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Apically Extruded Debris during Instrumentation using Different Engine Driven File Systems: A Comparative *In Vitro* Study

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Abstract

AIM: The aim of the present study was to evaluate and compare the amount of apically extruded debris using three engine driven systems.

METHODS: Sixty mandibular premolars with single root were used. The samples were divided into three groups with 20 teeth for each group: group 1 Neolix Neoniti A1 (25, 0.08), group 2 WaveOne GOLD Primary (25.07, red), and group 3 Protaper Next (PTN), using X1 (017/0.04), X2 (025/0.06) files. All files were used to prepare the root canals according to manufacturer instruction. Root canal preparation for each group was done according to manufacturer instructions using 16:1 gear reduction hand piece powered by a torque controlled electric motor. Debris collection was made using apparatus described by Myers and Montgomery. The extruded debris weight was measured by subtracting the weight of the empty Eppendorf tubes from the weight of the debris containing tubes results were statistically analyzed.

RESULTS: One-way analysis of variance test revealed that there was statistically significant differences between all the three groups being tested ($p < 0.001$) showed that apical extrusion of the debris of WaveOne Gold was the least followed by Neolix Neoniti and finally PTN which showed the most apical extrusion of debris with a significant difference between all groups.

CONCLUSIONS: WaveOne Gold was found to be the least apical extruded debris system among all groups.

Introduction

All systems used for root canal treatment lead to apical extrusion of debris [1]. These debris may contain dentinal remnants, necrotic pulp tissue remnants, microbes with their toxic byproducts, and some of the irrigation solutions that might also be forced to the periradicular tissues [2]. The extrusion of debris beyond the apex may trigger an inflammatory reaction in the apical region associated with post-operative pain revealed as moderate to severe pain during mastication or percussion being directly related with symptomatic apical periodontitis [3], [4], this may generate an inconvenient situation for both of the dentist and patient [5]. However, its prevalence is 40–65% during the first 24–48 h, and the rate decreases to 11% after 7 days [6]. Thus, efforts must be made to minimize the extrusion of debris through the apical foramen [7].

Although certain aspects of the endodontic treatment can be controlled by the operator, such as the properties of the file selected and the technique used for preparation, the microbial virulence is almost impossible to be controlled when extruded into the periapical tissues [8]. The most popular *in vitro* technique for quantifying the debris extrusion is the method of Myers and Montgomery in 1991 [9]. Using this method, it has been demonstrated that apical extrusion of debris will occur anyway while using manual or engine-driven instrumentation techniques [10].

In the beginning, manual files were used to prepare root canals. These stainless-steel instruments were designed with square or triangular cross sections and had a cutting tip with a 2% and filing movement that is effective (up and down into the canal); therefore, it will produce an extruded debris with a considerable amount [11]. When nickel-titanium engine-driven rotary files were introduced a major advance was achieved in the canal preparation protocol. However, this can yield variable results according to the number of instruments, instrument's design and the kinematics employed [12]. Engine-driven nickel titanium (NiTi) rotary and reciprocating files for root canal instrumentation have been successfully used [13].

The Neolix Neoniti A1 is produced with the electrical discharge machining method, which has advantages such as high precision, the creation of various designs without tool constraints, and limited manufacturing stress to the file surface. This method also produces a rough surface, which can enhance the cutting abilities of the file [14]. Along with the new features in designs or treatment processes, these new

continuous rotary single-file systems needed small torque values when used in the root canals and however it requires more studies whether these new instruments can maintain their cutting efficiencies to gain the optimal results using that low torque values [15].

WaveOne GOLD file has a cross-section that is off-centered and parallelogram in shape with 85° cutting edges that contact the root canal with reduced and variable taper generating one or two cutting edges that will greatly minimize the screwing effect on the canal walls so that the generated torque will be reduced and improving cutting efficiency with better removal of debris [16].

Protaper Next (PTN) system is a system with a rectangular cross-section of instruments that must be used with a conventional rotary motion. Due to its offset rotation center and mass center, when in motion, the device generates a mechanical wave similar to a sinusoidal wave (snake-like swaggering movement), making its movement asymmetrical [17].

The study aimed to evaluate the amount of apically extruded debris using three engine driven systems, the reciprocating file system WaveOne GOLD and the other two with a continuous rotation file system Neoniti A1 and PTN. The null hypothesis was that there is no statistically significant difference between the three systems in the property tested.

Materials and Methods

Sixty human single root mandibular premolars were selected for this study that was extracted for orthodontic purposes. Teeth were scaled and cleaned using an ultrasonic. The teeth were checked, any tooth with opened apex, calcification, root resorption, root curvature, or defect was neglected. The teeth were stored in normal saline till used.

Access opening was achieved using diamond bur at high-speed hand piece. All pulp tissue was extirpated using a barbed broach. Apical gauging was made using size 10 and 15 K files. Only the teeth that K file size 15 was closely fit to the apex and could not pass through their apices when gently pushed were used for this study to ensure apical size standardization. Working length was determined by subtracting 1 mm from the full working length taken when size 10 K file was just visible at the apex using magnification loops.

Debris collection was made using apparatus described by "Myers and Montgomery" [9]. Empty "Eppendorf tubes" without plastic stoppers were weighted using a digital microbalance 3 times and the average weight was taken then a hole was made in the plastic stopper of the "Eppendorf tube" using high-speed hand piece and the tooth was forced into the hole till the cementoenamel junction and sealed with cyanoacrylate to prevent any leak. A needle (25-G) was forced into the plastic stopper to equalize the pressure between the outside and inside the "Eppendorf tube." This "Eppendorf tube" served to collect the extruded debris. Then, each tube was fixed to a plastic container so that the collecting Eppendorf tube was suspended in a way without touching the plastic container (Figure 1) and the plastic bottle was covered with tinfoil so that the operator cannot visualize the collected debris.

Figure 1: Photo illustration of the collecting apparatus: Tooth, collecting Eppendorf tube, plastic container, and ventilating needle

Root canal instrumentation was done using the following file systems, Neolix Neoniti files A1(25, 0.08) (Neolix, Châtres-la-Forêt, France), WaveOne GOLD Primary files (25.07, red) (Dentsply Maillefer, Ballaigues, Switzerland), and PTN files X1 (017/0.04), X2 (025/0.06) (Dentsply Maillefer, Ballaigues, Switzerland).

The study based on three groups (each group had 20 teeth):

a. Group 1 (G1): Neolix Neoniti A1 (25, 0.08) files were used to prepare the root canals (20 teeth)
b. Group 2 (G2): WaveOne GOLD Primary (25.07, red) files used for preparation (20 teeth)
c. Group 3 (G3): PTN files were used according to manufacturer instruction using X1 (017/0.04), X2 (025/0.06) files (20 teeth).

Root canal preparation for each group was done according to manufacturer instructions using 16:1 gear reduction hand piece which is powered by

a torque controlled electric motor (X-smart plus motor, Dentsply, Maillefer, Switzerland, Europe). All the preparations were done by the same operator. Each tooth was irrigated with 5 ml distilled water for 3 min using a disposable syringe and a side-vented irrigation needle which was inserted about 2–3 mm shorter than the working length. After finishing instrumentation, final irrigation of the root apex was done using an additional 1 ml of distilled water for 1-min to collect any attached debris to the apex.

Then, the plastic stopper was removed from the Eppendorf tube together with the tooth attached to it. Then, the distilled water was evaporated by putting the Eppendorf tubes inside an incubator at 37°C for 15 days and collecting the dried debris without any humidity. Then each Eppendorf tube was weighted 3 times in a digital microbalance and the average weight was taken. The extruded debris weight was measured by subtracting the weight of the empty tube from the debris containing tubes weight. The data were analyzed using one-way analysis of variance test and the difference between the groups was found using *post hoc* Duncan's multiple comparison test employing a 95% level of significance (a = 0.05).

Results

Results showed that all groups produced apical extrusion of debris however WaveOne Gold showed the least apical extrusion of debris followed by Neolix Neoniti and finally PTN which showed more apical extrusion of debris than the other two groups with a significant difference between all groups. Statistics are shown in Table 1. Further analysis of the data was done using t-test (Table 2) indicated that there were statistically significant differences ($p \leq 0.05$) between all the pairs of groups being tested individually.

Discussion

All groups produced apical extrusion of debris with a significant difference between all groups. Therefore, the testing hypothesis should be rejected. Root canal instrumentation is very important to gain a successful endodontic treatment, to achieve this goal, proper technique with efficient files and irrigation is mandatory. Unfortunately, till now all the systems available may extrude debris apically even the engine driven types depending on the geometry of the file and the way it moves whether it's rotational or reciprocal [18]. This extruded debris may cause pain and severe tenderness and even swelling thus the patient might be discomforted and sometimes will lead to failure of the treatment [19].

The goals of this study are to evaluate the amount of extruded debris of a reciprocating engine driven files WaveOne GOLD and compare it to the rotary Neolix Neoniti and PTN. There are many methods for measuring apically extruded debris but the method of Myers and Montgomery was more reliable and reproducible than other methods therefore it was selected for this study. In this study, curved roots were neglected to prevent any loss in working length and apical transportation which may lead to more apical extrusion of debris [20], the crown was not decoronated to simulate the clinical situation during instrumentation.

In this study, the amount of the collected extruded debris was little which might be attributed to the type of teeth that were used. The mandibular premolars have wide canals that limit the pumping effect of the file during insertion and consequently result in less apical extrusion of debris; on the other hand, narrow canals with less coronal flaring may result in more extrusion of debris [21]. Furthermore, making the working length 1 mm shorter than the apical end may play a role in reducing the amount of extruded debris [22].

In this study, distilled water was used instead of sodium hypochlorite as the main irrigant solution although it is not preferred as the main irrigant compared to sodium hypochlorite which has an excellent antimicrobial activity. Sodium hypochlorite may produce particulate precipitates that have been reported to increase the weight of the extruded debris which may affect the reliability of the results [23].

The apparatus used in this study was described by Myers and Montgomery to collect extruded debris. Despite the ability of this apparatus to individually evaluate debris and irrigant weights but it does not simulate the periapical tissue in providing the resistance at the apical foramen that might limit the extrusion of debris by back pressure [24].

Results showed that the file with the least apical extrusion of debris was WaveOne Gold, followed by Neolix Neoniti and finally PTN which showed the greatest apical extrusion of debris and statistically all systems showed a significant difference in the apical extrusion of debris.

WaveOne Gold showed the least apically extruded debris which might be related to the design of

Table 1: Mean weight and SD of apically extruded debris after the use of different instrumentation systems

Group	n	Minimum	Maximum	Mean ± SD	Std. Error	Duncan Groups**
Neolix Neoniti	20	0.0025	0.0049	0.0036 ± 0.0082	0.0018	A
WaveOne GOLD	20	0.0017	0.0041	0.0030 ± 0.0069	0.00015	B
Protaper Next	20	0.050	0.069	0.0058 ± 0.00057	0.00013	C

*Means unit is gram, **Different letters mean significant difference at P ≤ 0.05.

Table 2: t-test for the three groups

Pairs	t-value	p-value	Sig/non sig. at P ≤ 0.05
G1+G2	-2.294	0.033	Significant
G1+G3	-13.440	0.000	Significant
G2+G3	-11.721	0.000	Significant

patented with an alternating cross section that makes only one cutting edge come into contact with the canal wall decreasing the area of contact between the file and the canal. This will provide more space for coronal removal of debris [25], and less apical extruded debris compared to Neolix Neoniti in which according to the manufacturer, the Neoniti A1 has Gothic-like tip design and built-in abrasive properties. These properties might reduce the torque required to cut the canal walls but, on the other hand, it might produce more debris that might extrude from the apical foramen. PTN moves in a continuous rotation which supposed to remove the debris in the coronal direction because its motion act as a screw conveyor besides the PTN have a rectangular cross-section which is off-centered, the center of mass in PTN differ from the rotation axis, as a result, the rectangular cross-section touches the canal wall at only two points at a time that makes the system to have an offset design which enhances coronal removal of debris rather than apically [17], but when comparing PTN to WaveOne Gold and Neolix Neoniti more files and time is mandatory for preparation with PTN which requires at least two files to finish the canal preparation which might provide more chance for apical extrusion of debris compared to a single file preparation with WaveOne Gold and Neolix Neoniti. The results of this study agree with other studies that reported a less debris extrusion is associated with reciprocating instruments [26], [27], [28].

Conclusions

According to the proposed methodology and results of this *in vitro* study, it was concluded that all systems extruded debris beyond the apical foramen. The WaveOne Gold was found to be the least mean value of apically extruded debris followed by Neolix Neoniti and finally PTN which showed the highest mean value of apically extruded debris value among all groups.

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