

QUANTITATIVE ASSESSMENT OF THE APICALLY EXTRUDED DEBRIS USING WAVE ONE GOLD AND PROTAPER NEXT IN ROOT CANAL SHAPING

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ABSTRACT

Aim of the study The aim of the present study was to compare the quantity of the debris extruded beyond the apex during root canal shaping with two commonly used endodontic nickel-titanium (NiTi) systems, one in reciprocation and one in continuous rotation. **Material and methods** 12 single-rooted teeth (6 incisors and 6 canines) with a fully formed apex and a single canal in one single root were used, divided into two groups: 3 incisors and 3 canines in Group 1, shaped with the WaveOne Gold (WOG) system (Dentsply Sirona), and another 3 incisors and 3 canines in Group 2, shaped with the ProTaper Next (PTN) system (Dentsply Sirona). All teeth were shortened to an overall length of 19 mm before shaping. The extruded debris during shaping were collected in 12 Eppendorf tubes and weighed, using the Montgomery and Myers method. The quantity of debris was calculated subtracting the weight of the empty tubes from the weight of the tubes after shaping. Three measurements were ensured for each sample before and after instrumentation, and the mean value was used for statistical analysis. **Results** After shaping with WaveOne Gold, the weight of the debris extruded beyond the apical foramen was higher compared to ProTaper Next. **Conclusions** Although quantitative differences between the two shaping systems existed, no statistically significant differences between them were observed.

Key words: nickel-titanium instruments, reciprocation, rotation, apical debris, extrusion

INTRODUCTION

Endodontic therapy plays a crucial role in modern dentistry. It is a complex sequence of procedures designed to address various dental problems, ranging from urgent cases caused by deep cavities complicating with pulp damage to the endodontic therapy of anterior teeth before prosthetic work. It is recommended in numerous scenarios, where dental caries or trauma leads to the irritation, inflammation, or infection of the pulp. When these conditions occur, endodontic treatment becomes a necessity. Endodontic therapy involves the removal of pulp tissues and

thorough cleaning and disinfection of the root canal system, followed by filling to prevent reinfection (1). The primary objective is to create a hermetic three-dimensional seal that prevents further microbial invasion, ensuring the long-term health and integrity of the tooth (2).

However, during the mechanical preparation of the root canal system, a common challenge emerges – the extrusion of debris containing dentin and pulp remnants beyond the apical foramen, in the periapical tissues. This extrusion is often due to the mechanical action of the endodontic

instruments, as well as of the active pushing of debris beyond the apex by using endodontic files. Although this step aims to maintain patency, there has been a concern that this may push contaminated debris through the apical foramen. Nevertheless, research indicates that maintaining canal patency throughout the procedure does not significantly increase post-treatment symptoms (3).

Tanalp and his colleagues were among the first to explore the phenomenon of apical extrusion of infectious material during canal preparation. Their research in 1968 highlighted the risk of infection when canals were not properly disinfected before mechanical preparation (4).

Van de Visse & Brilliant, in 1975, attempted to compare extrusion of debris from root canals with and without irrigation. They concluded that irrigation facilitated debris extrusion, and instrumentation without irrigation did not push debris beyond the apex (5). Although these studies pointed to the extrusion risks posed by irrigation, it is now widely accepted that the use of irrigants is crucial for successful endodontic treatment, and any potential extrusion risks are outweighed by the advantages of irrigation (4,5).

Recent studies have shown that all canal preparation techniques are associated with debris extrusion, even when the instrumentation is shorter than the root canal length (2). Studies have increasingly focused on single-file systems, which offer advantages such as reduced working time, lower risk of cross-contamination, and less fatigue, minimizing the risk of instrument fracture. Additionally, these studies have found that rotary instruments produce fewer extruded debris compared to manual instrumentation (2,6).

Apart from instrumentation techniques,

factors like coronal preflaring, canal size, the type of rotary movement during preparation, and the type of irrigating needle also influenced the extrusion of apical debris (2,7,8).

AIM OF THE STUDY

The aim of this study was to analyze the quantitative difference in extruded debris beyond the apex between two different shaping nickel-titanium systems commonly used in current endodontic practice: one utilizing reciprocation and the other, in continuous rotation. Due to the ease of use and of the shorter working time, rotary systems have become more popular than manual techniques with multiple file sequences in root canal shaping. Therefore, we compared two of the most popular NiTi rotary files in terms of debris pushed beyond the apex to determine whether differences exist, for practitioners looking to minimize this irritating factor.

MATERIAL AND METHODS

To facilitate sample standardization, 12 single-rooted teeth were used, comprising 6 incisors and 6 canines, each with a single fully formed apical foramen and a single canal. These teeth were divided into two groups. Three incisors and three canines were randomly selected for Group 1, which was shaped using the WaveOne Gold WOG system (Dentsply Sirona, Ballaigues, Switzerland), while the remaining 3 incisors and 3 canines constituted Group 2 and were shaped using the Protaper Next PTN system (Dentsply Sirona).

To ensure uniformity in tooth length, all teeth were reduced to a 19 mm length using a green-coded cylindrical diamond bur under air-water cooling. After reduction, access cavities were created using a long neck round diamond bur at high-speed.

Debris collection method

To collect the debris, 12 Eppendorf tubes were used. The tubes were initially weighed when empty, using the Series analytical balance AS 82/220.R2.Plus (Radwag, Radom, Poland) with a readability of 0.00001g/0.0001g (Fig. 1).

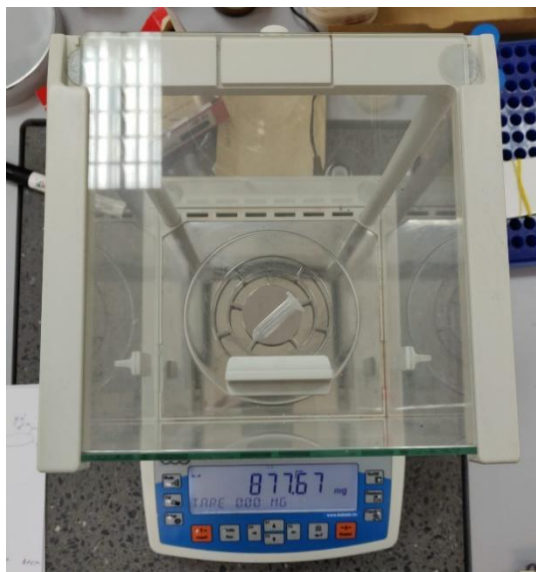


Figure 1. Radwag AS 82/220.R2Plus analytical balance

Each tube was individually measured three times and the average weight for each tube was calculated by determining the arithmetic mean of these three obtained values (Table 1). After weighing, each tube was placed into its designated compartment within a box and recorded in a table to ensure that the tubes remained organized during or after the tooth preparations.

In addition to the weighed Eppendorf tubes designated for debris collection, another set of 12 tubes was solely used for their caps. These caps were detached from the main body of the tubes and subsequently punctured using the NSK EX-6B straight handpiece - H260001 to create an opening where the teeth were later secured, respecting

the method described by Montgomery and Myers in 1991 (9).

The next step involved securing the teeth within the perforated caps. This was accomplished by using a two-component universal adhesive, specifically, transparent Poxipol, chosen for its viscosity and strong adhesion to various surface types. The tooth was affixed to the cap with the aid of a 25-gauge bonding needle. This needle was attached to equalize the pressure inside and outside the Eppendorf tube during tooth preparation and irrigation (Fig. 2).



Figure 2. The cap with the tooth and attached needle

The Eppendorf tubes that had been initially weighed were unsealed, and new caps containing the teeth were affixed to them. Incisors were positioned in the first row, while canines were placed in the second row. To prevent tube contamination and the accumulation of fats or other particles on their external surfaces, which could potentially affect the precision of the analytical balance, the tubes remained within their designated box support throughout the instrumentation process, and gloves were worn during all handling procedures (Fig. 3).

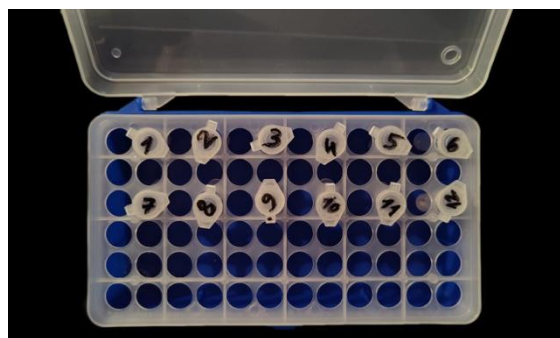


Figure 3. Sealed and labelled Eppendorf tubes following instrumentation

The negotiation of the canals was initially performed using K-file #10 (Kendo, VDW GmbH, Munich, Germany) hand-files to determine the working length. Subsequently, the glide path was achieved using the rotary instrument ProGlider (Dentsply Sirona). Before and after each instrument, irrigation was performed with distilled water. Sodium hypochlorite or citric acid were not used because they tend to crystallize, which could yield inaccurate results during the final weighing. The negotiation and glide path preparation were carried out on all teeth in this manner to ensure that this factor did not influence the results.

Canal shaping and preparation

As earlier mentioned, three incisors and three canines were shaped using the WaveOne Gold (WOG) system by Dentsply Sirona in reciprocating motion using an X-Smart Plus endodontic motor (Dentsply) according to the manufacturer's instructions of use. The gold NiTi instruments of the WOG set are milled from a nickel-titanium alloy, which undergoes post-manufacturing heat treatment, followed by a slow cooling process. This process imparts the instrument with its golden color (gold wire) and enhances their flexibility and strength. For the preparation of incisors and canines, only the red Primary WOG instrument with a 7% taper and a 0.25mm tip diameter was used.

The remaining teeth were shaped using the ProTaper Next system (Dentsply) and the same motor, in a rotational motion, at a speed of 300 rpm and a torque of 2 Ncm. These instruments are manufactured from a nickel-titanium alloy, which undergoes a heat treatment process to increase their flexibility and resistance to separation, known as the M-wire alloy. The ProTaper Next instruments offer improved cutting efficiency due to their rectangular cross-sectional. Teeth were shaped only using the first two instruments of the PTN set: the X1 instrument with a 0.17mm tip and a 4% apical taper, followed by the X2 instrument with a 0.25mm tip and a 6% apical taper.

Debris collection and final weighing

All debris formed and pushed beyond the apical foramen were collected in tubes. After the completion of canal preparation, the caps with the teeth attached were removed, and the root was rinsed with 3 ml of distilled water to collect any remnant debris that had not fallen into the tube during shaping. The containers were sealed, marked with a marker, and left undisturbed for 5 days to allow the debris to settle at the bottom (Fig. 3). Following this, the distilled water from the tubes was removed using a syringe, leaving a 2 mm layer of liquid above the debris to ensure that we didn't aspirate some of it. Next, the containers were placed in an incubator at 40 degrees Celsius for 5 days to allow water evaporation (Fig. 4).



Figure 4. Eppendorf tubes in the incubator

Following incubation, the remaining water evaporated completely, so only the debris remained in the Eppendorf tubes (Fig. 5).



Figure 5. The debris inside the Eppendorf tube after drying in the incubator

The tubes were organized again and re-taken to the analytical balance for the final weighing. As with the initial weighing, all the tubes with debris were measured three times

each, and using these values, the average weight of the filled tubes was recalculated in mg (Table 2).

To accurately determine the weight of the extruded debris, the weight of the empty tubes was subtracted from the weight of the tubes containing debris. This straightforward calculation provided the following results in Table 3.

RESULTS

During the experiment, two rounds of weighing the Eppendorf tubes were conducted. In the first round, the empty tubes, and in the second, or final round, the tubes after tooth preparation, which included debris were weighted. Then the initial weight was subtracted from the final, yielding the quantity of apically extruded debris in mg (Table 3).

Table 1. The initial weight of the empty tubes and the mean value (mg) for each sample

Group 1- WaveOne Gold (mg)		Group 2-ProTaper Next (mg)	
	Mean value		Mean value
875.31	875.23	929.77	929.75
875.22		929.67	
875.17		929.80	
878.93	878.78	879.61	879.56
878.76		879.52	
878.67		879.56	
863.28	863.18	860.06	860.00
863.18		859.97	
863.07		859.98	
861.54	861.53	860.27	860.21
861.53		860.17	
861.53		860.20	
898.96	898.89	888.99	888.93
898.85		888.91	
898.87		888.88	
877.21	877.19	884.88	884.80
877.17		884.74	
877.21		884.78	

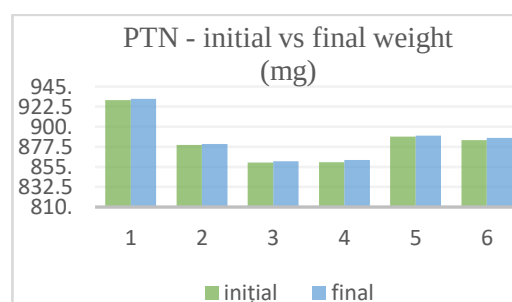
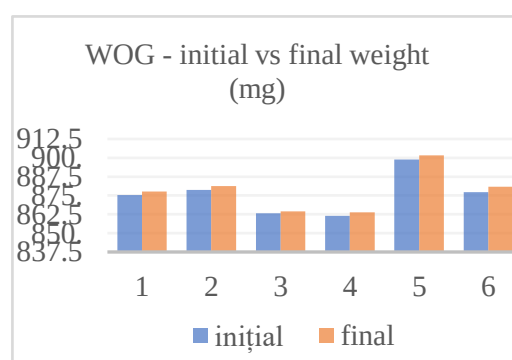
Table 2. The final weight of the tubes after shaping and the mean value (mg) of each sample

Group 1- WaveOne Gold (mg)		Group 2-ProTaper Next (mg)	
	Mean value		Mean value
877.67 877.71 877.58	877.65	931.46 931.37 931.30	931.38
881.40 881.23 881.22	881.28	880.92 880.73 880.67	880.77
864.50 864.43 864.54	864.49	861.30 861.23 861.18	861.24
863.77 863.68 863.81	863.75	862.80 862.76 862.83	862.79
901.60 901.49 901.54	901.54	890.13 889.94 890.07	890.05
880.93 880.72 880.70	880.78	887.51 887.52 887.57	887.53

Table 3. The mean weight of the apically extruded debris (mg)

Group 1- WaveOne Gold	Group 2- ProTaper Next
2.42	1.63
2.50	1.21
1.31	1.24
2.00	2.58
2.65	1.12
3.59	2.73

To enhance the differences between the initial and final weighing after preparation, a graphic representation was made for each group, with samples numbered consequently from 1 to 6 in each group (Fig. 6a and 6b).



Figures 6a and 6b. Graphic representation of the tube weights before and after instrumentation (mg)

By using these data, a mean value was determined and graphically represented for each system in Figure 7.

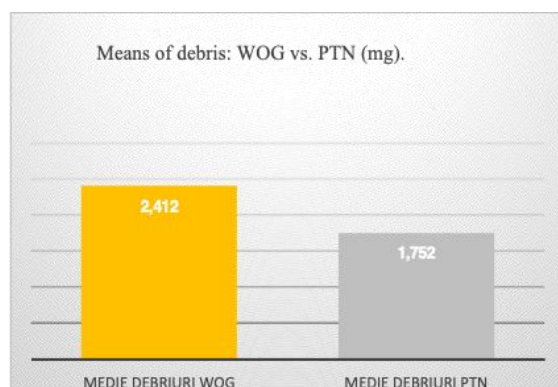


Figure 7. Mean value of the apically extruded debris with WOG in comparison to PTN

A simple ANOVA statistical test was used in Microsoft Excel to analyze the differences between the two Groups, with the null hypothesis (H0) considered: "There are no statistically significant differences in the amount of apically extruded debris between the two systems." The test was executed at a significance level p of 0.05 (Table 4).

Following this analysis, a p -value of 0.152 was obtained, which was higher than the significance level of 0.05. Additionally, the F -value was lower than the critical F -value. These data underscored the fact that the differences in the amount of apically extruded debris resulting from the preparation with the two systems do not have statistically significant relevance, and the null hypothesis is true.

Table 4. Results of the one-way ANOVA test

Anova: Single Factor						
SUMMARY						
Groups	Count	Sum	Average	Variance		
WOG	6	14,47	2,41166667	0,56725667		
PTN	6	10,51	1,75166667	0,52245667		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1,3068	1	1,3068	2,39842894	0,15249849	4,96460274
Within Groups	5,44856667	10	0,54485667			
Total	6,75536667	11				

DISCUSSIONS

As mentioned before, endodontic therapy is a frequently encountered practice in dentistry. Despite advancements in the improvement of instruments concerning their durability, flexibility and reduced working time, there have been no significant differences in minimizing the extrusion of debris beyond the apical foramen.

Apically extruded debris can be examined using a variety of laboratory experimental setups but for this study, we used the system outlined by Myers and Montgomery, to assess the quantity of apically extruded debris (7). pushed beyond the apical foramen in teeth shaped with reciprocating NiTi instruments from the WaveOne Gold and rotary files from ProTaper Next systems was investigated. Both systems are well-researched and commonly used in routine endodontic treatment. Although endodontic treatment is relatively predictable, with success rates reported as high as 86-98%, many factors can limit its success, and apical extrusion of debris is one of them (2). Material extruded apically in any form, such as obturation materials, interim medication, instrument fragments, irrigants, debris, or necrotic pulp tissue, can lead to an endodontic flare-up or treatment failure due to a foreign body reaction (10).

As a result of the present experimental in vitro study, it was found that there is a difference in the amount of apical extruded debris following preparation with a reciprocating motion system, WaveOne Gold (mean value of 2.412 mg), although it consists of only one instrument (the WOG Primary), in comparison to a system using continuous rotation, ProTaper Next (PTN X1 and X2 instruments used), with a mean value of 1.752 mg). Although a mean difference of 0.66 mg was recorded, this difference was of

no statistically significance, so no conclusion can be drawn regarding the superiority of one of the systems, or regarding the type of the motion used in root canal shaping. This result, although obtained on a smaller sample size (6 teeth in each analyzed group), is in concordance with recent studies comparing rotary and reciprocating systems (2, 11).

It is also recognized in literature that hand files are known to extrude a greater quantity of debris beyond the apical foramen in comparison to rotary NiTi instruments, so beyond most of their advantages, the low quantity of extruded debris of NiTi files could be one to be taken into consideration for using rotary instruments during root canal shaping (7, 12-15).

A common limitation in most studies related to this topic, including the present experiment, is that in vivo, the quantity of apically extruded debris is likely lower because the periodontal ligament and surrounding periapical tissues offer resistance against the extrusion of debris, and are believed to prevent such a quantity to be pushed out from the root canal during shaping. However, this is just a hypothesis, and to date, no studies have successfully simulated the presence of the periodontal ligament and of the bone and its resistance when evaluating the extruded debris via root canal shaping, and not on human patients (16,17).

Therefore, it is evident that apical debris do exist following endodontic therapy, and they can be the cause of an acute painful episode, which, in addition to the patient discomfort, can result in treatment failure because of the containing bacteria in infected cases. However, shaping of the root canal with mechanical instruments in association with irrigants is one of the most important steps during routine canal treatment, so they

must be performed to ensure its cleaning and shaping, but research studies should be conducted to explore solutions or methods to reduce this phenomenon (10).

The topic studied in the present paper has been investigated since early 1990, and although it has been approached from different angles and in various ways, uncertainties persist. These include: the exact resistance offered by the periodontal ligament, the precise harmful effect of debris on the peri-radicular system, how to predict patient flare-up reactions only by the quantity of the extruded debris, and how exactly to reduce the amount of apically extruded debris during endodontic treatment. These questions should be addressed in the future for a better

understanding of the phenomena associated with apical debris extrusion, and furtherly researched.

CONCLUSIONS

Despite the present study's limitations, after shaping the samples using two types of NiTi systems, one in rotation, and one in reciprocation, apically extruded debris were observed for both. Their weighing led to the conclusion that the samples shaped with WaveOne Gold extruded a larger quantity of debris than ProTaper Next, but without being statistically difference, no conclusion can be drawn regarding the superiority of one of the two compared systems.

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