423

Original research article

Comparison of apically extruded debris during root canal instrumentation using T-endo must, T-endo mis, and Reciproc Blue Files

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Abstract

Objective: The aim of this study was to compare the effect of nickel-titanium file systems with different taper angles working with rotation and reciprocation motion on the amount of debris extruding apically.

Materials and Method: The study was performed using the Myers and Montgomery model. Forty-five human maxillary anterior teeth were inserted into preweighed Eppendorf tubes and randomly classified into three groups. After manual glide-path preparation, the teeth in each group were instrumented to the working length set 1 mm short of the anatomical apex using the standard sequence provided by the manufacturers: Group 1: Reciproc Blue (Easy In Smile, New Jersey, USA), Group 2: T-endo must (Dentac, İstanbul, Turkey),Group 3: T-endo mis (Dentac, İstanbul, Turkey). Root canals were irrigated with 10 mL 2.5% NaOCl, 17% EDTA, and distilled water between each file insertion. The tubes with collected debris were stored in an incubator at 70°C for 7 days. Measurement of the weight of extruded debris was performed by subtracting the pre-instrumentation from the post-instrumentation weight of the tubes. Data were analyzed using one-way ANOVA and Tukey's Honest Significant Difference Test (α=0.05).

Results: The weights of the apically extruded debris were 0.0094±0.0015 g in Group 1, 0.0075±0.0012 g in Group 2, and 0.0044±0.0010 g in Group 3, and the difference between all groups was statistically significant (p<0.05).

Conclusion: The amount of apically extruded debris is related to the taper angle of the file used and the kinematics of the file.

Keywords: Apical foramen; endodontics; root canal preparation; root canal therapy

Received: July 13, 2022; Accepted: February 20, 2023.
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Citation: Fundaoğlu Küçükekenci F. Comparison of Apically Extruded Debris During Root Canal Instrumentation using T-endo must, T-endo mis, and Reciproc Blue Files Acta Odontol Turc 2023;40(3):79-83

Editor: Bağdagül Helvacıoğlu Kıvanç, Gazi University, Ankara, Türkiye

Conflict of Interest: The author declares no conflict of interest related to this study.

[Abstract in Turkish is at the end of the manuscript]

Introduction

Root canal therapy accounts for a large percentage of dental treatments. This treatment option has necessitated the development of many treatment equipment to improve the comfort of patients and clinicians.[1,2] Despite the new preparation systems developed, the extrusion of dentin and pulp debris into the periapical area during endodontic treatment is still considered one of the most common complications clinicians encounter, which negatively affects healing and causes pain and swelling in the patient.[3,4] While developing file systems with different apical diameters and kinematics, one of the targets is to minimize the extrusion of apical debris. Still, it has been reported that different amounts of apical debris are extruded in all the file systems used.[5-7] Recently, many different file systems have been introduced that work with different kinematics and allow root canal preparation with single or multiple files made of various alloys.[8-10]

The T-endo must,also named as TM wire technology, is a novel file with reciprocating motion made of a special heat-treated alloy with 0.25 apical diameter and 4% taper angle.[10] Reciproc files, known to work with reciprocating motion with their 2-cutting-edge design with an s-shaped horizontal section, have been updated as Reciproc Blueby undergoing a heat treatment that caused a blue titanium oxide layer to form on the surface of the file. This heat treatment allows Reciproc

Blue files to be more flexible.[11] T-endo mis files is a new file system that works with seven different files with continuous rotation to enable minimally invasive shaping. Rectangle cross-section for higher cutting efficiency ensures more debris removal. TM wire technology is safer for curved canals. This file system has been developed with TM wire technology, just like the T must endo files, which provides the files with break-resistant and flexibility.[12]

There are no studies examining the effect of these new file systems on apical debris extrusion. To this end, this study aims to investigate the effect of single and multi-file systems with different taper and kinematics on apical debris extrusion. Our null hypothesis is that the kinematics of the taper angle of the file used during shaping and the number of files used would not affect the amount of apically extruded debris.

Materials and Method

The present research was approved by the ethics committee of Ordu University (2022/168). According to power analysis software (G*Power 3.1.Universitat, Düsseldorf, Germany), the sample size of 15 samples per group was determined after a pilot study at an alpha error probability of 0.05 and power of 95% (effect size = 1.05). Forty-five maxillary incisors without previous canal filling, fracture, caries, and resorption were included in the present study. The teeth were separated at the cemento-enamel junction. The working length of the #15 K file (Mani, Utsunomiya Tochigi, Japan) was determined to be 1 mm shorter than the length seen to emerge from the apical. Before the experimental model was created, the apical diameter of all samples was standardized to #20 K files (Mani, Utsunomiya Tochigi, Japan). The experimental model defined by Myers and Montogemery[13] was used to measure the amount of apically extruded dentin. The caps of the Eppendorf tubes were removed from the tubes, and their weights were measured three times using anelectronic balance (AUW-220D, Shimadzu, Japan). The average of the three consecutive measurements was recorded as the initial weight of the Eppendorf tubes, and the roots were placed on the caps of pre-weighed Eppendorf tubes. The Eppendorf tube was placed in a glass tube and covered in a way that prevents the inside of the tube from being seen to avoid the researcher from seeing the amount of apically extruded dentin during shaping. An injector (Genject, Ankara, Turkey) was placed on the lid of the Eppendorf tube to equalize the internal and external pressure.

After the experimental set-up was created, the samples were randomly divided into three groups (n=15). New files were used on each root, and a single operator did all operations. First, each canal was irrigated with 2.5% NaOCl after advancing 2-3 mm in the canal. Between each filing, the residues in the file were cleaned with alcohol. During the irrigation procedure, 10 ml of 2.5% NaOCl was used. Then the roots were irrigated with 10 ml of 17% EDTA. Finally, all roots were irrigated with 10 ml of distilled water. Each irrigation solution was used in a total volume of 10 ml and samples were dried with paper points.

Group 1 (The Reciproc Blue group): The Reciproc Blue #25 file (Easy In Smile, New Jersey, USA) was used in the “reciproc all” mode of the VDW silver endodontic motor (VDW, Munich, Germany) following the manufacturer’s instructions.

Group 2 (The T-endo must group): The T-endo must #25 file (Dentac, İstanbul, Turkey) was used in the “reciproc all” mode of the VDW silver endodontic motor (VDW) following the manufacturer’s instructions.

Group 3 (The T-endo mis): First orificer (25/09), then glider (15/04), then shaper (20/04), and finisher (25/04) files (Dentac, İstanbul, Turkey) were used in the user mode of X-Smart endodontic motor (Dentsply) with 250 rpm and 2.5 torque values respectively.

Apical patency was achieved with #20 K files to prevent apical blockage after every 2-3 mm movement of the file in Group 1 and Group 2 working with reciprocal motion, and after each file in Group 3 working with rotational motion. After root canal preparation, the teeth were kept in a 70 °C incubator for one week to evaporate the apically extruded irrigation solution. Then, the eppendorf tubes were removed from the bottle, the caps of the Eppendorf tubes were removed, and the tubes containing the debris were reweighed three times. The average of the three consecutive measurements was recorded as the final weight. The debris weight was obtained by subtracting the first weight previously obtained from the final weight.

According to the Shapiro–Wilk tests of normality, the groups were normally distributed. Data were analyzed using one-way ANOVA and Tukey Honest Significant Difference Test (HSD) (α=0.05). Statistical software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY, USA) was used to analyze data.

Results

An extrusion of apical debris was observed in all experimental groups. The weights of the apically extruded debris were 0.0094±0.0015 g in Group 1, 0.0075±0.0012 g in Group 2, and 0.0044±0.0010 g in Group 3. While the least apical extrusion of debris was seen in Group 3, the most extrusion of debris was seen in Group 1, and the difference between all groups was statistically significant ($p<0.05$) (Table 1).

Table 1. *Weight of extruded debris of experimental groups as Mean±Standard Deviations (SD).*

File systems	N	Mean ±SD (g)
Reciproc Blue	15	0.0094 ± 0.0015^{A}
T-endo must	15	0.0075 ± 0.0012^{B}
T-endo mis	15	0.0044 ± 0.0010^{C}

**Different superscripts mean statistically significant difference. Significant at p<0.05.*

Discussion

During root canal shaping, debris that protrudes from the apical foramen contains pulp residues, microorganism products, and infected dentin tissue, causing a foreign body reaction in the periapical tissues. Thus, undesirable conditions such as pain, swelling, and fare-up may be seen after root canal treatment.[14-16]

One of the goals of developing new file systems is to reduce the extrusion of apical debris.In this study, the amount of apical debris T-endo must and T-endo mis of two new file systems were compared for the first time with the Reciproc Blue file system for which the apical debris amount was studied before.[17]According to the results of this study, different amounts of apically extruded debris were observed in the file systems with different tapers working with rotational and reciprocating motions. Thus, our null hypothesis was rejected.

Debris extrusion is reported to be related to the design of the instrument and the type of movement.[15] The instrumentation systems tested in the current study have different cross-sections. Reciproc Blue and T-endo must have an S-shaped cross-section with two cutting blades.[10,18] "S" cross-section shapes the root canal as needed with avoiding unnecessary material loss.[10] T-endo mis files have rectangle a cross-section for higher cutting efficiency. Unique design for cutting edge ensures more debris removal.[12] In this study, T-endo mis files with rectangular cross-section design cause less debris extrusion than Reciproc Blue and T-endo must files with S shape cross section.The T-endo must and T-endo mis files used in this study were produced with TM-wire technology, which provides heat treatment of nickel-titanium (Ni-Ti) material to increase its elasticity and increase its fracture resistance.[10,12] The Reciproc Blue system has recently been produced by modifying Reciproc files with special heat treatment. It has been reported that this special treatment causes a decrease in the amount of apically extruded debris as well as the mechanical properties of the file.[19,20] However, more apical extrusion of debris was seen with Reciproc Blue files in this study. The fact that the weight of apically extruded debris in all groups was less than the weights reported in studies with conventional Ni-Ti files may be due to the type of alloy and the cross-sectional design of the files.[21,22]

Contradictory results have been reported on the kinematics of movement and debris extrusion. Some studies have pointed out that reciprocal movement causes more debris extrusion than rotation,[6,23] while some studies report contrasting results.[24,25] In this study, the least apical extrusion of debris was observed in the T-endo mis file, which has the smallest taper and used rotary movement among the other experimental groups which used reciprocation movement. This result is parallel with previous studies showing more apical debris extrusion with reciprocating files than with other file systems operating with rotational motion.[15,17,26,27] The current meta-analysis showed that using the single-file rotary systems compared with the single-file reciprocating systems had a slightly lower amount of debris.[28] Although the rotary system files used in this study contained many files, they still caused the least amount of debris extrusion. In another current study, single file systems working with rotary and reciprocal motion were compared, again, less debris extrusion was observed in the rotary system.[29] However, in our study, the amount of apically extruded debris with Reciproc Blue was lower than in previous study results.[17] This difference may be caused by limitations such as the pressure applied by the operator can affect the amount of dentin extruded from the apical.[30] Since the pressure created by the operator may affect the amount of apically extruded debris, all procedures in this study were performed by a single operator. The fact that T-endo must causes less apical debris extrusion may be due to the design of the file and the taper of files.[17,31] Onalan and Oztekin[31] showed in their study that the amount of apically extruded debris increased as the file taper increased. In our study, the most extrusion of debris was observed in the Reciproc Blue file with 0.8 taper and the least extrusion in the T-endo mis file with 0.4 taper. Due to the greater tapered file and the increased canal diameter causing more debris production, it can also affect the amount of debris extrusion from the apical.[21] Since the tapers of T-must endo and Reciproc Blue files, which were used with reciprocation used in this study, were higher than the tapers of the T-endo mis files which were used with rotation. It cannot be predicted whether the amount of apically extruded debris is due to the kinematics of files or the taper of the files. This is the limitation of our study. However, the fact that the amount of debris extruded from the apically in the Reciproc Blue group, which is one of the two files working with reciprocation, was higher than the T-endo must group, suggesting that the increased taper affected the amount of debris. Therefore, comparing files with the same taper angle and apical diameter operating with rotation and reciprocation in future studies may provide a clearer explanation of the effect of kinematics.

One of the factors affecting the amount of extruded debris from the apical foramen is the diameter of the apical foramen. As the diameter of the apical foramen increases, the amount of extruded debris increases.[32] The standardization of the first apical diameter was achieved by shaping the apical foramen of the samples with #15 K file before the experimental set up was set up. Abou-Rass *a*nd Pinocchio[33] reported that if the irrigation needle can be placed in the apical third, #25 apical gauges provide adequate root canal disinfection. Therefore, we used items with an apical diameter of gauge #25 file. The amount of apically extruded debris is usually determined by the method described by Myers and Montogemery.[13] We also used this method to compare with other studies in the literature, but the limitation of our study is that this method does not simulate periapical tissues. The resistance created by the periapical tissues affects the amount of extruded debris

apically in clinical situations.[34] Some studies used floral foam[35] and agar gel to simulate the clinical situation.[36] However, the density of the floral foam is lower than that of the periapical tissues and may absorb some debris. The density of the agar gel is closer to the density of the periapical tissues.[36] However, agar gel was not used in this study. Further studies can evaluate the effect of agar gel on the amount of extruded debris. Since no other studies have previously examined the amount of apically extruded debris of T-endo must and T-endo mis files, we can not make a direct comparison.

The amount of apically extruded debris from file systems with small tapers and different motions can be evaluated in future studies which better simulate periapical tissues.

Conclusion

As the taper of the file used during root canal shaping gets smaller, the amount of apically extruded debris decreases. In addition, the kinematics of the file affects the amount of apically extruded debris. In this study, rotational motion caused less debris extrusion than reciprocal motion.

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T-endo must, T-endo mis ve Reciproc Blue kanal eğeleri ile kanal şekillendirmesi sırasında apikalden taşan debris miktarının karşılaştırılması

Özet

Amaç: Bu çalışmanın amacı, rotasyon ve resiprokasyon hareketi ile çalışan farklı koniklik açılarına sahip nikel titanium eğe sistemlerinin apikalden taşan debris miktarına etkisini karşılaştırmaktır.

Gereç ve Yöntem: Çalışma Myers ve Montgomery modeli kullanılarak yapıldı. Kırk beş insan üst kesici diş önceden tartılmış Eppendorf tüplerine yerleştirildi ve anatomik apeksten 1 mm kısa çalışma boyu olacak şekilde Grup 1: Reciproc Blue (Easy In Smile, New Jersey, ABD); Grup 2: T-endo must (Dentac, İstanbul, Türkiye), Grup 3: T-endo mis (Dentac, İstanbul, Türkiye) ile şekillendirildi. Kök kanalları 10 mL %2.5 NaOCl, %17 EDTA ve distile su ile irrige edildi. İçerisinde debris olan tüpler 7 gün boyunca 70 °C inkübatörde bekletildi. Tüplerin son ağırlığından ilk ağırlıkları çıkarılarak apikalden taşan debris miktarları elde edildi. Veriler, tek yönlü ANOVA ve Tukey çoklu karşılaştırma testi ile değerlendirildi (α=0,05).

Bulgular: Grup 1'de 0.0094±0.0015 g, grup 2'de 0.007±0.0012 g ve grup 3'te 0.0044±0.0010 g debris görüldü. Tüm gruplar arasındaki fark istatistiksel olarak anlamlı bulundu ($p<0.05$).

Sonuç: Apikalden taşan debris miktarı, kullanılan eğenin koniklik açısı ve eğenin kinematiği ile ilgilidir.

Anahtar Kelimeler: Apikal foramen; endodonti; kök kanalını hazırlama; kök kanal tedavisi