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Comparative Evaluation of the Effect of Different Rotary Instrument Systems on the Amount of Apically Extruded Debris

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ABSTRACT

Objectives: The purpose of our study is to examine in vitro the amount of debris extrusion from the apical after root canal preparation with different rotary instruments.
Materials and Methods: In the present study, 60 single roots single-canal lower premolar human teeth were used. The teeth were randomly selected and divided into 4 main groups (n=15). Root canals are shaped by using 2Shape, One Curve, and XP-3DEndo Shaper working in rotational motion and WaveOne Gold working in reciprocal motion. Later, the weight of each eppendorf tube was weighed on a precision scale and the amount of debris extrusion from the apical was determined with 10¯4 precision by subtracting the empty weight of the tube. Since the parametric test assumptions were fulfilled in the evaluation of the data obtained regarding the amount of debris extrusion from the apical of file systems by loading them into the SPSS 22.0 program, One-Way Variance analysis was used and the level of error was taken as 0.05.
Results: When the amount of debris extrusion from the apical is ordered from high to low, it was seen that there are 2Shape, One Curve, XP-Endo Shaper, and WaveOne Gold. However, the difference between study groups was not statistically significant.
Conclusions: Considering the results obtained in terms of debris extrusion from the apical about the new generation files with different metallurgy, kinematics, structural features, designs, and different configurations that we used in the present study, it was seen that these systems would not show any difference in terms of the effect of debris on the success of endodontic treatment.

Keywords: Root Canal Treatment, Debris Extrusion, Rotary Systems, Endodontics, Endodontic Treatment

Hastabaşı CAD-CAM Blokların Eroze Dentine Makaslama Bağlanma Dayanımı

Süreç

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ÖZ

Amaç: *Çalışmamızın amacı, farklı döner aletlerle kanal hazırlığı sonrası apikalden çıkan debris miktarını in vitro olarak incelemektir.*
Gereç ve Yöntemler: *Bu çalışmada 60 adet tek köklü tek kanallı alt premolar insan dişi kullanıldı. Dişler rastgele seçilerek 4 ana gruba ayrıldı (n=15). 2Shape, One Curve ve XP-3DEndo Shaper rotasyonel hareket ile WaveOne Gold ise resiprokal hareket ile kullanılarak kök kanalları şekillendirildi. Daha sonra her bir eppendorf tüpünün ağırlığı hassas bir terazide tartıldı ve tüpün boş ağırlığı çıkarılarak apikalden çıkan debris miktarı 10¯4 hassasiyetle belirlendi. Eğe sistemlerinin apikalinden debris ekstrüzyon miktarına ilişkin elde edilen verilerin SPSS 22,0 programına yüklenerek değerlendirilmesinde parametrik test varsayımları karşılandığından, Tek Yönlü Varyans analizi kullanılmış ve hata düzeyi olarak alınmıştır. 0,05.*
Bulgular: *Apikalden gelen debris ekstrüzyon miktarı yüksekten düşüğe doğru sıralandığında 2Shape, One Curve, XP-Endo Shaper, WaveOne Gold olduğu görüldü. Ancak çalışma grupları arasındaki fark istatistiksel olarak anlamlı değildi.*
Sonuçlar: *Bu çalışmada kullandığımız farklı metalurji, kinematik, yapısal özellikler, tasarımlar ve farklı konfigürasyonlara sahip yeni nesil eğeler hakkında apikalden debris ekstrüzyonu açısından elde edilen sonuçlara bakıldığında, bu sistemlerin artıkların endodontik tedavinin başarısına etkisi açısından herhangi bir farklılık göstermeyeceği görülmüştür.*

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Anahtar kelimeler: *Kanal Tedavisi, Kalıntı Ekstrüzyonu, Döner Sistemler, Endodonti, Endodontik Tedavi*

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Introduction

One of the most important stages of endodontic treatment is root canal preparation. Chemomechanical preparation made with different root canal files and techniques is the removal of the necrotic or infected pulp tissue, bacteria, toxins, and another immunological removal in the root canal system, as well as shaping the narrowest part of the canal in the apical foramen in a form that narrows from the coronal to the apical.[1] Chemomechanical preparation of the root canal, removal of infected residues can be achieved by mechanical shaping of the root canal and washing with chemical solutions.[2,3]

It has been supported by many studies that the debris extrusion from the apical that can occur during endodontic treatment is closely related to the irrigation agents used, the preparation techniques applied, and the preferred root canal ınstruments.[4-8] It has been determined in the researches that the technique used in root canal preparation, the type and size of the canal ınstruments, the point where the mechanical shaping in the apical area will be terminated, the irrigation method, and the amount of solution used affect the amount of debris extrusion from the apical in different rates.[4,9-14] Also it has been reported that none of the existing preparation systems can shape root canals without apical extrusion.[15,16]

Infected debris extrusion from the apical with the rotary instrument systems used during root canal preparation disrupts the microbial balance and may cause host defense and exacerbations that lead to acute inflammations. However, on account of the different structural features, metallurgy, kinematics, and designs of the new generation files produced, they will be able to minimize the complications that may occur by causing less debris extrusion compared to conventional rotary ınstrument systems.[17]

The purpose of this invitro study is the evaluation of comparatively, examined the amount of debris extrusion from the apical during root canal preparation by rotary instruments with different metallurgy, kinematics, structural properties, and design.

Material and Methods

Selection and Collection of Teeth

In this study, when $\alpha = 0.05$, $\beta = 0.10$, $1-\beta = 0.90$, 15 teeth in total were processed into each group and 60 teeth in total were processed, and in this case, the power of the test was found to be p=0.90919. To be used in the study, 60 pieces of apical development were completed for orthodontic and periodontal reasons and a single apical foramen with a slope less than 15º according to the Schneider method, without caries and restoration, lower premolar human extracted teeth were used.[18] Considering the current approaches, digital radiography was taken from the buccal and approximal surfaces of the teeth and single-rooted, single-canal teeth without any anatomical difference were included in the study.

The hard and soft tissue residues on the root surfaces of the selected teeth were cleaned with the help of a crescent. Teeth were kept in 2.5% NaOCl for 2 hours for disinfection and then kept in distilled water at room temperature until the time of the experiment.

Determination of Working Length of Teeth

All teeth are standardized by occlusal abrasion with the help of a fissure diamond bur under water cooling and the working length is adjusted to 16 mm. Again, the entrance cavities are opened with a diamond rond bur under water cooling. Under a dental microscope (Olympos 4477, Tokyo, Japan); The tip of the K-type file (Mani Inc., Tochigi, Japan) number 15 placed in the root canal is advanced in the canal until the tip can be seen through the major apical foramen and the canal length is confirmed 17mm with a rubber washer, and the working length is retracted by 1 mm and at 16 mm fixed.[19]

Preparation of Experiment Setup

While preparing the experimental setup, the experimental setup developed by Myers and Montgomery (1991) and modified by Tınaz *et al.*[13,20] was used. Teeth by prepared and run lengths determined, by providing suitable perforations in the coronal diameter of the stem to the center of the lid of the Eppendorf tube to remain in the tube when the apices door is closed, placed cyanoacrylate to (Pattex Instant Adhesive, Turkish Henkel, Istanbul, Türkiye) debris extrusion thereby rendered stable is intended to collect here. Each cover is sterilized and numbered after matching the teeth. In order to balance the air pressure inside the tube and the outside air pressure, the 27 G injector needle is placed in the caps so that the tip remains in the tube.

The tooth-cannula-cap unit was placed in the eppendorf tube and the excess fluid in the tube was ejected through the cannula. The eppendorf tube, whose initial weight was measured, was then mounted to the 15 cc bottle to hold the unit during the operations, thus preventing possible contact with the eppendorf tube and preventing any residue that would increase its weight. To prevent the extrusion debris from being seen by the physician during the procedures, a 15 cc bottle and plastic part of the cannula are wrapped in aluminum foil. The initial weights of the tubes were measured three times on a precision scale (Precisa, Dietikon, Switzerland) with a sensitivity of 10^{-4} g and averaged and the average weight of each tube was recorded.

Creating Working Groups and Shaping Root Canals

Teeth standardized in terms of root curvature, apical foramen widths, and working lengths were randomly selected as 15 in each group. 4 working groups were formed to use different rotary tool systems in each group;

Group 1: 2 Shape (Coltene micro mega, Besançon, France)

Group 2: One Curve (Coltene micro mega, Besançon, France)

Group 3: WaveOne Gold (Dentsply Maillefer, Baillagues, Switzerland)

Group 4: XP-3D Endo Shaper (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland)

Group 1: 2 Shape

Before starting to shape, working length was checked with K-type file number 15. The files were used in the form of 3 waves with an up-down progressive movement, at a speed of 250-400 rpm in continuous rotation, and the torque was adjusted to be 2-2.5 N.cm. The rotary was placed in the root canal until resistance was felt in the file and 2/3 of it was shaped by removing the initial resistance areas by using a circumferential brushing motion. It consists of 2 Shape, TS1 (0.4 taper, number 25) and TS2 (0.6 taper, number 25) shaping instruments and the instruments were used in the canals respectively.

Group 2: One Curve

The full length has been progressed with 8 and 10 files in the One curve system. Then, before starting the shaping, the working length was checked with a K-type file number 15. With continuous rotation, the endo motor was shaped so that its speed was 300 rpm and the torque was 2.5 N.cm. The coronal part was enlarged with the One Flare in the set. One curve was prepared by creating a leading canal path with a working length with a One G glide path. One curve preparation was made with a direct downward movement up to the working length in continuous rotation at the specified speed and torque.

Group 3: Wave One Gold

In shaping with Wave One Gold files, the Wave One Gold mode was used at a speed of 300 rpm and a torque of 2 N.cm. Working length was checked with no 15 K type file before starting to shape. Root canals were shaped using Small and Primary files in accordance with the manufacturer's instructions. The shaping was made by reciprocating movement (150° counterclockwise, 30° clockwise). Styling is terminated with Wave One Gold Primary.

Group 4: XP-3D Endo Shaper

Working length was controlled with 10 and 15 K-type files in the XP-3D Endo Shaper system. The instrument was operated with a speed of 800-1000 rpm and the endo motor adjusted to 1 N.cm of torque. In accordance with the manufacturer's instructions first before proceeding until after a maximum of 5 seconds along the longitudinal study was conducted within the channel 15 additional strokes.

During shaping, the canals were washed with distilled water at every exit of the file from the canal mouth or after every three back and forth movements. In total, irrigation was performed using 10 ml of distilled water for each sample. In all groups, root canal shaping was performed by a single operator, following the manufacturer's instructions and using the X-Smart Plus (Dentsply, Maillefer, Ballaigues, Switzerland) endodontic motor.

Identification and Measurement of Extrusion Debris

After the shaping was completed, the lids of the eppendorf tubes were opened and the root surfaces of the teeth were washed with 1 ml of distilled water so that the adhering debris residues were collected into the tube. Thus, debris residues stuck on the root surface were also collected in the tube. The tubes were then placed in the incubator with their mouths open. The tubes were kept in a dry oven at 37°C until the distilled water evaporated completely. After the liquid evaporated, in order to determine the amount of extrusion debris, the tubes were weighed three times on the digital scale where the first measurements were made with a sensitivity of 10^{-4} and the average values were calculated and the measurements were recorded. The difference between the initial weight of the Eppendorf tube and the weight measured after preparation was recorded as the amount of extrusion debris.

Statistical Evaluation

Since the parametric test assumptions were fulfilled in the evaluation of the data by loading the data obtained in the present study into the SPSS 22.0 program (Kolmogorov-Smirnov) when comparing the measurements obtained from more than 2 independent groups, One-Way Variance analysis was used and the level of error was taken as 0.05.

Results

When the weight of the tube and the amount of debris were measured together, the difference between the groups was found to be insignificant ($p>0.05$) (Table 1). Although the difference between groups is statistically insignificant, when the total amount of extrusion debris with the weight of the tube is examined from maximum to minimum; 2 Shape, One Curve, XP-Endo Shaper, and Wave One Gold.

In addition to this result, when the rotational rotary instrument systems were evaluated within themselves, it was determined that the maximum extrusion was 2 Shapes, while the least extrusion was the XP-Endo Shaper.

Table 1. Extrusion Debris Amounts

		n	Average	Standard Deviation	Result
Tube Weight and Amount of Debris	2 Shape	15	0.7207	0.0097	F=2.48
	One Curve	15	0.7153	0.0099	P=0.070
	Wave One Gold	15	0.7122	0.0086	
	XP-Endo Shaper	15	0.7136	0.0083	
Amount of Overflowing Debrice	2 Shape	15	0.022893	0.0097	F=2.50
	One Curve	15	0.017420	0.0099	P=0.069
	Wave One Gold	15	0.014333	0.0086	
	XP-Endo Shaper	15	0.015713	0.0082	

Discussion

The success of endodontic treatment depends on accurate diagnosis, effective dissolution of root canals, disinfection, and a tight apical and coronal occlusion data filling.[2] Success in root canal preparation depends on the length of the root canal, the type of tooth used, the width of the root canal, the curvature of the root canal, the size of the minor and major diameters of the apical foramen, the irrigation solution and method used, the kinematics and design of the root canal tools, the distance of the apical border of the preparation to the apical foramen, the design of the instrument used. may vary depending on the amount of debris extrusion from the apical.[11,12,21-26]

In the present study, two systems with rotational and reciprocal movements were chosen as the rotary tool systems we preferred. While the 2 Shape, One Curve, and XP-Endo Shaper rotary tool systems are rotational moving systems, the Wave One Gold system is included in the present study as a reciprocating rotary file system. Crown-down shaping method has been used in all rotary ınstrument systems in accordance with the recommendations of the manufacturers.

It has been observed that the method used during root canal preparation in rotary file systems has an effect on debris extrusion from the apical. Considering all these studies, this method was also preferred in the present study because of the advantage of the Crown down method, which reduces the amount of debris extrusion from the apical by shaping a part of the coronal region first and then gradually descending to the apical.[14,27]

From the studies carried out using files with different cones in the production of rotary ınstrument systems; In a study by Kuştarcı *et al.*[8], It was observed that the ProTaper Universal file system with a larger taper angle caused significantly more debris extrusion than the K3 file system. In the study of Pedrinha *et al.*[28,29], It was seen that WO (0.08) carries more debris than WOG (0.07). Contrary to our work, these studies have shown that files with larger taper angles carry more debris. In both studies, rotary files with reciprocal motion were compared among themselves, and ın present study, rotary file systems with different kinematic features were evaluated together. At the same time, while the file systems developed with Gold Wire used in the present study have exactly the same properties, it has been observed that other file systems developed with M Wire have different structural features. Accordingly, the main difference is that the XP-3D Endo Shaper, which has been developed with M-Wire heat treatment in the same way as the studies described above, has a different design (Booster type design / Adaptive core technology), and its S-shaped design is suitable for the expansion and contraction of the walls. We think that it arises due to its structural and design advantage, which enables the formation of less debris than files with more taper by abrading dentin evenly from the walls.

When other studies using files with different cones in the production of rotary instrument systems are evaluated, In a study conducted by Haridas *et al.*[30], It was observed that Wave One Gold (0.07) had a higher taper than Protaper Next (0.06), but it caused less debris extrusion. In the study conducted by Zan *et al.*, During root canal preparation of PTG (0.08) and WOG (0.08) rotary file systems, it was less than K3TMXF (0.06), OSNG (0.06), and TFA (0.08). It has been observed to carry an amount of debris.[31] Considering these studies, it was seen that, unlike other studies, the effect of the taper angle on the debris extrusion from the apical was not significant. Similar to these studies, in the present study, the Wave One Gold (0.07) with the highest taper angle carries the least debris, then the 2nd least debris is compared to the XP-3D Endo Shaper (0.04), without showing a correlation depending on the taper angle, 3. The least debris has One Curve (0.06) and the 4th most debris extrusion is shown by the 2 Shape (0.06) file system having the same taper angle. Although it is not statistically significant, this difference between the debris extrusion amounts is not due to the difference in the taper angle, but due to the metallurgical advantages of the rotary file systems used by different heat treatments such as T-Wire, C-Wire, M-Wire, and Gold technology, provided by increased flexibility. In addition, the amount of debris extrusion from the apical was found to be different due to the triple helix, variable, convex triangle, parallel side cross-section, and different knife-file designs.

When looking at the studies on the use of rotary file systems used for root canal preparation with different kinematics; As a result of the study conducted by Bürklein *et al.*[32], the most debris extrusion amount was seen in the Reciproc group, but no significant difference was found between the other groups. In the study conducted by Şerefoğlu *et al.*[33], It was revealed that the Reciproc group carried significantly more apical debris than the PTU-R and R-Endo rotary file systems during the preparation of seriously curved root canals, except for the H file system where manual preparation was made. In our study, it was observed that the reciprocating system caused less debris extrusion than the rotational movement systems. This different result causes different teeth selected in the studies, the flexibility provided by the production of rotary file systems with T-Wire, C-Wire, and Gold technology and heat treatment, with the 2-blade design with a parallelogram cross-section, causes less debris extrusion from the apical with the increase of the area created to carry the debris coronally and We think it depends on the use of different preparation procedures.

When looking at other studies on the use of rotary file systems used for root canal preparation with different kinematics; In a study by Haridas *et al.*[30]; The instrumentation technique with reciprocating motion has been shown to carry less debris compared to continuous rotation and backward- forwards motion. In a study by Silva *et al.*[34], They compared reciprocal (WaveOne and Reciproc) and rotational (ProTaper Universal and ProTaper Next) file systems and observed that the most debris extrusion was caused by the ProTaper Universal system. Although there is no significant difference between other systems, Reciproc showed the least debris burst. In the preparation performed with the Wave One Gold with reciprocal

movement, as in these studies, the preparation made with the rotational movement with 2 Shape, One Curve, and XP-Endo Shaper instrument systems was supported by the data with less debris extrusion than the preparation made with 2 Shape, One Curve and XP-Endo Shaper instrument systems. By its design, the off-center design of WOG due to its parallel cross-section and its friction-reducing two-blade design, with only one cutting edge in contact with the canal wall, the file attaches less to the canal wall and creates more space to move debris coronally creating more space to carry debris coronally during root canal treatment. Helped to minimize the amount of debris. We also think that the reciprocal movement is due to the fact that it moves with a pressure that imitates the known balanced force technique and removes less debris from the apical.[35]

Since it is thought that the metallurgical properties of the rotary instrument systems used during root canal preparation may affect the amount of debris extrusion from the apical, the studies should be evaluated. According to this; In a study conducted by Surakanti *et al.*[36], when the amount of debris extrusion from the apical during root canal preparation was evaluated, it was observed that the WaveOne and ProTaper rotary file systems were significantly higher than the Hyflex CM rotary file. In a study by Bürklein *et al.*, One file system with reciprocal movement Reciproc, a single file system with rotational motion F360 and OneShape were compared with the Mtwo system, which is a rotationally moving multiple file system, in one of the studies of apical extrusion. As a result of the study, while the amount of debris extrusion was mostly seen in the Reciproc group, no significant difference was found between the other groups.[32] When the metallurgical properties of the files used in the studies were examined, it was seen that the files developed with M-Wire and CM-Wire heat treatment technologies were used and the files developed with M-Wire technology carried more debris. Considering the metallurgical properties of the files in the present study, it was seen that the file system developed with Gold Wire technology carries less debris than the M-Wire system in preparations made using files developed with T-Wire, C-Wire, M-Wire, and Gold heat treatment and technologies. In this case, the flexible structure of the Gold file system and the double blade design, which reduces friction, cause a decrease in the amount of apical debris. In addition, although they were developed with similar heat treatment technologies such as M-Wire, according to Resiproc and Wave One, the XP-3D Endo Shaper used in our study was produced with adaptive core technology due to its superelastic feature, causing less pressure, and dentin evenly and in a small amount from the walls. We think that it causes less debris extrusion due to its removal.

There is an important study revealing the effect of metallurgical properties of rotary instrument systems used during root canal preparation on the amount of apically extruded debris. In a study by Sarıçam *et al*., the roots were randomly divided into 3 groups in the study: OneShape; One Curve; and 2Shape. It has been observed that the amount of extrusion debris produced by the One Curve rotary tool system is similar to that produced by the One Shape system and lower than that of the 2 Shape system.[37] In the present study, when the amount of debris extrusion from the apical during root canal preparation, like those of Sarıçam *et al.* It was observed that One Curve carried less debris than 2 Shape. This is due to the use of the glide path in preparation according to the manufacturer's instructions in One Curve, the use of a single file, the patented variable cross-section along the blade, its design, metallurgical (C-Wire technology) structure different from 2 Shape (T-Wire), especially in the apical. It is thought that the amount of debris extrusion as a result of the decrease in the pressure created on the canal walls causes less debris amount to extrusion than the apical compared to 2 Shape.

In the study conducted by De-Deus *et al.*[38], when looking at the amount of debris carried by single and multiple file systems from the apical during root canal treatment of teeth divided into 3 groups G1 (ProTaper), G2 (Wave One), and G3 (Reciproc); It has been observed that there is no significant difference between two single-file systems and they carry less debris than the multiple file system. In the present study, Wave One Gold, in which two files are used, caused the least debris extrusion, while the most debris extrusion was seen in 2 Shapes where two files were used, and the amount of debris extrusion was seen in single file systems was among these systems using two files. In the present study, as in the study of De-Deus *et al.*, single and multiple systems were evaluated together with different kinematics. However, the different results obtained from our study can be attributed to the different types of teeth selected in the study and the lack of a large difference between the number of files used. At the same time, while M-wire heat treatment technology was used in the above-mentioned study, we think that the superior features such as the reduction of friction with less pressure to the apical due to the more flexible file produced with Gold Wire technology depend on the prevention of the number of files.

In the study of Bürklein *et al.*[32], no difference was found between single and multiple rotary file systems and the amount of debris extrusion from the apical after preparing the root canals. In the study of Özsu *et al.*[39], it was observed that the SAF group carried the least debris, and the ProTaper Next and Wave One groups were associated with less debris than the ProTaper Universal group. In the single and multiple file groups, there was no direct ranking in relation to the number of files. Considering the results obtained, systems with different numbers of files as in the above-mentioned studies were used in our study. Considering the results obtained, in our study, while Wave One Gold, in which two files were used, caused the least extruded debris, the highest extruded debris was observed in 2 shapes using two files, and the amount of extruded debris seen in single file systems was determined by this study. The fact that it is among the systems has shown that there is no direct proportional distribution with the number of files. Accordingly, when the studies mentioned above are evaluated, we think that the use of single or multiple file systems during root canal treatment does not have a direct effect on debris extrusion from the apical if the difference

in the number of files is not too much, but the effect may be minimal. We think that the minimal amount of extrusion debris increases the amount of debris removed from the canal walls during the use of systems with a higher number of files in continuously rotating file systems, in parallel with the number of files. However, in cases where there is a large difference in the number of files, we think that the amount of debris extrusion from the apical may be higher due to the longer preparation time with the file in root canal preparation made with the rotary file system.

In our study, 2 Shape, One Curve, XP-3D Endo Shaper, and Wave One Gold rotary file systems used in root canal preparation were used together for the first time in a study, we believe that the results obtained in this context can be very useful.

Conclusions

Considering the results between the new generation file systems, it is thought that these systems, which have different metallurgical and structural features, different designs, and different kinematic features and configurations, have advantages that can affect the long-term success of root canal treatment. In the light of this information, we think that endodontic treatment should be started by choosing the most ideal file system suitable for the diagnosis and structural characteristics of the tooth to be treated, considering the superior properties of different new generation files.

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Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors. This experimental study was conducted in conformity with the principles set forth in the WMA Statement on Animal Use in Biomedical Research.

Conflict of Interest

The authors declare that they have no conflict of interest.

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