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Comparison of Two Reciprocating and Anatomical Single File Techniques in Cleaning Oval Anatomies

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Introduction: The present study aimed to compare the capability of two single-file shaping systems in disinfecting and cleaning long oval root canals. **Materials and Methods**: Fifty single-rooted teeth were prepared, contaminated with *Enterococcus faecalis* and divided into two groups. Two samplings were obtained; S1 before chemo-mechanical preparation and S2 after the preparation. Depending on the group, chemo-mechanical preparation was performed with XP-endo Shaper (XPS) and Wave One Gold (WOG). Five teeth from each group were observed under scanning electron microscopy (1000×) to evaluate the cleanliness of root canals at 3, 6 and 9 mm from the apex. All probability (*P*-values) were two-tailed, statistical significance was set at 0.05 and analyses were conducted using SPSS statistical software. **Results**: A significant reduction in the colony forming units was observed from S1 to S2 in both tested groups. In S2, XPS group obtained significantly lower colony forming units ($P<0.001$). In the cleanliness study, XPS group resulted in significantly cleaner canals compared to WOG. **Conclusions**: Based on this *in vitro* study XPS system was more effective in disinfecting and cleaning long oval canals.

Keywords: Anatomical Instruments; Oval Canals; Reciprocating; Wave One Gold; XP-endo Shaper

Introduction

The main purposes of root canal treatment are the shaping and disinfection of endodontic space in order to reduce bacterial population and stimulate periapical healing [1]. However, the complex root canal anatomy has always been the major difficulty in the achievement of above-mentioned goals. The irregularities of root canal space and tendency of anatomical sites to be more oval-shaped than round [2-4] pose a greater difficulty for the round rotary files to shape and disinfect properly. According to micro-computed tomographic studies, round files tend to leave a considerable amount of endodontic space untouched, which in large canines, can be estimated up to 80% of the whole anatomy [5, 6].

In the last decade, single-file instrumentation has become a common method for the treatment of root canals. Owing to the evolution in nickel-titanium (Ni-Ti) endodontic metallurgy and technology, cyclic fatigue is not deliberated as a major concern anymore. In addition, with the combination of the reciprocating movement, shaping root canals with a single file has become predictable, time wise and cost-effective. However, files used in single-file shaping techniques are round in shape, and the majority of studies conducted on single-file techniques have focused on resistance, cutting efficiency and cyclic fatigue [7-12].

The newest introduction in shaping files are the anatomical files which tend to be not round but mostly with an helicoid space, specifically designed to adapt for the root canal anatomy [13]. One of the earlier introduced anatomical files is XP-endo Shaper (FKG, La Chaux-De-Fonts, Switzerland) (XPS) [13-17]

The current study compared XPS and the reciprocating file, WaveOne Gold (WOG) (Dentsply Maillefer, Ballaigues, Switzerland), as well as their ability to remove *Enterococcus faecalis (E. faecalis)* biofilm from oval canals in extracted human teeth. The two files have different movements, alloys and applications, and several studies have highlighted their high performance in shaping ability [18, 19] and resistance to cyclic fatigue[13, 19]. A null hypothesis, that the two instruments were equally capable to erase bacteria and smear layer from the root canal space of long oval canals, was set.

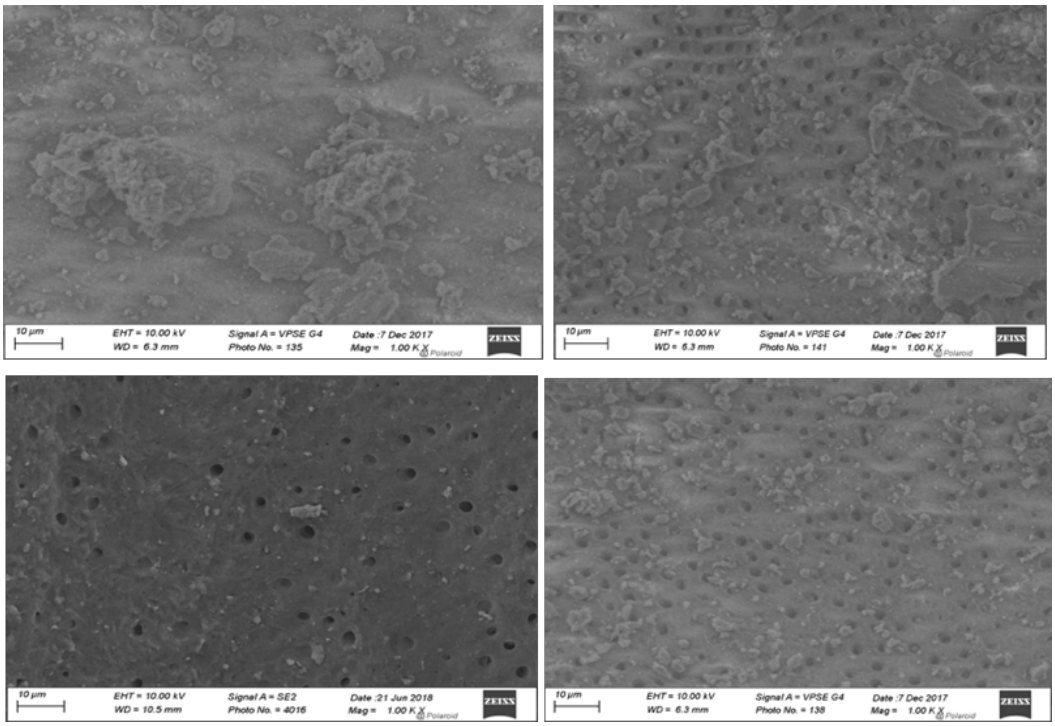

Figure 1. Representative captures of XP-endo Shaper samples with scores 4-1 clockwise

Materials and Methods

Fifty extracted teeth with oval-shaped canals (canines, premolars) were chosen the process is analysed underneeth. Radiographic examination was performed in two aspects, *i.e.* bucco-lingual and mesio-distal, in order to evaluate the integrity of roots and confirm the oval shape (bucco-lingual: mesio-distal > 2.5:1, 5 mm from the apex). Anatomical uniformity was ensured by selecting teeth 23-25 mm long.

A manual glide path with a #20 K-file (FKG, La Chaux-De-Fonts, Switzerland) was created for all teeth. Then, the irrigants used during access preparation were inactivated by 10 mL of 10% sodium thiosulphate (Na2O3S2), followed by 5 mL of distilled water. Next, all samples were immersed in trypticase soy broth (TSB), and were sonicated in an ultrasonic bath for 1 min to remove entrapped air and cause culture media infiltrate easier in the internal anatomy of the root. Finally, teeth were sterilised in an autoclave for 20 min at 121˚C [20-22].

The next step was to contaminate the sterile samples with *E. faecalis* strain (ATCC 29212) [23, 24]. To create the suspension, 1 mL of a pure *E. faecalis* culture, grown in TSB for 24 h, was added to 5 mL of fresh TSB. This suspension was used to contaminate the flasks where teeth were placed (1 mL for each flask). *E. faecalis* was allowed to grow for 30 days at 37˚C hand shaken in order to spread uniformingly. The culture media were replenished every week.

Following contamination, two shaping groups were created (n=25). Although division was random to maintain volumetric and anatomical correspondence, similar teeth were evenly divided between the two groups. An apical seal was placed through an epoxy resin block to avoid bacterial leakage and create vapour-lock [22-24]. Working length was determined by placing a #10 K-file up to the resin block, paying attention not to disrupt the seal. Before starting the shaping procedures, the first sample was taken (S1).

Sampling procedures

Bacterial sampling was performed before chemo-mechanical preparation (S1) where the root canal space was flooded with sterile saline solution in order to avoid overcoming the borders of the tooth. Then, the liquid was dried out with sterile paper cones of small diameters. The second sampling (S2) was performed after shaping. To avoid false negatives due to the presence of sodium hypochlorite in the canal, Na2O3S2 filled the canal for 5 min, which was then washed away through 10 mL of saline solution. Before sampling with the use of a pre-curved sterile K-file (#15), debris was scratched away for the irregularities. The content of canals was entirely absorbed by sterile paper cones. All sampling paper cones were immediately placed in cylinders with 1 mL of sterile solution and processed [22].

After vortex for 1 min, samples were diluted 10-fold in saline, and 100 mL of each solution was laid over blood agar plates and incubated at 37˚C for 48 h. Considering the known dilution, colony forming units (CFUs) were calculated and quantitative CFU evaluation was performed.

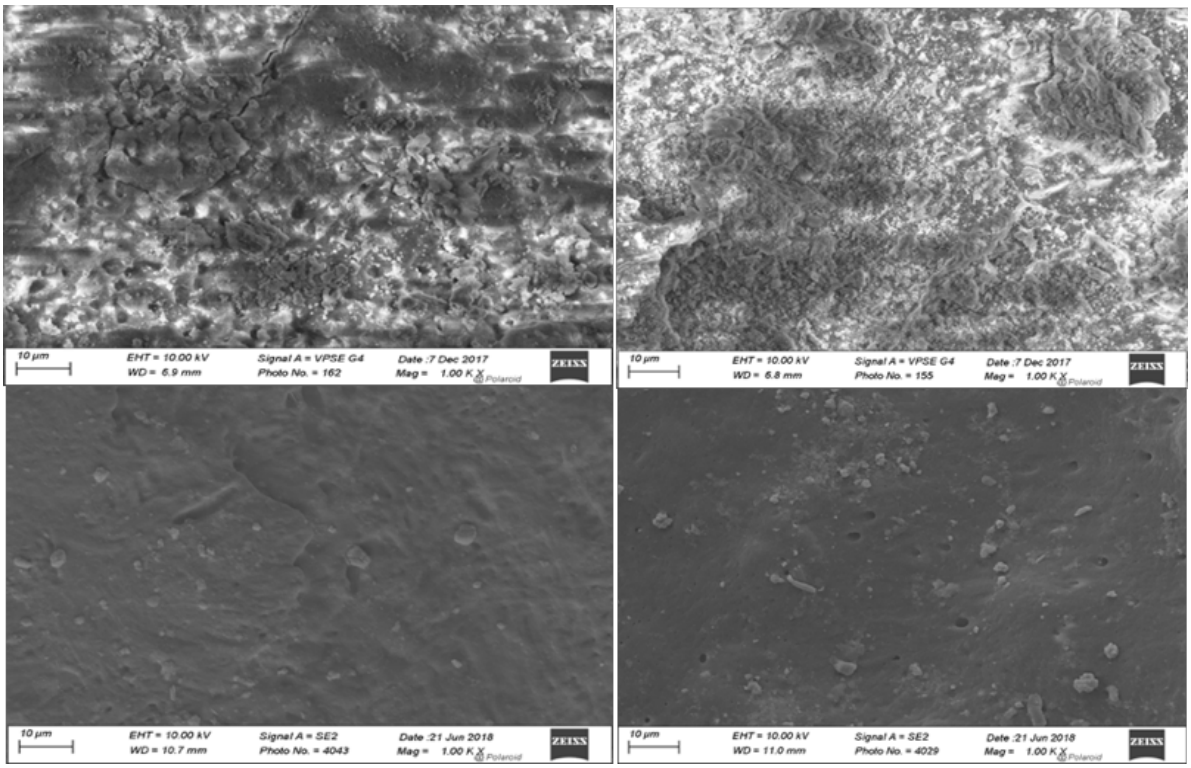

Figure 2. Representative captures of WaveOne Gold samples with scores 4-1 clockwise

Following the first sample (S1), teeth were treated according to their group:

XPS group: Chemo-mechanical preparation was performed with XP-endo shaper in accordance with the protocol provided by the manufacturer. Initially, the file had to reach the working length (WL) in three to five strokes. Once the WL was reached, the file was removed and cleaned with a sterile gauze, and reintroduced into the canal for ten more long strokes. The mean WL of teeth treated was 24 mm, and the average working time was calculated 3½ min (2.5-5 min).

WOG group: Chemo-mechanical preparation was performed with a medium (35.06) Wave One Gold in reciprocating motion. The file was introduced to the canal until it encountered resistance. At that point, it was removed, cleaned with a sterile gauze and re-introduced into the canal. The procedure continued until the file reached the WL. The mean working time was 4 min (3.5-5 min), and the average WL was 24.5 mm.

Identical irrigation protocols were followed in both groups. During chemo-mechanical preparation, sodium hypochlorite was utilised (2.5%, 15 mL) followed by EDTA (17%, 5 mL), which was then washed away by sodium hypochlorite (2.5%, 5 mL). Before the second sampling (S2), irrigation liquids were inactivated by sodium thiosulphate (10%, 5 mL), which was rinsed away by 10 mL of saline solution. All irrigants were brought in the canals with sterile luer lock syringes (10 mL) and sterile Irrflex needles (Products Dentaires SA (PD), Vevey, Swizerland). By the end of chemo-mechanical preparation, the second sampling (S2) was performed as described earlier.

Scanning electron microscope (SEM) evaluation

Subsequent to the second sampling, five teeth were selected from each group to be evaluated with SEM for the presence of smear layer. Selected samples were divided in half, along the long axis, to intactly preserve the large root area (in bucco-lingual dimension). The procedure was performed under an operating microscope, paying specific attention not to harm the internal side of the root. Sliced teeth were dehydrated and gold coated (40 μm) to become observable under SEM. The most intact of the two halves of each tooth was observed at magnification of 1000× in three spots; the apical (3 mm from the apex), mid (6 mm from the apex) and coronal (9 mm from the apex) third for smear layer. A score of 1-4 (score 1, best – score 4, worst) [25] (Figures 1 and 2) was attributed to the findings by the two independent examiners twice.

Statistical analysis tests

Non parametric Mann-Whitney U test was computed for the comparison of S1 and S2 among the two study groups. The intragroup comparison, S1 to S2, was performed using the Wilcoxon signed test. All p values were two-tailed. Statistical significance was set at 0.05, and analyses were conducted using SPSS statistical software (version 22.0).

Statistical analysis for SEM investigation

The agreement among measurements of the two examiners and the examiners themselves was analysed through Kappa values. Values ≥0.75 were considered as excellent agreement (maximum 1). Multivariable ordinal logistic regression models compared the resulting data. *P*-values were two-tailed, significance was set at 0.05, and data were analysed using SPSS version 22.00.

Results

Colony forming unit median values at the baseline were similar between WOG and XPS groups. Regarding S2 samples, CFUs were significantly higher in WOG group than those of XPS group (Table 1).

Intragroup analyses evaluating CFU reduction from S1 to S2 indicated a significant decrease in both WOG and XPS groups ($P<0.001$).

A lower probability for higher scores was found in XPS system as compared to WOG system. Additionally, it was found that location of the sampling was not significantly associated with the scores. (Tables 2, 3, 4).

Discussion

In the research conducted, the ability of removing viable bacteria and smear layer from long oval-shaped canals using two different single file techniques was investigated. Based on the obtained results, XPS group was significantly more effective in the cleaning of root canal space in long oval canals.

Currently, the single-file chemo-mechanical technique is a commonly used approach in endodontic treatments [26-28]. Even though it is easy and fast to perform, there is a deficiency in the effectiveness of such techniques in terms of disinfection and cleaning of root canal space. This is particularly observed in long oval root canal anatomies, which have always been difficult to clean and disinfect. In fact, it has been previously stated that during chemo-

Table 1. Colony Forming Unit (CFU) from the two samplings for each group

	S1		S2		
	Mean [a] (SD)	Median [b] (IQR)	Mean [a] (SD)	Median [b] (IQR)	*P*-value [c]
WaveOne Gold	5.87 (0.41)	5.75 (5.6-5.94)	2.59 (0.96)	2.65 (2.08-3.28)	<0.001
XP-endo Shaper	5.82 (0.41)	5.79 (5.5-6.26)	1.3 (0.82)	1.64 (1.06-1.93)	<0.001
***P*-value**	0.786		<0.001		

[a] Mann-Whitney test, [b] Wilcoxon signed rank test; [c] P<0.001, statistically significant

Table 2. Scores from the two examiners for each group

		Groups			
		WaveOne Gold		XP-endo Shaper	
		N	%	N	%
Score from the two examiners	**1**	5	17	11	36
	2	15	50	14	47
	3	6	20	5	16
	4	4	13	0	0
Total		30	100%	30	100%

N, stands for the actual number out of 30 samples that obained the score 1,2,3,4

Table 3: Results from the ordinal logistic regression analysis ($P<0.05$)

Groups	OR (95% CI)	*P*
XP-endo Shaper *vs.* WaveOne Gold	0.33(0.12-0.89)	0.029
LOCATION		
B *vs.* A	0.58 (0.18-1.91)	0.373
C *vs.* A	0.53(0.16-1.77)	0.308

OR: ordinal logistic regression

Table 4. The average scores separately for the three locations

Average score of the two examiners	Positions	Score	Groups			
			WaveOne Gold		XP-endo Shaper	
			N	%	N	%
Location	**A (apical)**	**1**	3	30	2	20
		2	3	30	5	50
		3	2	20	3	30
		4	2	20	0	0
	B (middle)	**1**	0	0	5	50
		2	7	70	4	40
		3	2	20	1	10
		4	1	10	0	0
	C (coronal)	**1**	2	20	4	40
		2	5	50	5	50
		3	2	20	1	10
		4	1	10	0	0
Total			30		30	

mechanical preparation of long oval canals, rotary files are in contact with a very small percentage of the root canal space; leaving up to 80% of the root canals untouched [21]. Therefore, it could be assumed that single file technique(s) might well perform even worse.

The tested instruments had two different characteristics: (i) reciprocating *vs* rotating movement, and (ii) WOG is a round file while XPS is an anatomical file, which has the ability to better follow the anatomy of long oval-shaped canals in comparison to the round files. In fact, it was shown that XPS achieved a significantly higher percentage of contact with dentinal walls compared to the Vortex blue file system in long oval canals [29] [14, 15].

In this study, the ability of two single-file techniques to clean the root canal space from viable *E. faecalis* through microbiologic examination and optical microscopy in long oval canals was tested. The microbiological technique utilised was not the most advanced through microbial cultures this method was utilised because it is actual relevant for this kind of experiment, but it is commonly used in such investigations [22, 24, 30]. Moreover, this technique has been found to be effective in the evaluation of the cleaning ability of endodontic instruments after bacterial contamination in previous studies [31].

Our findings showed that the intergroup analysis in both techniques produced a statistically significant result, which is mostly supported by similar investigations conducted previously [30, 32-37] and confirms that the use of endodontic instruments reduces intracanal bacterial load. Intragroup investigation in S1 showed no differences between the two groups, creating a relevant baseline. In this experiment, the contamination method depended on the anatomic site (volume of the root canal space of the tooth); therefore, the division of teeth into various groups needs to be carefully performed in order to segregate similar teeth into different groups [22, 30]. In the intragroup comparison in S2, the XPS obtained lower CFU counts than WOG, and the difference was significant. Similar results were obtained by Kaya *et al.* in a previous investigation. Although the investigation was conducted in round and not oval canals, the method was similar [37]. Furthermore, in a previous investigation in long oval canals using Wave One, which is similar in design and movement to WOG, the instrument obtained similar results in comparison to the round rotary files [30, 38].

Scanning electron micrographs revealed that XPS system shaped the dentinal walls better than WOG system. Consequently, it could be accepted that XPS system was able to clean the three portions of root canals better than WOG system. In other words, XPS instrument was able to contact a larger portion of dentinal walls compared to a round-designed instrument. This finding was also highlighted in previous studies; both in the direct comparison between XPS and WOG, and each instrument individually compared to different systems [29, 37, 39].

Conclusion

Both single file techniques obtained acceptable clinical results and significantly reduced the load of bacteria in comparison to the initial situation, *i.e.* before instrumentation. However, chemo-mechanical preparation through anatomical instrumentation with the XP-endo shaper resulted in more efficient cleaning and disinfection of the tested anatomies. Nonetheless, none of the two instrumentation systems rendered the root canals completely free from microorganisms.

Conflict of Interest: 'None declared'.

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