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Original Study

Quantitative analysis of apically extruded debris between selective rotary and reciprocating files by lyophilization & micro-balance

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ABSTRACT

Background: Extrusion of debris during root canal preparation into the periapical tissues, result in inflammation of the periodontal ligament. This may result in postoperative discomfort, flare-ups, or even apical healing failure, which could negatively impact the effectiveness of the endodontic therapy. This may result in postoperative discomfort, flare-ups, or even apical healing failure, which could negatively impact the effectiveness of the endodontic therapy.

Aim and Objectives: This study compared the amount of debris extruded from the apex during apical preparation using a reciprocating file system versus a rotary file system.

Materials and Methods: Twenty mandibular premolar teeth were divided into two groups at random. The root canals were created utilising rotary and reciprocating file systems in accordance with the manufacturer's specifications. During instrumentation, apically extruded material was gathered in preweighed tubes. The preweights and postweights of the tubes were subtracted to get the net weight of the apically extruded debris.

Results: The statistical analysis was done with parametric techniques (Independent t test). Tukey multiple comparisons were used for post hoc pairwise comparisons. 0.05 was chosen as the alpha-type error value. A significant difference was discovered between the Protaper Universal (PTU) rotary system which extruded more debris than the Wave One Gold (WOG) reciprocating system.

Conclusion

WaveOne Gold extrudes less debris compared to ProTaper Universal file system. So according to this study Wave One Gold can be used without harm in the current clinical practice.

***Keywords:** Root canal preparation, Nitinol, Periapical tissue, Freeze drying, Dental instrument.*

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INTRODUCTION

One of the most crucial stages of root canal treatment that gets rid of the infection is root canal preparation/mechanical instrumentation of the root canal. It involves removing infected root dentine as well as essential and necrotic tissues from the root canal system. To promote healing in a variety of disease conditions and prevent periapical illness are the ultimate goals of root canal preparation.[1] Infected dentine, dentin chips, fragments of necrotic pulp tissue, and bacteria can be transferred to the apical third of the canal during root canal preparation and extruded into the periapical tissues, resulting in inflammation of the periodontal ligament. This could alter the outcome and success of the endodontic treatment by causing postoperative pain, flare-ups, or even failure of apical healing.[2] The apical extrusion of debris during mechanical instrumentation and irrigation protocol plays a significant role in the operator-related factors, such as chemical, mechanical, or bacterial injury during root canal preparation, even though the periodontal ligament inflammation is dependent on the host-dependent factors. Iatrogenic and local host variables, as well as postoperative discomfort, can also exist. According to reports, the frequency of flare-ups during root canal therapy varies between 1.4% and 16%.[3] The operator should exercise extreme caution while selecting the preparation method and file qualities for root canal preparation in order to prevent these unplanned visits from the patients.

Canal preparation was significantly impacted by nickel-titanium (NiTi) instruments, which were first introduced as hand instruments by Walia et al. The traditional drawbacks have been overpowered by the introduction of NiTi rotary instruments and advanced preparation techniques for root canal preparation. The root canal procedure has now undergone a revolution thanks to the invention of nickel-titanium (NiTi) files and scientific advancements in the thermal treatment of alloys and kinematics. Despite these developments, practically every preparation method might result in debris extrusion from the apex. However, it has been discovered that using motor-driven tools results in less debris extrusion than manual file methods.

New design ideas and quicker, simpler approaches that maintain the original canal geometry with significantly fewer iatrogenic errors have been made possible by technological breakthroughs in rotary nickel-titanium (NiTi) instruments.[4] The crown-down and balanced force approaches resulted in the least amount of debris ejection, whereas linear filing motion techniques caused the greatest. The majority of nickel-titanium instrument (NiTi) systems operate with a file rotation push-pull movements Rotating devices typically draw dentinal debris into the file's flutes and push it toward the coronal part of the canal.[5] Given that they are more pleasant for both patients and practitioners, rotational NiTi tools are now most frequently employed for root canal preparations.

ProTaper Universal is the rotating file system that was examined in this trial (PTU). In 2001, ProTaper rotary technology (DENTSPLY Tulsa Dental) was introduced in the US. One of the ProTaper instrument versions is the PTU (Dentsply Maillefer, Ballaigues, Switzerland). These files are intended to spin constantly counterclockwise. These NiTi rotary instruments (ProTaper) have various shafts and a convex triangular cross-sectional shape.[6] The ProTaper instrument's progressive tapered shaft design was less affected by the mid-root curvature than the K3 instrument's constant tapered design, resulting in a satisfactory centering of the apical preparation. ProTaper instruments, however, tended to transfer in the direction of the coronal region's furcation.

Reciprocating instrumentation is the additional sort of equipment employed in this study. In order to imitate the balanced force technique and linear motion and to ease root canal instrumentation by minimising the steps and files needed, the reciprocating files move in varied degrees of arc. In order to improve the physical qualities of its instruments, the recently released WaveOne Gold (WOG) reciprocating system (Dentsply Tulsa Dental, Tulsa, OK) uses a specific heat treatment (gold alloy technology). This increases the instrument's strength and flexibility.[7] WaveOne Gold's torsional resistance is boosted by its off-center parallelogram-shaped cross-section

design, which also enhances its counter clockwise and clockwise reciprocating movements. There is an assumption that decrease in the number of files decrease the apical extrusion of debris.

The quantity of debris extrusion may be influenced by improvements in instrument design, including radial lands, flute depth, various tapers and cross-sections, and the employment of alternative operational principles.[2] The type of movement and instrument design are the important aspects to be taken into consideration for evaluation of the apically extruded debris8, even if instrumentation approaches drive intracanal content through periapical tissues.[8] This in vitro study compares the amounts of apically extruded debris produced by Wave One Gold reciprocating file systems and Protaper Universal rotary file systems.

MATERIALS AND METHODS:

Sample selection:

Twenty human mandibular premolar teeth that had been removed were gathered from our institution's Department of Oral and Maxillofacial Surgery. On the external root surface, calcification and leftover soft tissue were physically removed. The extracted teeth were collected, cleaned with 0.5% chloramine T, kept in distilled water at 4 °C, and used within six months.

This study comprised human mandibular premolar teeth with a single, straight canal, mature apices, and comparable root length. Digital radiographs of each tooth were examined in order to standardise the curvature of the root canals. Only teeth with a canal curvature of less than 10 degrees were chosen because the angle of curvature was thought to start at the coronal aspect of the apical third of the canal.[9] Teeth with apical root resorption, calcification, and open apices and previous endodontically treated teeth were excluded. After checking the inclusion and exclusion criteria, 14 teeth were included in this study.

Debris collection:

The model created by Myers and Montgomery for debris collection was the setup employed in the study.[10] The teeth were affixed to the polyethylene tubes' detachable tips. To balance the air pressure within and outside the tube, a bent 27-gauge needle was inserted into the top of the tube and used as a drainage cannula. During instrumentation, the debris that was ejected via the root's foramen was collected in these tubes. An Endo Access Bur (Dentsply Maillefer) was used to prepare endodontic access cavities in a high-speed handpiece, and pulpal remains were removed using a broach. To avoid putting the broach through the apical foramen, care was exercised. By advancing a size 10 K-file (Dentsply Maillefer) through the root canal until its tip was visible at the apical foramen, apical patency was assessed. The standard working length (WL) is 16 mm. The first file at the top was a 15 size K file. The samples were split into two groups, each including seven teeth.

Root Canal Preparation:

One knowledgeable operator completed the study. Following the manufacturer's advice, the rotary tools were discarded after three teeth were prepared and reciprocating tools were used once for each tooth. Each tooth's root canal preparation required the use of a total of 20 mL of distilled water for irrigation. The last irrigation was performed with a 30-gauge side vented needle and 3 mL of distilled water.

Group 1: ProTaper Universal (PTU)

PTU instruments were used to prepare seven channels at 300 rpm and 2 N-cm torque (X-Smart; Dentsply Maillefer). The sequence utilised was as follows: SX, S1, S2, F1, F2, F3, and F4 files are also available. SX file was applied in an outstroke brushing motion until canal resistance was encountered. After that, the file was removed, cleaned, and examined before being used again. Distilled water was used to irrigate. Repeating these steps allowed the SX file to fill up half of the WL. The S1 and S2 files (which make up two thirds of the WL), as well as the F1, F2, F3, and F4 files, underwent the identical procedures (full WL) .

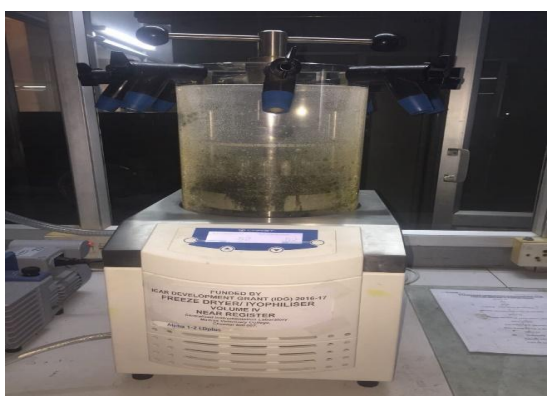
Group 2: WaveOne Gold (WOG)

WOG system was used to prepare seven canals. They were employed in a brushing action together with a slow in-and-out pecking motion with a 3-mm amplitude limit. The file was removed after three pecking motions, cleaned, and examined before being reused. Distilled water was used to irrigate the canal.

Up till the file reached the WL, this step was repeated. The lateral walls of the root canal were brushed while applying gentle apical pressure. 3 mL of distilled water were used for the final irrigation. The root apex was flushed with 0.1 ml of distilled water to wash any remaining debris into the vial after canal instrumentation. Any debris that was visibly adherent to the root end was scraped off with the inside of the tube.

Figure 1: Root apex flushed with 0.1 ml of distilled water to wash any remaining debris into the vial after canal instrumentation

Figure 2: The lyophilized root canal debris was freeze-dried after being transferred from the polyethylene tubes into the vials for lyophilization.



The caps with the attached teeth were taken out of the collector tubes after lyophilization. On a precision electronic microbalance (Sartorius AG, Gottingen, Germany) with an accuracy of 10-4 g, tubes with the residual debris were weighed three times. The average value was then recorded. The net weight of the dry debris was computed by subtracting the gross weight from the original weight of the empty collector tube. The average weight of the debris that was ejected for each group was then calculated. The values were gathered and calculated.

STATISTICAL ANALYSIS

A bell-shaped distribution was found by preliminary analysis of the raw pooled data, therefore parametric approaches were used for statistical analysis (Independent t test). Tukey multiple comparisons were used for post hoc pairwise comparisons. The alpha-type error was set at 0.05.

RESULTS:

The mean values and the standard deviation data of each experimental group are shown in Table 1, 2 and Figure 3. Significant difference was found between Protaper Universal rotary system and Wave One Gold reciprocating file system. Wave One Gold (WOG) reciprocating system extruded less debris than Protaper Universal (PTU) rotary system.

Table1: Mean and Standard Deviation

Groups	Mean	SD	p value
Protaper Universal	0.1156	0.06537	0.024
Wave One Gold	0.0414	0.02514	

Table2: Levene's test for equality of variances

	Levene's test for equality of variances		t- test for Equality of Measures			
	F	Sig.	Df	Sig (2-tailed)	Mean difference	95% confidence lower
AED	6.362	.027	12	.016	.07426	.01658
Equal variances assumed			7.737	.024	.07426	.01285
Equal variances not assumed						

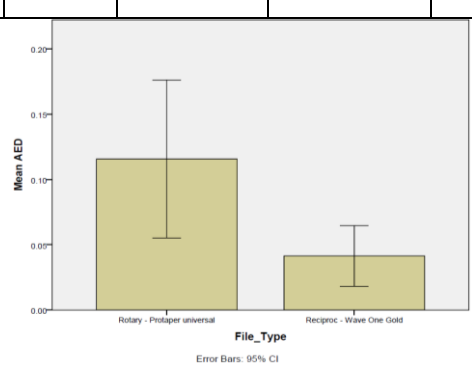


Figure 3 : Independent T Test

DISCUSSION

One of the most crucial procedures in endodontic therapy is root canal system preparation. The intricate anatomy of the root canal system is shaped as well as cleaned. The entire root canal system has been biomechanically prepared and disinfected using a variety of tools and methods. The success of root canal therapy depends on a variety of factors, including the tooth's preoperative condition and other intraoperative conditions, in addition to cleaning and shaping the root canals. Similarly, the amount of apically extruded material is a crucial consideration. In this study, the Protaper Universal rotary and Wave one Gold reciprocating file systems' levels of apically extruded debris were Protaper Universal rotary system was chosen because it is the most commonly used rotary file systems among the general dentist and endodontists. Wave One Gold is also one of the most commonly used reciprocating file systems. In the endodontic literature it has been reported that single file systems remove more dentin when compared to multi-file systems. Although preparation technique and the characteristics of the file can be selected by the clinician, it is almost impossible to limit the entry of microorganisms that are being extruded in the periapical tissue.

Due to several methodological issues in the literature, it is challenging to compare various file systems with varied kinematics and their impact on apically extruded debris. The method of Myers & Montgomery has been the most widely used method in many in-vitro research.[10] Several methods have been described to quantify the ejection of debris. According to this paradigm, all manual or engine-driven instrumentation methods result in the apical ejection of root canal debris.[11,12,13] Lyophilization, a legitimate process for dry freezing, was used to quantify the ejection of debris (reference). Due to the fact that the measurements are performed in a confined environment, it not only determines the quantity of debris but also regulates external factors like temperature and humidity.[14]

When canals were created, previous research in the literature claimed that both rotary and reciprocating file systems were linked to apical debris extrusion.[15] More detritus was connected to the Protaper Universal file system than the ProTaper Next, WaveOne, or Reciproc systems. There were no discernible variations between the ProTaper Next, WaveOne, and Reciproc systems.[16]

The current study's findings showed that, when compared to the Protaper Gold rotary file system, the Wave one gold file system with reciprocating kinetics extruded less debris. Different kinematics, alternate one-point contact, and a reduction in the number of instruments in the Wave-one Gold file system appear to have positively impacted the extrusion of debris. Single file systems make up the majority of reciprocating file systems. Another benefit of this file system is that it has had heat treatment, which reduces its torsional resistance when compared to file systems that have not undergone heat treatment. So, the file tends to flex rather than cutting the dentin whereas the Protaper Universal has three-point contact with active and semi active cutting edges and it was reported that this file system has high cutting efficiency which leads to more apical extrusion of debris.

The main drawback of this study was that the periapical tissues were not imitated because the extracted teeth with their apices were suspended in air (zero back pressure). The stated outcomes might differ if used in a clinical setting where the periapical tissues serve as a natural barrier that restricts the ejection of apical debris.[17] Along with the presence or absence of a lesion, the pulpal state plays a role in debris ejection. Distilled water was chosen since using sodium hypochlorite as an irrigating solution causes crystallisation, which could change the weight of dentine debris and jeopardise the validity of the results.

Despite the fact that WOG extrudes less debris periapically, we are unsure whether the other reciprocating single file systems extrude debris similarly apically. Future research should therefore concentrate on numerous different single file systems and their impact on the apical extrusion of debris.

CONCLUSION

Within the limitations of this study, it can be concluded that, extrusion of debris was less with the use of WaveOne Gold compared to ProTaper Universal file system. So according to this study Wave One Gold can be used without harm in the current clinical practice.

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Conflicts of interest - There are no conflicts of interest.

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