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ORIGINAL ARTICLE

Comparative Evaluation of Apical Extrusion Debris and Irrigant During Calcium Hydroxide Removal and Endodontic Instrumentation Using Three Types of Instrumentation Systems

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ABSTRACT

Many root canal preparation techniques and instruments produce apically extruded materials to a certain extent depending on the preparation system adopted. **Objective:** The extrusion of debris from the apical foramen during chemomechanical preparation may cause postoperative pain and failure of endodontic treatment. **Objective:** This study evaluates the differences in the apical extrusion of debris and calcium hydroxide (CH) during endodontic instrumentation by using Reciproc Blue (RB), WaveOne Gold (WOG), and F6 Skytaper (F6). **Methods:** Six experimental study groups (n = 13) were established. The root canal procedures for all groups were prepared with different methods: Group I: One Shape (OS) instrumentation, CH filling for 21 days, removal of CH using RB; Group II: OS instrumentation, CH filling for 21 days, removal of CH using WOG; Group III: OS, CaOH filling for 21 days, removal of CH using F6; Group IV: root canal instrumentation using RB; Group V: root canal instrumentation using WOG; Group VI: root canal instrumentation using F6. Apically extruded debris was collected into preweighed Eppendorf tubes by using the Myers and Montgomery method. Data were statistically analyzed with one-way ANOVA and Kruskal–Wallis tests. **Results:** All the tested instruments caused the extrusion of debris and irrigant from the apical foramen. The difference among the six groups was not statistically significant ($p > 0.05$). **Conclusions:** The tested instruments caused similar apical extrusions of debris and irrigant during CH removal or instrumentation procedures.

Key words: calcium hydroxide, extrusion, F6 Skytaper, instrumentation, Reciproc Blue

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INTRODUCTION

Pulp tissue residues and bacteria can be introduced from the apical foramen during chemomechanical preparation.[1] Their presence may cause postoperative sensitivity and failure of endodontic treatment and thereby adversely affect the clinical outcomes of the treatment.[2,3] Dressing with calcium hydroxide (CH), an intracanal medicament, is the most commonly used method to disinfect an infected root canal. The complete removal of CH is important in ensuring a successful root canal filling.[4,5] Many techniques have been used to remove CH.[6] Although previous investigations have shown that all instrumentation methods and instrumentation systems are useful in debris extrusion, the amount of extruded debris and irrigant may be affected by several factors, such as the dimensions and styles of endodontic instruments, the instrumentation, and the irrigation methods.[7,8]

Rotary systems have been produced with advanced metallurgical properties and different designs using different production methods to improve fatigue resistance. These systems offer high flexibility, high fatigue resistance, and high performance.[9] Despite their advanced metallurgical features and high performance, many root canal preparation techniques and instruments produce apically extruded materials to a certain extent depending on the preparation system adopted.[10] Reciproc Blue (RB, VDW, Munich, Germany) is a single-file instrumentation system used with reciprocal movement. It was developed with a new heat treatment method to improve its flexibility.[11,12] The WaveOne (WO) file system has been updated as WaveOne Gold (WOG, Dentsply Sirona, Ballaigues, Switzerland), and only their movement types are similar. The WOG system was produced with a heat treatment technique, and it has been used to develop dimensions, file numbers, apical sizes, and tapers.[13] Another single file system, the F6 Skytaper (F6, Komet, Brasseler GmbH&Co., Lemgo, Germany), is a single-use single-file NiTi system that is available in five different sizes (20, 25, 30, 35, and 40); it has an S-shaped cross-sectional design and requires a constant taper of 0.06 for root canal preparation.[14] This literature review reveals the lack of studies that compare these file systems in the context of apically extruded debris and irrigant during CH removal and instrumentation processes.

The present study investigated the differences in apically extruded debris and irrigant during root canal instrumentation and CH removal with RB, WOG, and F6. The null hypothesis is that no difference exists between the RB, WOG, and F6 file systems in terms of the amount of extruded debris, irrigant, and CH particles.

METHODS

The study protocol was approved by the University Ethics Committee (No: 2019-155). Seventy-eight extracted human mandibular premolar teeth extracted for periodontal or orthodontic reasons were selected for the study. Each tooth was examined with a radiographic examination to confirm a single straight root and root canal with a fully formed apex. Residual tissues, bones, and calculus on the teeth were removed. The crowns of the teeth were removed with a diamond disk. The lengths of the root canals were measured with a 15-K file (Dentsply, Sirona, Baillagues, Switzerland) until the tip of the instrument was visible from the apical foramen. The root canal lengths of all teeth were adjusted to 16 ± 1 mm. The apical patency was controlled with 10-K file (Dentsply, Sirona). The samples (n = 39) were assigned to the CH removal and instrumentation groups.

CH removal process

Root canals were prepared with One Shape files (25/.06) (MicroMega, Besançon, France), irrigated with copious amounts of distilled water and were then dried with sterile paper points (Diadent, Diadent, Diadent Group International, Burnaby, BC, Canada). The specimens were then filled with CH paste (Calsin, Dilman, Turkey) with a lentulo spiral (Dentsply-Sirona, Switzerland) and temporarily filled with CavitG (3M ESPE, Seefeld, Germany). The samples were kept for 21 days. After 21 days, the root canals were transferred to the test apparatus.

Figure 1. Installation of experimental device. An external glass bottle was used to stabilize the tooth and the residual recipient tube. A needle inserted into the bottle's silicone cap was used to equalize the pressure.

The samples were assigned to three groups (n = 13) according to the instrumentation techniques for the CH removal process: Group I: CH removal, RB (40); Group II: CH removal, WOG (35); Group III: CH removal, F6 (40).

Instrumentation process

The root canals were transferred to the test apparatus. The root canals were prepared with RB, WOG, or F6 for the instrumentation protocol. The samples were assigned to three subgroups (n = 13): Group IV: instrumentation, RB (40); Group V: instrumentation, WOG (35); Group VI: instrumentation, F6 (40).

For the irrigation procedure, 2 mL of distilled water was used for each tooth in all six groups. The procedure with the RB (40) instruments was performed with the X-Smart Plus motor (Dentsply, Sirona, Switzerland) in "Reciproc" mode. WOG (35) instruments were used with the X-Smart Plus motor in the "WaveOne" mode. The procedure with the F6 (40) instruments was performed with the X-Smart Plus motor with a conventional motion of 300 rpm and 2.5 torque.

After using the aforementioned file systems, 2 mL of distilled water was used as a final irrigation solution in all six groups.

Irrigant collection

Empty Eppendorf tubes were weighed three times on a 10^{-5} precision scale, and the average weight was recorded as the initial weight. The experimental model described by Myers and Montgomery (1991) was used. A hole was made in each stopper, and the tooth was fixed to the stopper by using an acrylic resin. A 27 gauge open-ended needle was inserted into each stopper to equalize the air pressure. Each stopper with the tooth and needle was then inserted into an Eppendorf tube; all tubes were placed in vials during instrumentation to prevent hand contamination (Figure 1). [15,16] After the instrumentation procedures, the calibrated tubes were prepared for volume measurements of extruded irrigant by filling them with the irrigation solution in 0.05 mL enhancements using a micropipette. The calibrations were marked at each level. The volume of the extruded irrigant was measured by placing the collection tube next to the calibrated tube. The volume of the extruded irrigant was recorded in milliliters (mL).

Debris collection
The Eppendorf tubes were removed from the test model and stored in a 70 °C incubator for 5 days. Upon evaporation of the available irrigant, the tubes were weighted thrice, and their average weight was recorded as the final weight. The weight of the extruded debris was calculated by subtracting the initial weight from the final weight.

Statistical analysis
The statistical analysis of the amounts of extruded debris and irrigant particles was performed using IBM SPSS Statistics 22 software (IBM SPSS, Inc., Chicago, IL, USA). The Shapiro–Wilk test was used to evaluate the assumption of normality. The amount of apically extruded irrigant for each file was normally distributed ($p > 0.05$), but the amount of apically extruded debris was distributed non-normally in the CH removal and instrumentation processes. The differences between the amounts of extruded irrigant and the file systems in the instrumentation and CH removal processes were statistically compared using one-way ANOVA. Meanwhile, the differences between the amounts of extruded debris and the file systems in the instrumentation and CH removal processes were statistically compared using the Kruskal–Wallis test. The significance level was set to $p < 0.05$.

RESULTS

All file systems caused the apical extrusion of debris and irrigant. Table 1 presents the median values and the mean values and standard deviations of the amounts of apically extruded debris and irrigant during the instrumentation and CH removal processes. Extruded debris and irrigant were observed in all six groups, but no significant difference was noted between the groups in terms of the amount of apically extruded debris and irrigant ($p > 0.05$). Moreover, no statistically significant difference was found between the three file systems.

DISCUSSION

Pain may occur as a result of preoperative pain history and occlusal trauma or chemical, mechanical, or bacterial irritants during root canal preparation.[17] During these procedures, the debris consisting of dentin, necrotic pulp tissue, and bacteria extrude to the periapical tissue, resulting in the inflammation of the periodontal ligament.[3] The design of the files in the statement of neuropeptides after root canal preparation is known to be more effective than the number of files and the type of motion.[18] To date, no instrumentation technique has been shown to completely obstruct debris extrusion.[19] In the present study, all the tested instruments caused the apical extrusion of debris and irrigant to some degree; these results are in accordance with the findings reported in previous studies.[20,21] No statistically significant difference was observed between the tested instruments and the other systems. Thus, the null hypothesis was not rejected.

Different from rotational systems that enable the movement of debris coronally, reciprocating systems move the debris toward the apex.[22,23] In this study, two reciprocating instruments produced different sums of apically extruded debris and irrigant. Karatas et al. showed that the WOG system extrudes less debris than the WO system. The WOG system has a parallelogram design and two cutting edges and is thus more flexible than the WO system. This feature may be responsible for the lower amount of apical debris in the former.[21] Keskin and Sarıyılmaz also reported that in the retreatment process, the WOG system extrudes less apical debris than the RB system.[20] In the CH removal process in the current study, the RB system produced more extruded debris and irrigant than the WOG system. This result may be due to the different reciprocation movements of the systems. The WOG system is used in the "WaveOne all" mode, which features 120° counterclockwise and 60° clockwise movements. The RB system is used in the "Reciproc all" mode, which features 150° counterclockwise and 30° clockwise movements. In the comparison of reciprocating systems and continuous rotation systems, Topçuoğlu et al.[24] and Nayak et al.[25] showed that reciprocating systems cause more debris extrusion than some rotation systems. In parallel with the results of the present study, Kocak et al.[26] found no statistically significant difference between reciprocating systems and rotary systems. In the present study, although the F6 system caused less debris and irrigant extrusion than the other systems, no statistical difference was observed.

Apart from instrument movement, the final apical diameter has been shown to be related to apical extrusion.[10, 21] In this study, the apical widths of the root canals were 35 in the WOG file system and 40 in the RB system and F6 file systems. Moreover, the files used in this study had different cross-sectional designs, that is, the RB and F6 files were S-shaped while the WOG was a parallelogram.[11,13,14] The offset cross section and the reduced taper can explain the amount of debris and irrigant extrusion in the WOG group relative to the RB group. The alternative one-point contact with the cutting edges of the WOG in line and the enhanced alloy (M-Gold Wire) can explain the low amount of

Table 1. Comparison of debris and irrigant extrusions for CH removal and instrumentation groups

		Debris extrusion			Irrigant extrusion		
	Groups (n = 13)	**Median (g)**	**Test**	**p**	**Mean ± SD (mL)**	**Test**	**p**
CH removal groups	Group I	0.001			0.9469 ±0.16		
	Group II	0.0007	2.280[a]	0.320	0.7153 ±0.119	0.852[b]	0.435
	Group III	0.0005			0.7115± 0.154		
Instrumentation groups	Group IV	0.0004			0.9769 ±0.186		
	Group V	0.0005	0.324[a]	0.725	0.9307 ±0.149	0.324[b]	0.725
	Group VI	0.0003			1.1153 ±0.168		

[a]Chi-square value for Kruskal–Wallis test, [b]F value for ANOVA test

CH debris extrusion. The similar results of the F6 and RB files may be attributed to their cross-sectional similarities.[27]

In the present study, debris was gathered in Eppendorf tubes, and the specimens were irrigated with distilled water to avoid the formation of sodium hypochlorite (NaOCl) crystals. In the study conducted by Farmakis et al.,the specimens were irrigated with NaOCl and EDTA and consequently showed debris caused by the crystal formation of NaOCl.[28] Therefore, we did not use NaOCl for the irrigation solution.

The experimental model designed by Myers and Montgomery,[15] which is generally accepted, was used to measure the amount of apically extruded debris.[15] However, this experimental design is limited because it is unable to mimic periapical tissues; thus, the back pressure simulation provided by periapical tissues cannot be imitated. Altundasar et al.[29] used a cube-shaped floral foam attached to each root end to mimic the resistance of periapical tissues; although the amount of irrigant and debris was measured using this arrangement, the individual quantities could not be measured.[29] Therefore, the technique was not used in the current work to measure the amount of irrigant. Lu et al. proposed a 1.5% agar gel model because it mimics periodontal tissues.[30] The agar gel model shows similar resistance to periapical tissues during debris extrusion. However, this method suffers from limitations because the agar gel does not imitate all periapical tissues and its thickness around the apex is standardized. The intensity of periapical tissues varies in some cases, such as in granulation tissues, cysts, and periapical bone destruction.[31] Therefore, this method is also not realistic to use. The results may differ in teeth surrounded by periapical tissues. Therefore, the results could not be generalized and applied directly to clinical conditions.

CONCLUSION

No difference was observed between the amounts of apically extruded debris and irrigant during the removal of CH or root canal preparation procedures using three different endodontic file systems.

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