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Short Communication

Comparison of Apically Extruded Debris Using Neoniti A1, ProTaper Gold, and WaveOne Gold Rotary Files in Mandibular Premolars: An In Vitro Study

Zakiyeh Donyavi[1], Somaye Dehghan Banadkooki[1], Narges Ranjpour[1], Soheil Karimi Mianji[2*]

[1]Department of Endodontics, Clinical Research Development Unit, School of Dentistry, Alborz University of Medical Sciences, Karaj, Iran

[2]Student Research Committee, School of Dentistry, Alborz University of Medical Sciences, Karaj, Iran

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***Corresponding author:**
Soheil Karimi Mianji,
Email: mpvmpv559@gmail.com

Abstract

Background: One of the main stages of root treatment is mechanical preparation, which is performed using manual and rotary instruments with rotational and reciprocal movement. Complete debridement of the root canal in the preparation process is essential for a successful endodontic treatment. This study investigated the amount of apically extruded debris using WaveOne Gold, ProTaper Gold (PTG), and Neoniti A1 rotary files in mandibular premolars.

Methods: As many as 60 mandibular premolar teeth were divided into three equal groups. Each group was prepared with a rotary file (WaveOne Gold, PTG, or Neoniti A1). Then, debris measurements were performed using the Montgomery method, and SPSS v-26 and robust and Brown-Forsythe tests were used for data analysis.

Results: The results showed that the highest and lowest amounts of extruded debris were in the PTG and WaveOne Gold files, respectively. There was a significant difference between the means of the three groups ($P < 0.05$). In addition, to further evaluate the difference, the Games-Howell post hoc test was utilized, demonstrating a significant difference between the means of all three groups ($P < 0.001$).

Conclusion: The findings revealed that all systems extrude debris beyond the apical foramen. The WaveOne Gold system showed the lowest average value of apically extruded debris, followed by Neoniti A1, while ProTaper had the highest average value of apically extruded debris among the investigated systems. Thus, it is recommended that future studies investigate the effects of the properties and characteristics associated with the type of rotary files.

Keywords: Apical debris extrusion, Neoniti, ProTaper Gold, WaveOne Gold

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Background

One of the main stages of root treatment is mechanical preparation, which is conducted using manual and rotary instruments with rotational and reciprocal movement. Mechanical preparation of the root canal system is a major step in achieving a successful endodontic treatment (1). Apical debris extrusion is present in all preparation systems and may extrude debris and fluid through the apex, such as a mechanical piston. Reducing the amount of extruded apical debris is one of the necessities to prevent post-treatment flare-ups. Preparing the channel with one file instead of multi-file systems makes the preparation process easier (2). The recommendation for single use of these files adds the advantage of reducing cyclic fatigue, file breakage, work time, cost, and cross-contamination among patients, a common problem associated with the use of sequential files (3,4). The WaveOne-Gold system is single-file and disposable, used in the reciprocating motion, and made of the M-wire WaveOne (Dentsply Maillefer) tool (5). ProTaper Gold (PTG) is a multi-file system consisting of 3 shaping files (SX, S1, and S2) and 5 finishing files (F1-5), which are utilized in continuous movements (6). Recently, the Neoniti rotary system (Neolix, Châtres-la-Forêt, France) has been introduced to the market. This is a rotary single-file system with a non-homogeneous rectangular section and multiple cones (7). In some studies, apical debris extrusion in sequential systems is significantly higher compared to single-file

rotary systems, because during preparation, the file is placed inside the canal several times and washed, causing more production compared to single-file systems (8,9). In chronic asymptomatic periradicular lesions, there is a delicate balance between infected canal microbes and host defenses. If, during root canal preparation, some amounts of bacteria are extruded apically, this balance is disturbed, which may trigger an acute inflammatory response to re-establish the balance (10). Therefore, minimizing the apical extrusion of debris can minimize the reactions after endo treatment (11). In the last decade, root canal preparation with rotary NiTi systems has become popular; tools with non-cutting tips, different sections, and tapers are available in preparation to improve safety and reduce operating time (12,13). Studies have shown that the step-back technique produces more significant debris than the drive motor and balanced force technique (14,15). In fact, root canal treatment methods make up a significant part of the dental treatments offered in Iran and allow patients to maintain their natural teeth with the same success rate as implant methods (16,17). However, complications such as perforation, transport, and instrument breakage are likely to occur in all its stages, all of which may make it impossible for the dentist to achieve the primary goal of treatment, namely, infection control and treatment and disinfection of the root canal space (18,19). Another unavoidable complication during root canal treatment is the apical extrusion of debris (20). Previous studies have shown that almost all preparation methods are associated with apical extrusion of debris, causing an inflammatory reaction due to the presence of microorganisms in periapical tissues and given the physiopathological phenomena such as increased gene expression of substances, creating endogenous and transmitters (21,22). The occurrence is 40–65% within the initial 24-48 hours and declines to 11% after 7 days (23). As a result, it is necessary to make efforts to reduce the extrusion of debris through the apical foramen (24). This study seeks to investigate the amount of apically extruded debris using WaveOne Gold, PTG, and Neoniti A1 rotary files in mandibular premolars.

Methods

This study is an in vitro experiment. For this purpose, 60 mandibular premolar teeth extracted for orthodontic purposes or periodontal diseases underwent investigation. The teeth were kept in normal saline until use. The access hole was prepared using a diamond fissure bur (No. 837, L 0.016, Teeskavan) in the handpiece at high speed. All samples were measured with endometrium and cut from a height of 12 mm from the apex, and the access hole was obtained using a diamond fissure bur in a high-speed handpiece. Apical measurement was conducted using k-files of sizes 10 and 15. Only teeth with a size 15 K-file that fit the apex and could not pass through the apex (when gently pressed) were used to ensure standardization of the apical size. In addition, the length of the run was determined when the k-file of size 10 was only visible in Apex. Debris was collected using the Myers and Montgomery method. The system that has received the most attention and has been adopted by most studies pertaining to the apical extrusion of debris is the one described by Myers and Montgomery (25). This system consists of a rubber stopper through which the instrumented root is forced and secured, a glass vial where the extruded debris or irrigants are collected, and a flask made of glass into which the vial is placed. A 25-gauge needle is also placed within the rubber stopper to balance internal and external pressures. The debris-collecting apparatus has shown variations in different studies. Empty Eppendorf tubes with plastic caps were weighed 3 times using a digital microbalance to collect the extruded debris. Further, the average weight was taken, and then the teeth were placed on the tube and mounted on a putty to prevent any leakage. This "Eppendorf tube" was utilized (Figure 1), and the teeth were divided into three 20-individual groups. In groups A (G1) and B (G2), the Neoniti A1 file (25, 0.08) and PTG files (25.07, red) X1 and X2 were employed for root canal preparation, respectively. In group C (G3), the WaveOne Gold file (25, 0.08) was applied for root canal preparation.

Canal Preparation With Neoniti A1

The files were used with a speed of 300–500 rpm, a torque of 1.5 N.cm, and a pecking and brush motion. The Neoniti A1 file was utilized passively to prepare the middle and apical areas of the canal. It was washed with distilled water during and after filing. Finally, the file was employed with a pecking motion until the working length was reached and the shaping was completed.

Canal Cleaning With ProTaper Gold

It was cleaned using (X1 and X2) PTG with a torque of 300 N.cm and a speed of 150–350 g per cm. Then, it was washed using 1 mm of additional water. The plastic cap, along with the tooth attached to it, was removed from the Eppendorf tube, and each tooth was placed in its place to be completely dry and measurable within 2 days due to evaporation.

Canal Cleaning Using WaveOne Gold

It was cleaned using a WaveOne Gold file size 25 and 0.08 and washed with 1 mm of extra water. Next, the plastic cap, along with the tooth attached to it, was removed from

Figure 1. Teeth Mounted on Eppendorf Tubes Using Putty

the Eppendorf tube. Each of the teeth was placed in its place to be completely dry and measurable within 2 days due to evaporation.

Final Preparation

All preparation steps were conducted by an operator with an electric motor with torque control (X-Smart Plus Motor, Dentsply, Maillefer, Switzerland, Europe). After the completion of the instrumentation, the final irrigation of the root apex was performed using 1 mL of distilled water to collect the debris stuck to the apex. The plastic cap with the attached tooth was removed from the Eppendorf tube. Then, the distilled water was prepared for weighing by placing the Eppendorf tubes for 2 days and collecting the dried debris without moisture (Figure 2). Each Eppendorf tube was weighed 3 times on a Precisa scale (Dietikon, Switzerland) with an error of 0.001, and a weighted average was taken (Figure 3). The weight of the extruded debris was measured by subtracting the weight of the empty pipe from the debris containing the weight of the pipe.

Inclusion/Exclusion Criteria

The inclusion criteria were (*i*) a newly extracted tooth, (*ii*) canal length of more than 12 mm, and (*iii*) teeth with one canal and one orifice.

On the other hand, the exclusion criteria were (*i*) canal with severe curvature, (*ii*) calcification, and (*iii*) tooth with external or internal root resorption.

Statistical Analysis

The obtained data were analyzed using SPSS, version 26. The normality of the data was confirmed using the *Shapiro–Wilkes test*. The Levene's test showed heterogeneity of variances; therefore, the Brown-Forsythe robust test was used and demonstrated a significant difference between the means of the three groups ($P < 0.05$). For further analysis, the Games-Howell post-hoc test represented a significant difference ($P < 0.001$) in the pair-by-pair comparison of the groups (26,27).

Results

The results of the present study revealed that all three groups had apical debris extrusion. There was a significant difference between the means of the three groups ($P < 0.05$). The WaveOne Gold file produced the highest amount of debris, while the ProTaper file produced the least amount of debris (Table 1). Pairwise comparisons showed the largest difference was between WaveOne Gold and Neoniti A1, whereas the smallest difference was between Neoniti A1 and ProTaper files ($P < 0.001$, Table 2).

Discussion

Mechanical preparation of the root canal is one of the most essential stages of root canal treatment (28). Previously, the preparation was conducted only with the help of manual and non-flexible tools. However, today, rotating and reciprocating nickel-titanium tools have received more attention due to reducing the fatigue of the clinician and saving time (29,30). Unfortunately, until now, all the existing systems may extrude debris based on the geometry of the file and its motion, either rotational or reciprocal (30). These extruded debris may cause severe pain, sensitivity, and even swelling, occasionally leading to treatment failure (31). Therefore, the present study was performed to compare the rate of apical debris extrusion in a laboratory using WaveOne Gold, PTG, and Neoniti A1 rotary files in the premolars of the mandible. The results demonstrated that all three rotary files (i.e., WaveOne Gold, PTG, and Neoniti A1) cause measurable apical extrusion of debris. Thus, the instrumentation technique and the design of tools related to root canal treatment affect the amount of extruded debris (32). The low amount of collected extruded debris in this study may be due to the choice of teeth used, as mandibular premolar teeth with wide canals limit the effect of debris pumping during file insertion, resulting in less apical extrusion of debris. Additionally, narrow canals with less coronal flaring may result in more debris extrusion (33). Reducing the working length by 1 mm from the apical end could also reduce the amount of extruded debris (34). Distilled water was used as the main washing solution for the canal in this study instead of sodium hypochlorite. While distilled water is not the preferred detergent compared to sodium hypochlorite owing to its excellent antimicrobial activity, sodium hypochlorite may produce deposits that increase the weight of the extruded debris, affecting the reliability of the results (35). The WaveOne Gold file in this study exhibited the least extruded debris particles, possibly due to its design with an alternating cross-section, causing only one cutting edge to contact the canal wall and reducing the contact surface between the file and the canal (36). This feature provides more space

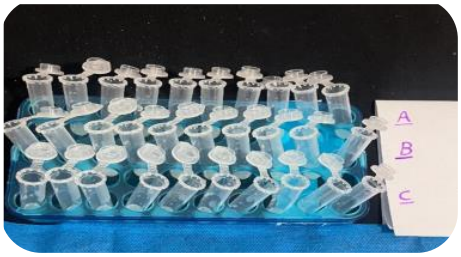

Figure 2. Eppendorf Tubes After Removing Teeth and Putty

Figure 3. Eppendorf Tube Weighed 3 Times on a Precisa Electric

Table 1. Descriptive Statistics of the Weight of Extruded Debris in gram

Groups	Number	Mean	Standard Deviation	Standard Error of the Mean	Minimum	Maximum
Neoniti	20	0.0105	0.0016	0.0003	0.0072	0.0146
WaveOne	20	0.0035	0.0004	0.0001	0.0027	0.0044
ProTaper	20	0.0217	0.0031	0.0007	0.0014	0.0271

Table 2. Games-Hole Post hoc Test Results for Pairwise Comparisons

Groups	File Type	Mean Difference	Standard Deviation	*P* Value
ProTaper	Neoniti	0.0070	0.0003	0.000
	WaveOne gold	- 0.0112	0.0007	0.000
Neoniti	ProTaper	- 0.0070	0.0003	0.000
	WaveOne gold	- 0.0182	0.0007	0.000
WaveOne Gold	ProTaper	0.0112	0.0007	0.000
	Neoniti	0.0182	0.0007	0.000

for coronal extrusion of debris, resulting in less apical extrusion of debris compared to Neoniti A1, which has a gothic-like tip design and internal abrasion properties according to the manufacturer. PTG moves in a continuous rotation, which is supposed to extrude debris in the coronal direction owing to its motion acting as a screw conveyor. However, the design of ProTaper, with an offset that increases the coronal extrusion of debris instead of apical, may produce more debris that may extrude from the apical holes (37). Comparing ProTaper files with WaveOne Gold and Neoniti A1, it is noted that more time is required for preparation with ProTaper, requiring at least two files to complete canal preparation (multi-files), which may increase the chance for the apical extrusion of debris compared to single-file preparation with WaveOne Gold and Neoniti A1. These results align with those of other studies that have demonstrated less debris extrusion with reciprocating tools (38-40).

Recently, Bürklein and Schäfer have reported that the Reciproc system produces more debris than the ProTaper system; they attribute this to the cross-sectional design and cutting efficiency of that tool (41), which contradicts the results of the present study. In the study conducted by De-Deus et al, the ProTaper-F2 tool was used in a normal sequence and in reciprocal or reciprocal motions. The results showed that although the reciprocal motion of F2 has less apical debris extrusion than the normal sequence, this difference is not significant (2). This finding represents that only motion kinetics, such as the balanced force technique, affect periapical debris extrusion. Although the Reciproc has a different design from the ProTaper, it was found that the Reciproc introduced less debris into the canals, which conforms to the results of another study (1).

Conclusion

Our findings revealed that all systems extrude debris beyond the apical foramen. The WaveOne Gold system showed the lowest average value of apically extruded debris, followed by Neoniti A1 and finally ProTaper, the highest average value of apically extruded debris among the intended systems. Accordingly, it is recommended that other studies evaluate the effects of the properties and characteristics related to the type of rotary files, such as stainless steel, nickel-titanium, and newer alloys, on the amount of debris extrusion.

Authors' Contribution

Conceptualization: Zakiyeh Donyavi, Narges Ranjpour.
Data curation: Soheil Karimi Mianji.
Formal analysis: Soheil Karimi Mianji.
Methodology: Zakiyeh Donyavi.
Project administration: Narges Ranjpour.
Software: Soheil Karimi Mianji.
Supervision: Somayeh Dehghan Banadkooki, Zakiyeh Donyavi.
Writing–original draft: Zakiyeh Donyavi, Soheil karimi Mianji.
Writing–review & editing: Zakiyeh Donyavi, Somayeh Dehghan Banadkooki.

Competing Interests

The authors declare no conflict of interests.

Ethical Approval

The present study was presented and approved by the Research Ethics Committee of Alborz University of Medical Sciences (IR-ABZUMS.REC.1402.004).

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