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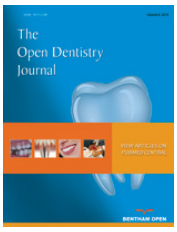

Ability of Three Endodontic Sealers to Fill the Root Canal System in Association with Gutta-Percha

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Abstract:

Introduction:

The present study compared the ability of the endodontic sealers AH Plus, Pulp Canal Sealer and EndoREZ to fill the root canal system in association with gutta-percha.

Methods:

Ninety mandibular premolars were accessed, prepared and divided into three groups of 30 teeth each, according to the sealer used to fill the canals: AH Plus, Pulp Canal Sealer and EndoREZ. All the teeth were filled using the continuous wave of condensation technique. The specimens were then decalcified, dehydrated, rendered transparent, and analyzed by three independent evaluators with 8x magnification. Chi-squared test (χ^2, $p < 0.05$) was used to compare the groups in relation to the totally filled, the partially filled and the non filled ramifications. The same test was used to compare the directions of filled ramifications and the number of ramifications among the three thirds of the roots.

Results:

EndoREZ filled a significantly higher number of ramifications than AH Plus and Pulp Canal Sealer (χ^2, $p < 0.05$). All the groups showed higher number of totally filled ramifications than partially filled and unfilled ramifications. The ramifications were more frequently detected in the apical third, followed by medium and coronal thirds, respectively (χ^2, $p < 0.05$). The ramifications were more frequently detected towards lingual direction (χ^2, $p < 0.05$).

Conclusion:

EndoREZ presented higher ability to fill the root canal system in association with gutta-percha when compared to AH Plus and Pulp Canal Sealer. The ramifications were more frequently detected in the apical third, running in a lingual direction.

Keywords: Endodontic sealer, endodontic treatment, ramifications, root canal anatomy, root canal filling, root canal system.

INTRODUCTION

The root canal system (RCS) has a complex internal anatomy with high prevalence of ramifications [1 - 4]. In cases of endodontic infection, the ineffective cleaning and shaping of this system can cause failure of endodontic treatment and maintenance of the disease due to bacterial biofilm colonizing accessory canals [5]. Filling procedures also have a role in favoring and maintaining adequate conditions for endodontic repair [6]. Therefore, the three-dimensional filling of the RCS is considered one of the most important requirements of a satisfactory endodontic treatment [7]. The use of sealing materials able to fill accessory canals can be seen as the correct approach to prevent any further contamination and diffusion of bacteria present in the deepest part of dentinal tubules and accessory canals [8].

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Currently, gutta-percha is used in association with an endodontic sealer to fill RCS. Endodontic sealers are used to fill the gap between the gutta-percha and the canal walls and to fill the irregularities of the RCS where gutta-percha cannot penetrate. Several materials have been studied aiming at improving the three-dimensional filling, thus providing an increase in the success rate of the endodontic treatment [6, 9 - 11]. According to some authors, gutta-percha usually penetrates the large accessory canals located at the coronal third of the root [3, 12]. The thin ramifications located at the medium and apical thirds are ordinarily filled by endodontic sealers. Consequently, the ability to penetrate in irregular areas is a very important property of the filling materials and must be considered when choosing an appropriate one [9]. Almeida *et al.* [9] observed that AH Plus, Epiphany Root Canal Sealant, Endométhasone, Pulp Canal Sealer (EWT) and Sealapex have similar ability to fill artificial lateral canals when the lateral condensation technique is used. However, according to Venturi *et al.* [13], AH Plus has a higher ability to fill lateral canals than Pulp Canal Sealer (EWT) when the vertical compaction with the apical backfilling technique is used.

AH Plus sealer (Dentsply, Maillefer, Ballaigues, Switzerland) is an epoxy based sealer which has an extensive history of use. It has good dimensional stability and promotes adherence to the canal walls [14]. Pulp Canal Sealer (SybronEndo, Glendora, CA USA) is a zinc oxide and eugenol based sealer widely used in endodontic practice. This sealer has plasticity, reduced setting time and reduced dimensional variation after setting [13]. EndoREZ (Ultradent Products Inc, South Jordan, UT) is a hydrophilic, dual-cured sealer containing zinc oxide, barium sulphate, resins and pigments in a matrix of urethane dimethacrylate resin. It can be used in the wet environment of the root canal system and is very effective in penetrating dentinal tubules and adapting closely to the canal walls [15].

In this context, the aim of the present study was to compare the ability of the endodontic sealers AH Plus, Pulp Canal Sealer and EndoREZ to fill the root canal system in association with gutta-percha. The frequency, location, and direction of the ramifications filled with these sealers were investigated.

MATERIALS AND METHODS

The present study was approved by the Research and Ethics Committee of the University Hospital of the Federal University of Rio de Janeiro (CAAE no. 0024.0.239.000-09). Ninety recently extracted human mandibular premolars were used in this study. They were immersed in a 5.25% sodium hypochlorite solution for two hours and stored at 4°C in distilled water until required. An endodontic access cavity was prepared in all teeth and the root canals were prepared using K3 files (SybronEndo, Glendora, CA USA), according to the Segmented Preparation Technique used by Barbosa *et al.* [2]. According to this technique, the coronal and medium thirds of the canals were prepared using a 25.06 NiTi rotary file (SybronEndo, Glendora, CA USA) mounted on an electric motor (Easy Endo, Belo Horizonte, Brazil) at 350 rpm. Gates-Glidden drills 1, 2, 3 and 4 (Dentsply, Maillefer, Ballaigues, Switzerland) were then sequentially used on these thirds of root canals with decreasing penetration and brushing movements. After this phase, the working length was determined introducing a #10 file (Dentsply, Maillefer, Ballaigues, Switzerland) in the canal until it was visible at the apical foramen. The apical portion of the canals was then prepared following the sequence of files: 15.04, 20.02, 20.04, 25.04, 20.06 and 25.06 (SybronEndo, Glendora, CA USA). All NiTi files were used to the working length. Irrigation with 5.25% sodium hypochlorite was carried out during all the instrumentation procedure. After the cleaning and shaping, the root canals were washed with 10 ml of EDTA solution during 3 minutes and then with 5.25% sodium hypochlorite. The final irrigation was made with 5 ml of distilled water. The root canals were dried with .06 paper points (Dentsply, Maillefer, Ballaigues, Switzerland).

Obturation of the Root Canals

The teeth were then randomly divided into three groups of 30 teeth each, according to the sealer used to fill the root canals: AH Plus sealer (Dentsply, Maillefer, Ballaigues, Switzerland), Pulp Canal Sealer (SybronEndo, Glendora, CA USA) and EndoREZ sealer (Ultradent, South Jordan, UT, EUA). All the teeth were filled using the Continuous Wave of Condensation Technique. According to this technique, medium gutta-percha cones (Endopoints Ind. e Comercio Ltda., Paraíba do Sul, Brazil) were fitted 1.0 mm from the working length. The sealers were prepared according to the manufacturers' instructions and introduced into the canals using a #15 file. The selected gutta-percha cone was coated with sealer and placed in the canal. More than one cone was used depending of the canals' shape. The System B Heat-Source (Analytic Technologies, Redmond, EUA) was used to remove the coronal portion of the cone. A medium size tip was placed in the canal with a silicone stopper set at 5 mm short of the working length, with temperature of 200°C. The Obtura II system (Obtura Corporation, Fenton, MO) was used for the back-filling, with application of gutta-percha in 4mm increments. The temperature of gutta-percha was 200°C when injected into the canal space. Once the obturation

of the root canals was concluded, the pulp chamber was cleaned with a small piece of cotton and alcohol, to remove the excess of sealer.

Sample Decalcification and Analysis

After twenty four hours, the filled teeth were immersed in a 5% hydrochloric acid solution during approximately four days at room temperature for decalcification. The decalcifying solution was changed every twenty four hours and agitated for five seconds twice a day. After the completion of the decalcifying process, the teeth were washed in running water during twelve hours to eliminate any trace of the acid substance. The teeth were then dehydrated with different gradients of ethyl alcohol - 75, 85, 96 and 100%, - by immersing them in each solution for four hours. After that, the teeth were rendered transparent in methyl salicylate and analyzed by three previously calibrated and independent evaluators using an optical microscopy (DFV, Valença, Brazil) with 8x magnification. Each evaluator analyzed the frequency, location and direction of the filled accessory canals. The evaluators were not informed to which group the teeth pertained, thus characterizing a blind study.

Statistical Analysis

The reliability among the evaluators was evaluated using the kappa coefficient (k). Chi-squared test (χ^2, $p < 0.05$) was used to compare the groups in relation to totally filled, partially filled and non filled ramifications (Fig. **1**). Chi-squared test (χ^2, $p < 0.05$) and Tukey test were used to compare the directions of filled ramifications and the number of ramifications among the three thirds of the roots.

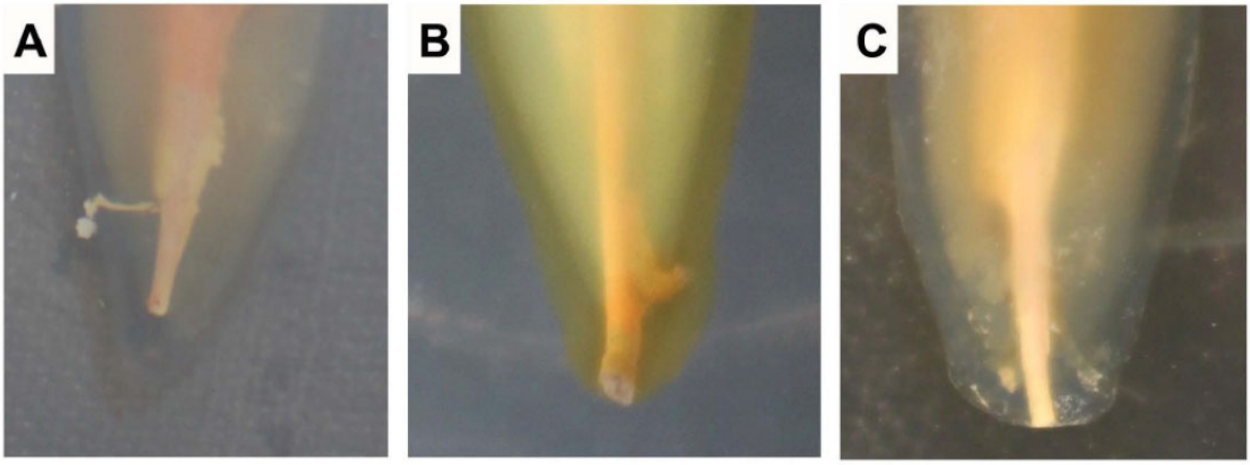

Fig. (1). (**A**) Totally filled ramification. (**B**) Partially filled ramification. (**C**) Non filled ramification.

RESULTS

The reliability among the evaluators was considered perfect (k=1.00). Homogeneity of the groups was confirmed, as they showed no statistical difference for the total number of ramifications (χ^2, $p < 0.05$). Table **1** summarizes the frequency and location of the totally filled, partially filled and unfilled ramifications in the three groups. All the groups showed higher number of totally filled ramifications than partially filled and unfilled ramifications (χ^2, $p < 0.05$). EndoREZ filled a significantly higher number of ramifications than AH Plus and Pulp Canal Sealer (χ^2, $p < 0.05$). There was no difference between AH Plus and Pulp Canal Sealer in relation to the number of filled ramifications.

Table **2** summarizes the direction and location of the ramifications. There was no significant difference among the groups in relation to these variables (χ^2, $p < 0.05$). In all groups, the ramifications were more frequently detected in the apical third, followed by medium and coronal thirds, respectively (χ^2, $p < 0.05$). The ramifications were more frequently detected towards lingual direction in comparison to buccal, mesial and distal directions (χ^2, $p < 0.05$).

DISCUSSION

The present study compared the ability of the endodontic sealers AH Plus, Pulp Canal Sealer and EndoREZ to fill the ramifications of the root canal system using the tooth-clearing technique. This method renders the teeth transparent and therefore allows to investigate the internal anatomy of the root canal system [2]. Nevertheless several methods have

been used to investigate root canal morphology, micro-CT examination and the tooth-clearing technique have been considered the gold standard methods for this purpose [16, 17]. Micro-CT examination is reproducible and applied both quantitatively and qualitatively for a three-dimensional assessment of the RCS, however it is an expensive technology that requires much time to acquire and process the images of a high number of specimens [18, 19]. On the other hand, the tooth-clearing technique used here is a simple and inexpensive method that also allows three-dimensional assessment of RCS. This method has been used to investigate the filling of accessory canals and the occurrence of microleakage after root canal filling with different techniques and materials [2, 3, 8, 9, 12, 13]. The present study evaluated the ramifications filled with three different sealers based on these studies. Mandibular premolars were used here because this group of teeth has a high number of ramifications, according to previous studies about RCS anatomy [1, 5].

Three different endodontic sealers were associated with gutta-percha to fill RCS: AH Plus, Endo Rez and Pulp Canal Sealer. The results showed that all the groups presented higher number of totally filled ramifications than partially filled and unfilled ramifications, which demonstrates that all sealers presented adequate flowing ability and were able to fill ramifications. A higher incidence of ramifications was observed in the lingual and buccal directions when compared to the other directions, which is in agreement with De Deus [1] and Barbosa *et al.* [2]. Consequently, a high percentage of the ramifications of the root canal system is not visible in the radiographs. According to our results, EndoREZ filled a significantly higher number of ramifications than AH Plus and Pulp Canal Sealer, which suggests superior flowing ability of the EndoREZ compared to the other sealers analyzed There was no difference between AH Plus and Pulp Canal Sealer in relation to the number of filled ramifications.

Table 1. Frequency and location of ramifications.

		AH Plus			**Pulp Canal Sealer**			**EndoRez**		
		TF	**PF**	**UF**	**TF**	**PF**	**UF**	**TF**	**PF**	**UF**
1/3 A	Apical delta	3	2	0	3	2	0	3	1	2
	Secondary	5	3	3	8	6	3	11	2	1
	Accessory	0	0	0	1	0	0	0	0	0
1/3 M	Intercanal	1	0	1	0	2	4	1	1	0
	Recurrent	0	1	0	0	0	0	1	1	0
	Colateral	1	0	0	1	1	0	1	0	0
	Lateral	1	1	0	0	0	2	0	0	0
1/3 C	Isthmus	0	0	1	1	0	0	1	0	0
Total		**11**	**7**	**5**	**14**	**11**	**9**	**18**	**5**	**3**
Percentage (%)		**47.82**	**30.44**	**21.74**	**41.18**	**32.35**	**26.47**	**69.23**	**19.24**	**11.53**

* TF = totally filled; PF = partially filled; UF = unfilled; 1/3 C = coronal third; 1/3 M = medium third; 1/3 A = apical third

The results presented here are in agreement with Almeida *et al.* [9], who reported that AH Plus and Pulp Canal Sealer have similar ability to fill artificial lateral canals when the lateral condensation technique is used. However, this result is not in agreement with Venturi [13], who reported that AH Plus has a higher ability to fill lateral canals than Pulp Canal Sealer. This discrepancy can be related to the different type of teeth used by that author. Our results are also in conflict with Chandra *et al.* [20], who observed that AH Plus sealer, presented higher penetration into the dentinal tubules than EndoREZ sealer. The results presented by those authors suggest that AH Plus presents a better flowing ability than EndoREZ. However, the authors used confocal microscope to determine the depth of penetration of the sealer into the dentinal tubules, which characterizes different experimental conditions compared to those used here. It should be noted that the ramification filling is not likely to exert significant antibacterial effects to eliminate residual bacteria in the ramification [5]. Consequently, it is extremely important to exhaust the strategies of RCS disinfection before filling this system, regardless the sealer to be used. The solution used to irrigate the RCS must have low surface tension and high antibacterial effect to clean and disinfect the irregularities and ramifications where the endodontic instruments cannot penetrate. The irrigation with 5.25% sodium hypochlorite used here has both properties.

The ramification filling does not ensure its complete sealing [5]. The sealers may have polymerization shrinkage and fail to avoid microleakage, debonding, and void formation. Consequently, the shrinkage associated with the polymerization reaction of resin based sealers like EndoREZ is a serious drawback in comparison to other sealers [10]. EndoRez presented higher shrinkage than AH Plus and TubliSeal, a zinc oxide-eugenol based sealer [10, 21], while Pulp Canal Sealer presented reduced dimensional variation after setting [13]. Regarding the sealing ability, EndoREZ exhibited significantly higher leakage than AH Plus [22]. However, its seal may be improved with the use of a dual-

cured self-etch adhesive, which produces apical and coronal seals at least as good as the AH Plus associated with gutta-percha [22, 23]. It should be noted that EndoREZ exhibited significantly higher solubility and water sorption than AH Plus [21], which tends to enable leakage.

The flowing and the sealing abilities of the material are not the only relevant aspects to be considered in the choice of the endodontic sealer. Radiopacity, clinical performance and biocompatibility of the sealers are also important properties. Though all the sealers tested here present acceptable radiopacity value according to ANSI/ADA Specification 57, EndoREZ radiopacity is significantly lower than that exhibited by AH Plus and Pulp Canal Sealer [24]. Regarding the clinical performance, a retrospective clinical and radiographic study suggests that EndoREZ used in conjunction with gutta-percha cones performs similarly to conventional endodontic sealers during a period of up to 8 years [25].

Regarding the biocompatibility, there is no consensus among the researches [6, 26 - 30]. Though Karapinar-Kazandag *et al.* [26] observed no or minimal cytotoxicity of both AH Plus and EndoREZ, some authors observed that AHPlus presented lower cytotoxicity than EndoREZ and EndoFill sealers [21, 27, 28]. In contradiction to those studies, Brackett *et al.* [29] observed that AH-plus and Pulp Canal Sealer were severely cytotoxic initially, but cell viability in contact with AH-plus increased markedly with time during a 6-week testing period. Zmener *et al.* [30] also observed that Pulp Canal Sealer showed a severe subcutaneous connective tissue reaction in rats and considered EndoREZ biologically acceptable when used with accelerator.

Table 2. Location and direction of lateral and secondary.

	Apical Third	Medium Third	Coronal Third	Total
Buccal	9 (20.93%)	4 (44.44%)	0	13 (24.52%)
Lingual	14 (32.55%)	3 (33.33%)	1 (100%)	18 (33.96%)
Mesial	9 (20.93%)	0	0	9 (16.98%)
Distal	11 (25.58 %)	2 (22.22%)	0	13 (24.52%)
Total	43 (100%)	9 (100%)	1 (100%)	53 (100%)

CONCLUSION

The conclusion from the results presented here is that EndoREZ presented higher ability to fill the root canal system in association with gutta-percha when compared to AH Plus and Pulp Canal Sealer. The ramifications were more frequently detected in the apical third, running in a lingual direction.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

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