Comparison of the Amount of Debris Extruding from the Apical in Teeth Using Nickel Titanium File Systems with Different Taper Angles with Rotation Movement

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Abstract

Background: The aim of this study is to compare the amounts of debris extruding from apical of nickel titanium file systems with different taper angles that make rotation movement.
Materials and Methods: Sixty mandibular premolar, round, never having had endodontic treatment before, non-fractured teeth, the apex of which were fully formed, having a root canal were selected. Care was taken so as to ensure that the selected teeth were of similar length and dimensions. It was confirmed that the teeth have round, single-rooted, non-resorption and having straight canals according to the radiographs from mesiodistal and buccolingual directions. The One-way Anova test was used so as to determine if there was any difference in the amount of debris extruded with respect to the varying taper angles of the file system. The Bonferroni test was used as the Post Hoc test for the paired comparison of the groups.
Results: According to the results obtained, there is a statistically significant difference in the amount of extruded debris between the groups (F=469,279; p<0, 05).
Conclusions: It was determined that while the weight of the extruded debris amount was at the file with the highest 0.6 taper angle (0.031±0.003), it was lowest at the file with a taper angle of 0.2 (0.008±0.002).

Experimental Article (HRU Int J Dent Oral Res 2022; 2(1): 34-40)

Keywords: Debris extrusion; apical foramen; debris; different taper angle**.**

Introduction

The main purpose of root canal treatment is to remove the irritants from the root canal system both mechanically and chemically and to fill and block it in a three-dimensional way to prevent it from becoming infected again (1). The mechanical preparation and irrigation application that generate the biomechanical preparation allow the removal of the microorganisms and necrotic tissues in the root canal (2, 3). The pain that occurs after endodontic treatment is usually caused by mechanical, chemical and microbial factors. These factors are interrelated and directly interdependent (4). One of the causes of the pain is the infected debris extruded from apical during root canal shaping. Furthermore, the extruded infected debris was clinically proven to cause flare-up, postoperative inflammation and apical healing deficiency (5). Exacerbation is characterized by swelling, pain or both pain and swelling during or after endodontic treatment (6). The file systems and the methods of root canal preparation cause the extrusion of debris. Furthermore, the amount of debris extrusion relates to the technique of preparation used, the design of file systems and tip diameter (7).

Ni-Ti rotary file systems are engineered to allow the clinicians to clean and shape theroot canals more efficiently and effectively (8). In order to simplify the preparation procedure during root canal instrumentation of Ni-Ti files, new systems with different configurations and designs have been developed (9). The Ni-Ti systems with fewer conical and more flexible tools should be used in order to prepare the apical preparations of the canals having complex curvature (10). Depending on the design of the files used on the curved canals or the skill of the physician, there may be loss of study size, apical transportation, zipping formation, disruption of the original canal form or excessive debris extrusion from apical caused by these complications (11).

The aim of this study is to compare the amounts of debris extruding from apical of nickel titanium file systems with different taper angles that make rotation movement. The results of this study will shed light on the clinical practices by providing information about extruded debris, causing exacerbation following the root canal treatment.

Materials and methods

In our study, mandibular premolar teeth extracted for periodontal or orthodontic purposes at the Faculty of Dentistry of Fırat University, with the decision of the ethics committee of Fırat University, with session numbered 2021/13-03, were used.

Care was taken to ensure that the selected teeth were of similar length and dimensions. Sixty mandibular premolar, round, never having had endodontic treatment before, non-fractured teeth, the apex of which were fully formed, having a root canal were selected. Care was taken so as to ensure that the selected teeth were of similar length and dimensions. Only the teeth with Vertucci type I classification were selected. It was confirmed that the teeth have round, single-rooted, non-resorption and having straight canals according to the radiographs from mesiodistal and buccolingual directions. The selected teeth were divided into three groups with twenty each. Canal preparation was completed with three files having different taper angles (Figure 1) for these groups (Table 1).

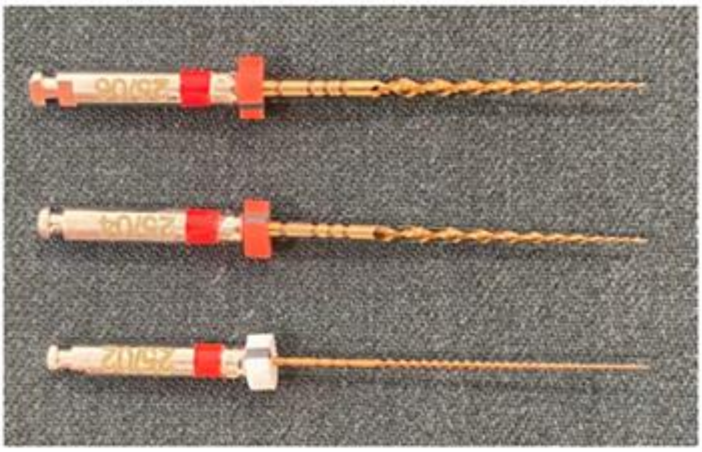

Figure 1. The three different files used in the study.

Table 1. The files used in the study and their characteristics

The files used in the study	Manufacturer	Alloy	Size and Taper
EndoArt Touch Gold Files	(Incidental, Istanbul,Turkey)	GOLD	#25/0.06
EndoArt Smart Gold Files	(Incidental, Istanbul,Turkey)	GOLD	#25/0.04
EndoArt Smart Gold Files	(Incidental, Istanbul,Turkey)	GOLD	#25/0.02

Preparation of the Canal

Coronal access was done with 1014HL round diamond drill (KG Sorensen, Cotia, SP, Brazil) and Endo-Z drill (Dentsply Sirona, York, PA, USA). In order to standardize the apical orifices of all groups, nail polish was applied to the apical orifice and an artificial foramen was generated by hand file in all samples. The apical orifice was confirmed by placing gauge 10 K-file in the root canal until the end of which was visible in the apical foramen and the study size was set as 1.0 mm shorter than this measurement. Each tooth was prepared with Ni-Ti rotating tool files in its group. Each time, the files used in the preparation were removed from the root canal and cleaned with a sterile sponge. After each file use, the teeth were irrigated with 2.5% NaOCl and the orifice was checked by using the gauge 15 K-file in the apical foramen. In all groups the root canals were irrigated with 30-G Endo-Eze needles (Ultradent Products Inc., South Jordan, UT, USA) located 3 mm above the apical foramen, with a total of 10 mL 2.5% NaOCl. The final irrigation was done with 2 mL NaOCl and then with 2mL 17% ethylenediaminetetraacetic acid for 1 minute and 2mL NaOCl. All root canal instrumentations were carried out by a single operator that received three years of specialized endodontics training. Each tool was used for a single tooth and then was thrown away.

EndoArt Touch Gold Group (0.6 Taper)

The tools were operated with a VDW Silver motor (VDW GmbH, Munich, Germany) at 300-350 rpm with 2.5 Ncm torque according to the instructions provided by the manufacturer. First, root canals were washed with 2 mL 2.5% NaOCl, then root canals were prepared with gauge 15 K-file and were irrigated again with 2 mL 2.5% NaOCl. The root canals were instrumented with approximately 2-3 mm slight inward and outward pecking action by using (10/0.06), (15/0.06), (20/0.06) and (25/0.06) files, respectively, three times .

EndoArt Smart Gold Group (0.4 Taper)
Each tool was operated with a VDW Silver motor (VDW GmbH, Munich, Germany) at 300-350 rpm with 1.8 Ncm torque according to the instructions provided by the manufacturer. Root canals were prepared with gauge 15 K-file after irrigation with 2 mL 2.5% NaOCl. Then, another 2 mL of 2.5% NaOCl was used. The root canals were instrumented with approximately 2-3 mm slight inward and outward pecking action by using (10/0.04), (15/0.04), (20/0.04) and (25/0.04) files, respectively, three times.

EndoArt Smart Gold Group (0.2 Taper)
Each tool was operated with a VDW Silver motor (VDW GmbH, Munich, Germany) at 300-350 rpm with 1.8 Ncm torque according to the instructions provided by the manufacturer. After irrigation with 2 mL 2.5% NaOCl, root canals were prepared by gauge 15 K-file as in the other groups. Then, another 2 mL of 2.5% NaOCl was used. The root canals were instrumented with approximately 2-3 mm slight inward and outward pecking action by using (10/0.02), (15/0.02), (20/0.02) and (25/0.02) files, respectively, three times.

Collection of the Amount of Debris Extruded from the Canal
A previously described assembly was adopted in this study so as to collect the extruded debris. The prepared experiment assembly schema for this study was given in Figure 2. Each sample was secured to the cover of an Eppendorf tube through a premade special hole with the apical 5 millimeters section in the tube and the coronal side out. The orifice between the sample and the Eppendorf tube was filled with Top Dam (FGM, Joinville, SC, Brazil). Subsequently, the Eppendorf tube was turned over and the bottom was cut off. An orifice was generated through which 1.5% agarose gel was poured until the apical root was completely covered. The assembly remained in the same position until the gel solidified. Agarose gel provided a matrix in order to collect debris (12) (figure 2).

Statistical Analysis
In the study, SPSS 23 statistical program was used. Before the analyses, the normal distribution was checked, and it was considered appropriate to perform a parametric test by assuming that the distribution was normal because the skewness kurtosis values were in the range of -2, +2 and the sample size was suitable for conducting a parametric test. The statistical significance was regarded as 0.05 in the study. The One-way Anova test was used so as to determine if there was any difference in the amount of debris extruded with respect to the varying taper angles of the file system. The Bonferroni test was used as the Post Hoc test for the paired comparison of the groups.

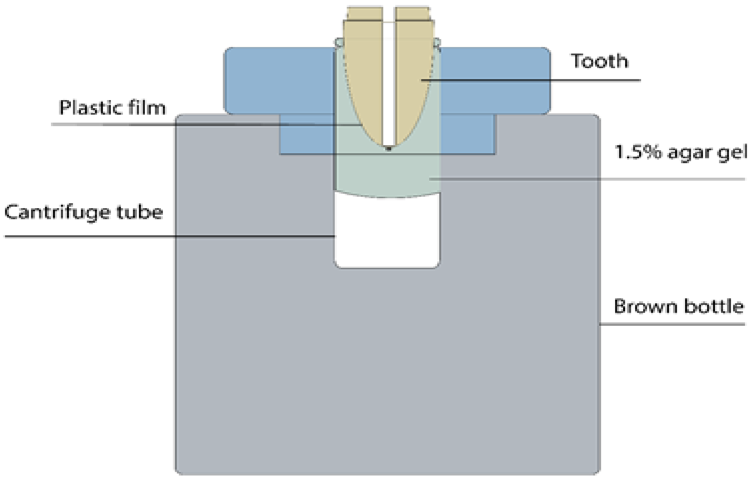

Figure 2. The prepared experiment assembly schema.

Results

According to the results obtained (Table 2), there is a statistically significant difference in the amount of extruded debris between the groups (F=469,279, p<0, 05). It was determined that while the weight of the extruded debris amount was at the file with the highest 0.6 taper angle (0.031±0.003), it was lowest at the file with a taper angle of 0.2 (0.008±0.002). It was determined that there was a debris extrusion in all the samples evaluated within the scope of the study. The Bonferroni test was used as the Post Hoc test for the comparison of the groups. In the Post Hoc test conducted, it was determined that there was a statistically significant difference between each other in the paired comparisons of all the groups (table 2).

When compared statistically, it was determined that there was a difference between 0.6 taper file and 0.4 taper file (p<0.05). It was also established that the amount of extruded debris from 0.6 taper was higher. It was found out that there was a difference when 0.6 taper file was compared statistically to 0.2 taper file (p<0.05). It was determined that the amount of extruded debris was higher at 0.6 taper. When a statistical comparison was made between 0.4 taper and 0.2 taper files, it was determined that there was a difference between them (p<0.05) and that the amount of extruded debris was higher at 0.4 taper (Figure 3).

Table 2: Comparison of the distributions of the amount of extruded debris according to the file systems groups.

	N	Mean ± S.D.	Min.-Max.	F	p
0.6 Taper Angle	20	0,031±0,003	0,025-0,038		
0.4 Taper Angle	20	0,011±0,002	0,008-0,017		
0.2 Taper Angle	20	0,008±0,002	0,004-0,013	469,279	0,001

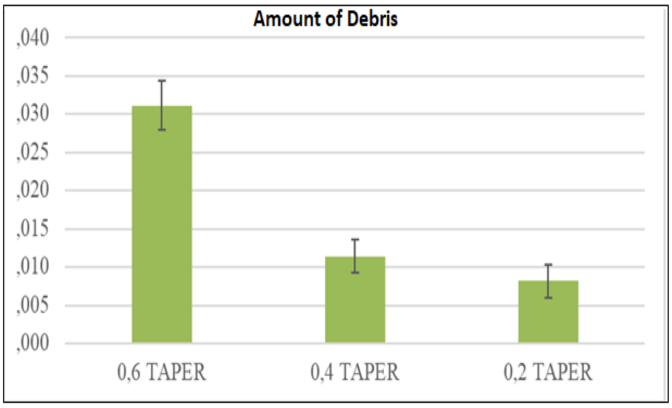

Figure 3. Comparison of the distributions of the extruded amount of debris according to file system groups.

Discussion

The purpose of root canal treatment is to eliminate bacteria and their products, as well as necrotic tissues and pulp residues in the canal and to ensure the related tooth functions as required in the mouth (13). The biomechanical preparation that includes mechanical preparation and irrigation is one of the most important stages of endodontic treatment in removing the microorganisms and necrotic tissues present in the root canals (2, 3). Despite the attention paid to the biomechanical preparation, the studies carried out have demonstrated that the irrigation solutions used, the pulp and dentine residues and infected debris extrude from apical to the tissues (14, 15).

The causes of the inflammatory response in the apical region are the loss of size of the study, depletion of apical obturator or extrusion of necrotic debris, various irritants, tissue residues and microbial products in the root canal due to various iatrogenic reasons (16). Such variables as the design and the number and size of the files used, preparation technique and kinematics may affect the amount of the debris (17). Our study assessed the debris extruding amounts of Ni-Ti files designed at different taper angles.

According to Schneider, the root file classification is as follows: The roots of less than 5° are considered flat while the roots of 10°-20° are considered medium and the roots of 25°-70° are considered significantly curved. It was determined in a study that the roots with a significant degree of inclination extrude more debris than the flat roots (18). However, in a study carried out by Leonardi et al., no statistically significant difference was determined when the amounts of debris extruding from the flat and moderate curved roots were compared (19). Another study indicates that curved canals do not affect the amount of debris extruded from apical (20). In our study, single-rooted, flat-canal teeth were used so as to prevent non-standardized preparation, irrigation or loss of study size in curved canals.

Proper determination of the working height in root canal treatment is crucial for the success of endodontic treatment. Incomplete determined study size may lead to the fact that there are areas in the root canal that are not disinfected, as well as leading to extrusion of the debris, damage to the periapical tissues or extrusion of irrigation solutions. The narrowest part of the root canal is called apical narrowing. The optimal treatment limit of canal treatment should end in apical narrowing at 0.5 or 1 mm coronal of apical foramen (21, 22). A study conducted has shown that the extrusion of the root canal pathway into the periapical tissue or lateral canal used in the treatment of the canal histologically causes foreign body reactions even though it does not produce a clinical symptom (23). In our study, we determined the study size by retracting 1 mm after gauge 10 K-type hand file was visible from apical.

The assembly developed by Myers and Montgomery, which is the most frequently used experimental assembly today, is preferred because it is easy to apply in terms of examining the amount of debris extruded from apical and providing the same conditions in each experimental group (24). Due to the fact that accurate scales are used for the measurement of debris and also on account of the fact that the upper limit that these scales can measure is limited, the teeth were placed in Eppendorf tubes having less empty weights instead of in glass tubes (25). One of the issues to consider when measuring the amount of debris that extrudes from apical is the fact that the oral environment is not completely simulated. Salzgeber and Brilliant reported in their in-vivo study that in the vital teeth, less irrigation solution extrudes to apical tissues compared to necrotic teeth (26). In the literature review, flower foam and agarose gel were used so as to simulate periapical tissue pressure. In a study in which flower foam was used, it was reported that flower foam was determined to absorb extruded irrigation solution and debris, resulting in inaccurate results (27). The density value of 1.5% agarose gel is 1045 kg/ m3, and for human tissues, it is 1000-1100 kg/ m3. Because these values are close to each other, Lu et al., stated that they used agarose gel so as to simulate the apical area better. They also argued that the density formed by the flower foam in the apical area does not meet the density inside the mouth (28).

Acrylic and resin blocks were preferred in some studies examining the amount of debris extrusion in the apical area. However, it was reported that these models do not simulate the three-dimensional structure of the canal, the region of apical narrowing and the irregularities in the canal. Furthermore, the Ni-Ti files used during the canal preparation were indicated to be able to soften the heat inside the resin blocks and affect the results of the study (29).

The file systems in our study were used in accordance with the instructions of the manufacturer, and the tests were carried out by a single researcher in order to ensure standardization in the study.

As the root canal system has complex and variable anatomy, effective cleaning and disinfection is not always available. In general, the root canal preparation is done under irrigation using rotating file systems (30). As the depth of the irrigation needle increases, although the debris extrusion efficiency of irrigation solutions increases, the debris and irrigation solution extruded through the apical also increase (31, 32). In one study, it was reported that the side-vented irrigation needle (side orifice) extruded less debris and irrigation solution through the apical than open-ended conventional needles (27). In order to ensure standardization in our study, a gauge 31 side-vented irrigation needle was used in all test groups.

Abou-Rass et al., specified that if the irrigation needle can reach the apical one- third of the canal, the preparation of the root canals until gauge 25 file can ensure adequate disinfection (31). The files were used as per the manufacturer’s specifications in our study, and the apical enlargements were finished with EndoArt Touch Gold (25/0.6) EndoArt Smart Gold (25/0.4) and EndoArt Smart Gold (25/0.2) file.

The apical width is another factor that affects the amount of extruded debris. Lambrianidis et al., stated in their study that less debris is extruded at the teeth where apical narrowing was maintained than the teeth where apical narrowing enlarged (33). However, in another study, it was indicated that the group the apical orifice of which was 0.2 mm extruded less debris than the group the apical orifice of which was 0.4 mm (34). In some studies, stereomicroscope was used so as to standardize the apical orifice (24). In another study, the size of the apical orifice was measured by hand file (7). In our study, the teeth in which the gauge 15 hand file did not come out of the apical region were selected and the apical orifices of the samples were standardized.

While NaOCl was used in some in vitro studies examining debris extrusion from apical in literature, in some studies the researchers preferred distilled water because they argued that sodium chloride (NaOCl) crystallization would affect the amount of debris extruded from apical (35). In our study, the use of NaOCI was preferred in order to simulate the root canal treatment performed in the clinical setting. Moreover, NaOCI was not removed while determining the amount of debris because the sodium hypochlorite extruded from apical may adversely affect recovery and cause post-treatment pain like debris.

In our study, it was established that all the files with different taper angles that make rotation movement extruded debris to the apical area. The literature review did not reveal any studies on the effect of different taper angles on the amount of debris extruded from apical. The study we carried out has indicated the fact that different taper angles have a statistically significant effect on the amount of debris extruded from apical. While the files with a taper angle of 0.6 had the most debris extrusion, the files with a taper angle of 0.2 had the least debris extrusion. In the in-vitro study, periapical tissue pressure and clinical conditions were not exactly simulated and, thus, it should not be forgotten that these factors may well affect the amount of debris extruded from apical. The extruded debris and irrigation solutions can cause inflammation in the periapical tissue and delay in healing. We believe that the files with less taper angle will extrude less debris into the periapical region and reduce post-treatment pain and flare-up. Further researches are needed to allow comparison on this issue. In the case that the experimental assemblies are developed in which the apical region can be better simulated in subsequent studies, then the results closer to clinic may well be obtained.

Conclusion

According to the results of our study, which was carried out in limited conditions in vitro, the following conclusions were reached : Debris was extruded from apical in all of the compared groups. In the three groups with different taper angles that perform the same movement, there is a statistically significant difference in terms of the amount of debris extruded from apical. The amount of extruded debris from the files with an angle of 0.6 is much greater than that of with 0.4 and 0.2 angle. When the amount of extruded debris is determined, the pressure of periapical tissues is not generated exactly in in-vitro environment. This disadvantage can be eliminated by developing the test assemblies to be used in the studies to be conducted in the future. In our study, Ni- Ti files that make rotation movements with different taper angles were used.

Descriptions

Author Contrubitions : FO: conceived the ideas. FO: led the writing. ACO: collected and analyzed the data.
FO and ACO: design of the manuscript; work with graphic material; editing and processing of the manuscript.

Conflict of Interest : There is no any conflict of interest.

Funding : There is no any funding

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