Effectiveness of three final irrigation protocols for debris and filling removal from simulated irregularities

Angela Longo do **NASCIMENTO**[1]
Aline Teixeira **MENDES**[1]
Lilian **TIETZ**[1]
Paula Barcellos **SILVA**[1]
Pedro Henrique Marks **DUARTE**[1]
Ricardo Abreu **DA ROSA**[1]
Natália **VILLA**[1]
Marcus Vinícius Reis **SÓ**[1]

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ABSTRACT

This study aimed to assess three final irrigation protocols on debris and filling removal from simulated irregularities. **Methods:** Seventy-eight mandibular premolars were prepared with WaveOne Gold system 45.05, splitted longitudinally, and a standardized groove was performed in the apical portion of the canals. Six roots served as negative control. The roots were randomly divided into two main groups (n = 36). The grooves were filled with dentin debris in thirty six roots. The others thirty-six were filled with gutta-percha and endodontic sealer using Tagger hybrid technique. Each main group was then divided into three groups (n = 12) according to the final irrigation protocol: Easy Clean, passive ultrasonic irrigation (PUI), and XP Clean. In Easy Clean 2.5% NaOCl activation was performed for 3 cycles of 20 seconds and XP Clean for one minute under reciprocating and continuous rotary motion and continuous rotary motion, respectively. In the PUI group, the irrigant was activated in three periods of 20 seconds. **Results:** No association was found among the scores of debris removal and the irrigation protocols (p = .165). An association was observed among the filling material removal scores and irrigation protocols (p< .05). **Conclusion:** Easy Clean, PUI and XP Clean were effective for dentin debris removal, but did not for filling material from artificial grooves in the apical third.

Keywords: Endodontics. Microscopy, Electron. Root Canal Filling Materials.

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[1] Universidade Federal do Rio Grande do Sul, Departamento de Odontologia Conservadora (Porto Alegre, RS, Brazil).

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Contact address: Angela Longo do Nascimento
E-mail: angelalongo@gmail.com

Introduction

The root canal anatomy presents a complex morphology with areas of irregularities, lateral canals, isthmuses, and apical deltas, favoring the presence of pulp tissue, microorganisms, dentin debris from root canal preparation and even remaining of root filling material in cases of endodontic retreatment.[1-5] Studies have shown that the presence of debris hamper the correct cleaning and sealing ability of the root canal system.[3,6]

The disinfection of root canal system is achieved with chemical, mechanical and physical preparation enabling a better cleaning in areas of anatomic complexity as isthmuses and lateral canals.[7] According to Peters, Schonenberger and Laib[8] irrespective of the root canal preparation technique, 35% of the root canal surface remain uninstrumented. So, the nickel-titanium (NiTi) instruments perform the root canal shaping and then the irrigant can act in those areas promoting its antibacterial effect, tissue dissolution, and smear layer and filling material removal.

To improve the disinfection of the root canal system, several techniques and irrigation devices have been proposed.[9,10] Passive ultrasonic irrigation (PUI) is an ultrasonic activation of the irrigant using a smooth instrument positioned within the root canal.[11] PUI demonstrated a cumulative effect on removing dentin debris from the root canal.[12]

EasyClean (Easy Equipamentos Odontológicos, Belo Horizonte, Brazil) consists in plastic instruments with the goal of optimize the action of the irrigant over the biofilm and debris.[13] This device presents a smooth surface, and tip size of 0.25 mm and taper 4% with an ''aircraft wing''- shaped cross-section. EasyClean was designed to operate in reciprocating motion (i.e., a 1800 clockwise and 900 counterclockwise).

Recently, a new instrument (XP Clean, MK Life, Porto Alegre, RS, Brazil) was developed to activate the irrigant, optimizing the remaining debris removal, by touching areas that were not cleaned during root canal shaping. XP Clean has a snake-like presentation, a size #25 tip, taper of .02, triangular cross section. It must be used under rotary motion with speed of 800 rpm and 1N of torque.

This study aimed to assess three final irrigation protocols (EasyClean, PUI, and XP Clean) on debris and filling removal from simulated irregularities. The null hypothesis was that there would be no differences among the final irrigation protocols for dentin debris and filling material removal.

Material and Methods

This study was submitted and approved by the Ethics Committee of the Federal University of Rio Grande do Sul (number 78299717.7.0000.5347).

Sample size and selection

For sample size calculation it was considered an average proportion of 25% and power of 80% in the chi-square test of homogeneity to compare the groups[14]. Seventy-eight human mandibular premolars were select and stored in distilled water until use. The crowns were removed and the roots were standardized to a length of 15 mm.

Experimental procedures

The working length (WL) was established in 14 mm. The root canal preparation was performed with performed with the reciprocating WaveOne Gold system 45.05 (Dentsply-Sirona, Ballaigues, Switzerland) activated by an electric motor (VDW Silver; VDW Company, Munich, Germany) using the "WaveOne all" mode as recommended by the manufacturer. During root canal preparation, the teeth were irrigated with 2 mL of 2.5% NaOCl after each file change (Biodinâmica Ltda, Ibiporã, PR, Brazil). The irrigant was delivered into the root canals by using a 5 mL silicon syringe (Injex, Ourinhos, SP, Brazil) with 27-G tips (Navitip; Ultradent, South Jordan, UT, USA) placed 3 mm shorter than the WL.

The specimens section and groove preparation were designed as described on material and methods by Justo.[7] Six roots served as negative control. The groves were kept empty, and the protocols were performed as described soon. Half of the specimens had the simulated canal irregularities filled with dentin debris.

The root halves were joined together, and fixed with a ligature (0.2 mm in diameter) (Morelli, Sorocaba, SP, Brazil). Next, they were interlocked with orthodontic pliers #121 (Golgran, São Paulo SP, Brazil). The apexes were sealed again using utility wax. Then the specimens were embedded in condensing

silicone (Dentsply, Petrópolis, RJ, Brazil). The other half of the specimens were joined together as described before and filled with gutta-percha (MK Life) and with calcium salicylate-based sealer (Sealer Plus BC; MK Life) using the Tagger's hybrid technique. The coronal cavity was sealed with temporary material (Cavitec; Coltene, USA). All roots were stored for 1 week at 37°C and 100% humidity to allow the sealers to set.

After one week, retreatment procedures were performed in the specimens filled with gutta-percha and sealer. The root canal fillings were removed with R50 files of Reciproc system (VDW GbmH, Munich, Germany) with an electrical motor X-Smart Plus, in reciprocating mode.

Irrigation protocols

The samples filled with dentin debris and those submitted to endodontic retreatment were randomly divided into three groups each (n=12) according to the final irrigation protocol:

» EasyClean - The canals were irrigated with 6 mL of 2,5% NaOCl and activation with Easy Clean was performed for 3 cycles of 20 seconds with an electrical motor (X Smart Plus; Dentsply - Sirona) in a reciprocating mode according to the instructions of the manufacturer. After the activation of the irrigant, the root canals were rinsed with 5 mL of saline solution (Quinta Essência, Porto Alegre, RS, Brazil).

» PUI - The canals were irrigated with 2 mL of 2.5% NaOCl and PUI was performed, with an Irrisonic tip (HelseUltrasonics, Santo Antônio do Viterbo, São Paulo, Brazil), for 1 minute, divided in 3 cycles of 20 seconds of activation.[12] Between each period of activation, 2 mL of the irrigant was delivered into the root canal. The total volume of NaOCl was 6 mL. After the ultrasonic activation, the root canals were rinsed with 5 mL of saline solution. PUI was performed using NAC Plus device (AdielLtda, Ribeirão Preto-SP, Brazil) with a 30 kHz frequency, an intensity of 7.5 W and extend between 20 and 30 µm, at 1 mm from WL. The insert remained in the center of the root canal oscillating parallel to the direction of the groove and with no touching in the canal walls.[15]

» XP Clean - Canals were irrigated with 6 mL of 2.5% NaOCl and activation with XP Clean file was performed for 1 minute with an electrical motor X-Smart Plus in continuous rotary motion (900 rpm and torque of 4 N) according to the instructions of the manufacturer. After activation, the root canals were rinsed with 5 mL of saline solution.

The final irrigation protocols were performed equally in dentin debris groups and in those roots submitted to endodontic retreatment.

Scanning Electronic Microscopy (SEM) and Assessment Criteria

The root half of each specimen that had the groove was analyzed using a scanning electron microscopy (JEOL 6060; JEOL, Tokyo, Japan). The grooves were assessed at a magnification of ×30 and ×90.

The effectiveness of debris removal and filling material from the grooves was evaluated by assessment criteria described by van der Sluis, Vogels, Verhaagen, Macedo, & Wesselink.[12]

Two examiners previously calibrated and blinded for the experimental groups performed the assessment of the SEM images. The examiners received the images to evaluate, and repeated the evaluation after 24h, to determine the agreement intra-examiner. The agreement intra- and inter-examiners was evaluated using the kappa test.

Data analysis

All the obtained data was put in a spreadsheet (Microsoft Office Excell 2007, Microsoft Corporation, Redmond, WA, USA) and statistically analyzed using SPSS 19.0 software (SPSS Inc., Chicago, IL, USA). Debris and filling removal among the groups and the association among then were analyzed by chi-square distribution and the adjusted Pearson residual analysis. The frequency scores of debris removal and filling material were analyzed by the nonparametric Kruskal-Wallis test. The significance level was set at 5%.

Results

The Cohen kappa coefficient of interrater reLaibility was 0.83. In 13 SEM images, the scores attributed by the examiners were divergent. Then, the scans were evaluated again and a consensus was reached.

The scores of debris removal and the final irrigation protocols were not associated (P = .165). Debris removal scores were not dependent on the protocols tested. An association was observed among the filling material removal scores and the final irrigation protocols (P < .05). The adjusted residual analysis revealed that the frequency of score 3 was significantly lower than expected in Easy Clean group and higher than expected for XP Clean. Table 1 presents the frequency distribution of debris and filling material removal scores for Easy Clean, PUI and XP Clean.

Figure 1 shows SEM images that represent the median scores for debris and filling material removal after the experimental protocol using Easy Clean, PUI and XP Clean.

Table 1. Frequency distribution of debris and filling material removal scores for each experimental group.

Scores	Debris				Material Obturador			
	Easy	IUP	XP	Total	Easy	IUP	XP	Total
1	8 (66.7%)	11 (91.7%)	7(58.3%)	26 (72.2%)	0 (0%)	1 (2.8%)	0 (0%)	1 (2.8%)
2	4 (33.3%)	1 (8.3%)	5 (41.7%)	10 (27.8%)	5 (13.9%)	3 (8.3%)	2 (5.6%)	10 (27.8%)
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1* (2.8%)	5 (13.9%)	8† (22.2%)	14 (38.8%)
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (16.6%)	3 (8.3%)	2 (5.6%)	11 (30.6%)
Overall	12 (33.3%)	12 (33.3%)	12 (33.3%)	36 (100%)	12 (33.4%)	12 (33.3%)	12 (33.3%)	36 (100%)

Pearson's chi-square test (P = .165) for debris; Pearson's chi-square test (P < .05) for filler material. *Frequency of scores significantly lower than expected, measured by adjusted residual analysis. †Frequency of scores significantly higher than expected, measured by adjusted residual analysis.

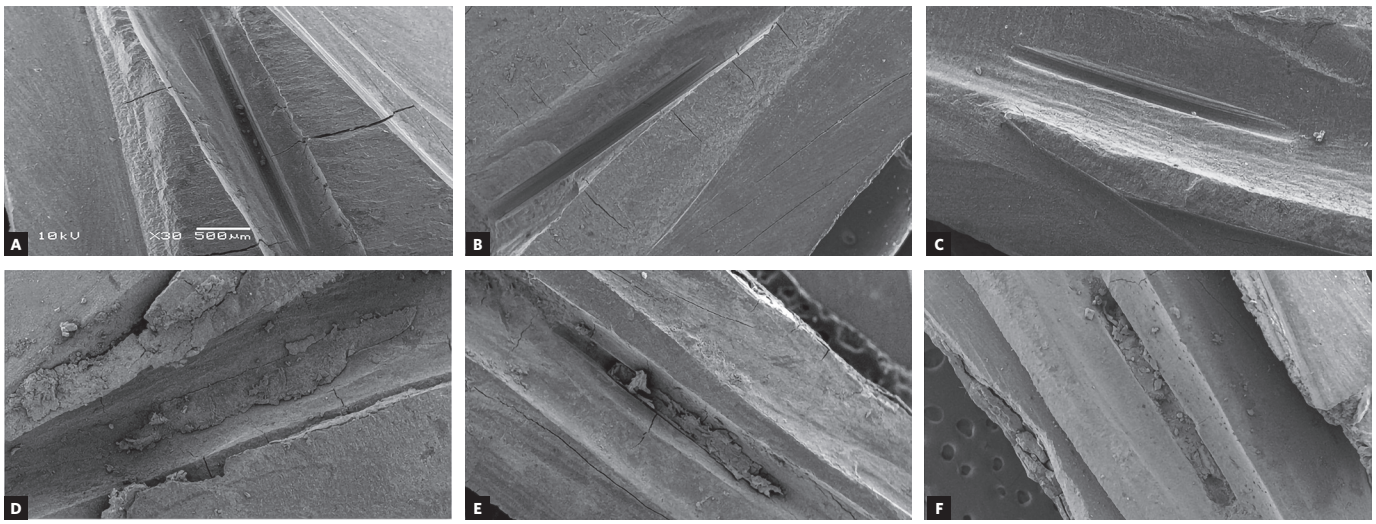

Figure 1. Scanning electron microscopic images (×30 and ×90) representing the median scores for dentin debris and filling material removal. Empty groove for debris: EasyClean **(A)**; PUI **(B)**, and XP Clean **(C)**. Groove completely filled with filling material: EasyClean **(D)**. More than 50% of the groove filled with filling material: PUI **(E)**, and XP Clean **(F)**.

Discussion

This study was designed based on a previous study[7] and aimed to evaluate dentin debris removal and remaining of root canal filling from simulated grooves in the apical third of single-rooted teeth. The irregularities performed artificially in this study consisted in a groove with semicircle shape. This anatomic feature is found in isthmuses, extremity of oval canals, and untouched canal walls after canal preparation. In these situations, remaining dentin debris and, in endodontic retreatment cases, filling material may remain obliterating the dentinal tubules and protecting microorganisms against the action of the irrigant or root canal dressing.[16]

The null hypothesis was rejected. An association was observed among the filling material removal scores and the final irrigation protocols. However, no association was found among the scores of debris removal and the final irrigation protocols (p=.165). All groups presented significantly lower scores for debris removal, but no differences were observed among Easy Clean, PUI and XP Clean (p >.05).

For the EasyClean group, the reciprocating motion for irrigant activation is a new idea, and it was used in recent studies.[13,17] XP Clean is a new instrument to be used with de same aims of EasyClean but under continuous rotary motion. Up to this moment, there are no studies that aimed to evaluate the effectiveness of XP Clean to activate the irrigant after complete root canal preparation.

Contrary to our findings, Kato et al.[13] showed that activating the irrigant with EasyClean promoted more effective debris removal from the apical third of canals when compared with PUI. The effectiveness of PUI in this study is in accordance with previous studies[7,12,18] that showed that debris removal was related more closely to the physical phenomenon of PUI than the chemical nature of the irrigant. XP Endo presented results comparable to those observed in EasyClean and PUI groups. The scores in XP Endo group for dentin debris could not be compared to other studies because there is no study with XP Endo. But this result can be explained for the design of this instrument, which in the continuous rotary motion promotes a snake-like movement enabling the touching of the root canal walls, mainly in areas did not prepared by the rotary files.

Only the scores 1 and 2 was observed, when the protocols were used to remove dentin debris from the groove. On the other hand, when the final irrigant protocols were performed to remove root canal filling from the grove, scores 3 and 4 were predominant. This can be explained because the micromechanical retention between the endodontic sealer and the root canals walls, that makes the sealer removal harder than the dentin debris removal.

The scores of filling material removal were influenced by the final irrigation protocols (P < .05). The frequency of score 3 was significantly lower than expected in the EasyClean group and higher than expected for XP Clean. The median of the scores of filling material after final irrigation protocols were similar among the groups (P > .05). Also, no study assessed the action of EasyClean and XP Endo regarding filling material removal of root canal walls and natural or simulated isthmus.

It´s important to highlight the use of a calcium-silicate based sealer because no studies discussed its removal from canal irregularities. Reyes-Carmona, Felippe, & Felippe[19] observed that the precipitation of the calcium-silicate based sealers induces a biomineralization process responsible for the development of an interfacial layer with tag-like structures at the dentin-cement interface. This fact can explain the root filling material that remained in the isthmus area. Additionally, Barreto et al.[20] showed that mesial roots of mandibular molars with an isthmus contained a more substantial amount of residual filling material at all root thirds evaluated. The penetration of gutta-percha and sealer into the isthmus and irregular areas make removal of the filling more critical in roots with such anatomical features. In our study, a large amount of root filling material remains in the simulated isthmus.

Conclusion

EasyClean, PUI, and XP Clean equally improved the dentin debris removal from the simulated irregularities in the apical third of single rooted teeth, but they were not efficient in removing the root canal filling. The lowest scores were observed for dentin/debris evaluation and the highest ones for filling removal.

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