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Comparison of three endodontic sealers penetration into simulated lateral canals

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Abstract

In vitro study was carried out to evaluate the ability of AH plus, Apexit Plus and IRoot SP sealers to fill artificial lateral canals in acrylic blocks with straight and curved main canals. Material and methods: Three root canal sealers were used: resin-based sealer AH Plus; calcium hydroxide based sealer Apexit Plus and bioceramic sealer IRoot SP. Fifteen Thermafil (Dentsply Maillefer) training resin blocks with two curved canals with curvature of 25° and fifteen custom made resin blocks with two straight canals were used in this study. Each canal had two lateral canals, apical lateral canal branched 5 mm from the apical end and coronal lateral canal branched 11.5mm from the apical end. Prepared samples were divided into 6 groups (*n* =10). In groups 1 and 2 IRoot SP sealer was used. In groups 3 and 4 Apexit Plus sealer was used, while AH Plus sealer was used in groups 5 and 6. In all groups obturation was made with cold lateral condensation technique. Each block was examined at an original magnification of 10X by means of stereomicroscope and photographed by digital camera at special settings as recommended by manufactures mounted on the stereomicroscope. The obtained digital images were captured with built-in digital camera at resolution of 1024x768 pixels and stored using IBM computer. Results showed that in straight canals the highest mean depth value was in AH Plus sealer at coronal level (4.47mm) and the lowest depth value was in IRoot SP sealer at apical level (2.88mm). In curved canals the highest mean depth value was in Apexit Plus sealer at coronal level (4.09mm) and the least depth value was in IRoot SP sealer at apical level (2.19mm). In conclusions, many types of sealers can be used with cold lateral condensation technique to obturate lateral canals effectively. The depth of sealer penetration into lateral canals is dependent on the flow property of the sealer used.

Keywords: Sealer, Penetration, Lateral canal, Root canal.

Introduction

The root canal system has a complex anatomy with irregularities, isthmuses, fins, and lateral canals that may contain bacteria and necrotic tissue (Peters *et al.,* 2003; Venturi *et al.,* 2005). Even with great advances in endodontic technology such as nickel-titanium rotary instruments and irrigation systems, it is not possible to clean and shape every irregularity and lateral canal present in the root canal system (Venturi *et al.,* 2005).

Root canal ramifications, such as lateral, secondary and accessory canals can establish connection between the main root canal and periodontal ligament, as well as the apical foramen (De Deus, 1975).

Several authors described that localized periodontal problems might be associated with necrotic and infected root canal ramifications (Barkhordar and Stewart, 1990) highlighting the importance of the capacity of the endodontic sealer to flow into these irregularities. Despite the significance of this physical property, the relationship between flow and its ability to penetrate narrow root canal ramifications has not been investigated (Venturi *et al.,* 2003).

Gutta-percha in combination with a root canal sealer is the most commonly used filling material. The sealer fills the minor irregularities and acts as a lute between the gutta-percha and canal wall (Najar *et al.,* 2003).

The amount of sealer should be restricted to a thin layer between the gutta-percha and the walls of the canal (Wu *et al.,* 2000), but it should be sufficient to restrict the passage of microorganisms and their by-products that are responsible for periradicular disease (Gutmann and Witherspoon, 2002).

An endodontic sealer must have several properties to be considered suitable. Flow is important as it reflects its ability to penetrate into small irregularities and ramifications of the root canal system and dentinal tubules (Siqueira *et al.,* 1995; Weis *et al.,* 2004). Moreover, flow along with the sealer's antimicrobial effectiveness may aid the disinfection of the root canal system (Siqueira *et al.,* 2000; Saleh *et al.,* 2004).

Due to the difficulty of obtaining human teeth with natural ramifications to allow comparisons, several authors have produced artificial canal ramifications in resin blocks which resemble those found in natural teeth (Goldberg *et al.,* 2001; Goldberg *et al.,* 2002; Pecora *et al.,* 2002; Moraes *et al.,* 2004).

The aim of this study was to evaluate the ability of AH Plus, Apexit Plus and IRoot SP sealers to fill artificial lateral canals in acrylic blocks with straight and curved main canals. The null hypothesis of the present study was that there are no significant differences between the apical sealing techniques.

Materials and Methods

Root Canal Sealers: Three root canal sealers were used: resin-based sealer AH Plus; calcium hydroxide based sealer Apexit Plus and bioceramic sealer IRoot SP. All materials were prepared according to manufacturers' instructions.

Specimens Preparation: Fifteen Thermafil (Dentsply Maillefer) training resin blocks with two curved canals with curvature of 25° (Figure 1) and fifteen custom made resin blocks (Figure 2) with two straight canals were used in this study. All canals had 18mm length and 0.04 taper with 0.3mm apical diameter. Each canal had two lateral canals, apical lateral canal branched 5 mm from the apical end and coronal lateral canal branched 11.5mm from the apical end. Those two lateral canals were parallel to each other in all blocks, and had circular cross-section. All lateral canals had three parts: the inner part (with which it branched from the main canal) diameter was 0.5mm, the length was 1mm in coronal lateral canals and 0.2mm in apical lateral canals. The middle part was diameter 0.7mm and 1mm length. The outer part was 1mm diameter and 3mm length (Venturi *et al.,* 2006). sealer was used. In groups 3 and 4 Apexit Plus sealer was used, while AH plus sealer was used in groups 5 and 6. In all groups obturation was made with cold lateral condensation technique. A master gutta-percha cone #30 was saturated with sealer and inserted to full working length and then lateral condensation was performed with finger spreader #15 that reached 2mm from the apical end, spreader was removed and accessory gutta-percha #15 inserted and lateral condensation was repeated until spreader no longer penetrate more than 2mm from coronal canal orifice. Then the excess of gutta-percha seared off with hot hand plugger and vertical compaction was made with the plugger.

Each block was examined at an original magnification of 10X by means of stereomicrosope and photographed by digital camera at special settings as recommended by manufactures mounted on the stereomicroscope (Motic, Gloucester Road Causeway Bay, Hong Kong).

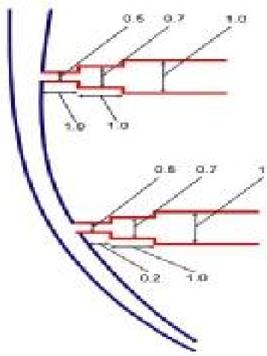

Figure (1): Dimensions of lateral canal (C).

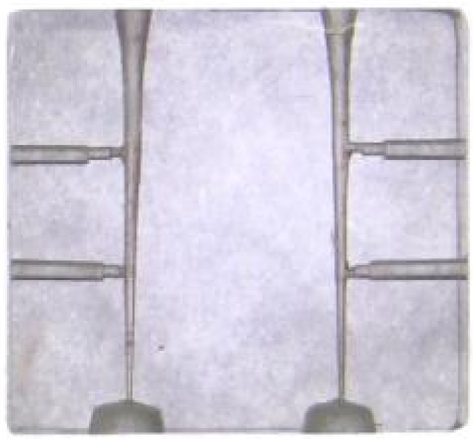

Figure (2): Custom made block.

Table (1): Grouping of samples.

No. of groups	Type of canal	Type of sealer
1	Curved	IRoot SP
2	Straight	
3	Curved	Apexit Plus
4	Straight	
5	Curved	AH Plus
6	Straight	

The obtained digital images were captured with built-in digital camera at resolution of 1024x768 pixels and stored using IBM computer (IBM Corporation, Armok, New York). Motic Images Plus 2.0 software (Motic, Gloucester Road Causeway Bay, Hong Kong) that is supported with the stereomicroscope by manufacturer was used to measure the distance from the wall of main canal to the deepest point that gutta-percha had penetrated into lateral canals. All measures made and readings were taken by the same trained examiner. The data obtained were subjected to analysis of variance (ANOVA), least significant difference (LSD) and Student's *t*-tests at a 5% level of significance.

Results and Discussion

The ANOVA showed a P-value of 0.0016, so the null hypothesis was rejected, indicating highly significant differences between all groups (Table 2).

Table (2) and Figure (3) showed that in straight canals the highest mean depth value was in AH Plus sealer at coronal level (4.47mm) and the lowest depth value was in IRoot SP sealer at apical level (2.88mm). In curved canals the highest mean depth value was in Apexit Plus sealer at coronal level (4.09mm) and the least depth value was in IRoot SP sealer at apical level (2.19mm).

Least significant difference test (LSD) was performed and showed that there was non-significant difference between AH Plus and Apexit Plus at coronal level in both straight and curved canals, and non-significant difference between AH Plus and IRoot SP at apical level in both straight and curved canals. Otherwise all other groups exhibited highly significant differences (Table 3).

Student's *t*-test was performed to evaluate the difference of sealer depth between apical and coronal lateral canals in the same main canal type. Only two groups in straight canals showed non-significant differences which were Apexit Plus and IRoot SP. Other groups showed highly significant differences (Table 4).

Table (2): Descriptive statistics and sealers differences.

Type	Level	Sealer types	Descriptive statistics		Sealers differences (ANOVA)	
			Mean	S.D.	F-test	P-value
Straight	Coronal	AH Plus	4.47	0.31	43.37	0.000 **
		Apexit Plus	4.17	0.43		
		IRoot SP	2.99	0.38		
	Apical	AH Plus	3.01	0.30	33.19	0.000 **
		Apexit Plus	4.05	0.43		
		IRoot SP	2.88	0.31		
Curved	Coronal	AH Plus	3.89	0.19	60.38	0.000 **
		Apexit Plus	4.09	0.32		
		IRoot SP	2.97	0.21		
	Apical	AH Plus	2.44	0.34	17.62	0.000 **
		Apexit Plus	3.00	0.36		
		IRoot SP	2.19	0.22		

** highly significant difference

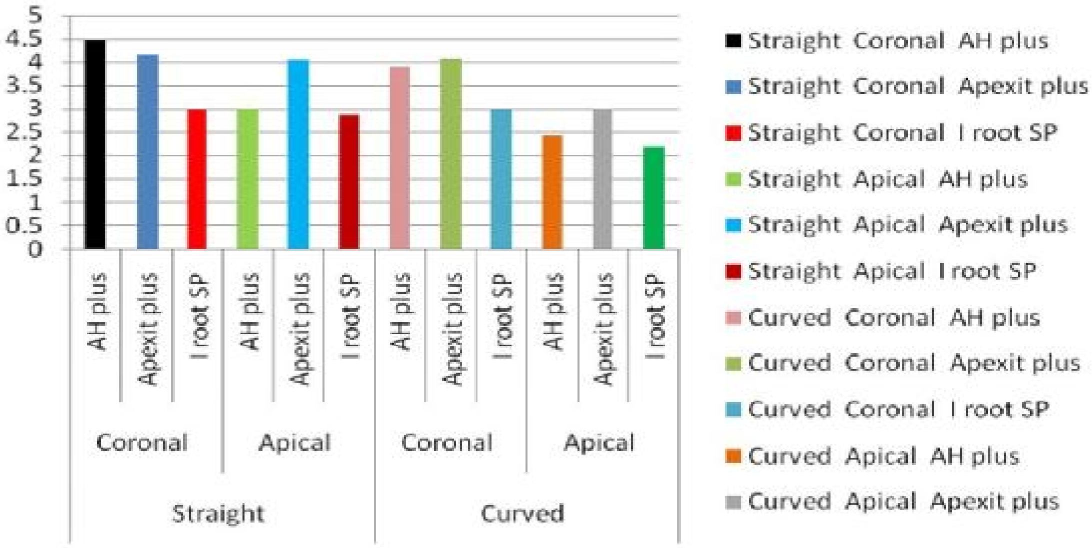

Figure (3): Bar graph showing the mean values of sealer depth.

Table (3): LSD between different sealer types in straight and curved canals

Type	Level	Sealer types		Mean Difference	P-value
Straight	Coronal	AH Plus	Apexit Plus	0.30	0.087 (NS)
			IRoot SP	1.48	0.000 **
		Apexit Plus	IRoot SP	1.18	0.000 **
	Apical	AH Plus	Apexit Plus	-1.03	0.000 **
			IRoot SP	0.14	0.391 (NS)
		Apexit Plus	IRoot SP	1.17	0.000 **
Curved	Coronal	AH Plus	Apexit Plus	-0.21	0.066 (NS)
			IRoot SP	0.92	0.000 **
		Apexit Plus	IRoot SP	1.13	0.000 **
	Apical	AH Plus	Apexit Plus	-0.56	0.000 **
			IRoot SP	0.25	0.087 (NS)
		Apexit Plus	IRoot SP	0.81	0.000 **

** highly significant difference NS= non-significant

Table (4): Student's *t*-test for sealer depth between apical and coronal lateral canals

Canal type	Sealer types	Level	Descriptive statistics		Areas differences	
			Mean	S.D.	*t*-test	P-value
Straight	AH Plus	Coronal	4.47	0.31	10.63	0.000 **
		Apical	3.01	0.30		
	Apexit Plus	Coronal	4.17	0.43	0.65	0.52 (NS)
		Apical	4.05	0.43		
	IRoot SP	Coronal	2.99	0.38	0.72	0.48 (NS)
		Apical	2.88	0.31		
Curved	AH Plus	Coronal	3.89	0.19	11.81	0.000 **
		Apical	2.44	0.34		
	Apexit Plus	Coronal	4.09	0.32	7.27	0.000 **
		Apical	3.00	0.36		
	IRoot SP	Coronal	2.97	0.21	8.13	0.000 **
		Apical	2.19	0.22		

** highly significant difference NS= non-significant

Table (5): Student's *t*-test for sealer depth between straight and curved canals within the same lateral canal level.

Level	Sealer types	Canal type	Descriptive statistics		Canals differences	
			Mean	S.D.	*t*-test	P-value
Coronal	AH Plus	Straight	4.47	0.31	5.06	0.000 **
		Curved	3.89	0.19		
	Apexit Plus	Straight	4.17	0.43	0.45	0.66 (NS)
		Curved	4.09	0.32		
	IRoot SP	Straight	2.99	0.38	0.13	0.89 (NS)
		Curved	2.97	0.21		
Apical	AH Plus	Straight	3.01	0.30	3.99	0.001 **
		Curved	2.44	0.34		
	Apexit Plus	Straight	4.05	0.43	5.95	0.000 **
		Curved	3.00	0.36		
	IRoot SP	Straight	2.88	0.31	5.66	0.000 **
		Curved	2.19	0.22		

** highly significant difference NS= non-significant

To evaluate the difference of sealer depth between straight and curved canals within the same lateral canal level, Student's *t*-test was performed and the results showed that only at coronal level in both Apexit Plus and IRoot SP sealers there was non-significant differences. Other groups showed highly significant differences (Table 5).

In an effort to standardize the experiment and obtain sufficient number of samples to do the research acrylic resin blocks were used instead of natural teeth. Although extracted teeth offers more accurate simulation of the clinical situation (Goldberg *et al.,* 2002), the advantage of using acrylic resin block is reduction of variables associated with canal instrumentation and provide adequate samples with standardized dimensions (Gurgel-Filho *et al.,* 2006).

In this study, obturation was made to acrylic resin blocks with simulated straight and curved canals with two lateral canals (coronal and apical lateral canals). All obturations were performed by the same operator. Cold lateral condensation technique was used with three different sealers (AH Plus, Apexit Plus and IRoot SP). These sealers were verified for their ability to penetrate into lateral canals by measurement the depth of its penetration into the lateral canals.

Endodontic sealer's property that affects its ability to penetrate into irregularities, lateral canals and dentinal tubules is termed as Flow.

Comparison of sealers: Results (Table 3) showed that in straight canals AH Plus exhibited the higher mean sealer depth value than other two sealers in coronal lateral canals, although the difference between AH Plus and Apexit Plus was non-significant. IRoot SP mean sealer depth was the least and the differences with other two sealers were highly significant.

In apical lateral canals Apexit Plus showed higher mean sealer depth value than other two sealers. The differences with other two sealers were highly significant. AH Plus and IRoot SP showed non-significant difference in between although AH Plus mean sealer depth was greater.

Results of curved canals at coronal lateral canals were not similar to that of straight canals. Apexit Plus exhibited greatest mean sealer depth than other two sealers. However its difference with AH Plus was statistically non-significant. Both (Apexit Plus and AH Plus) had highly significant difference when compared to IRoot SP sealer.

Apical lateral canals of curved groups showed similar results to those of straight groups where Apexit Plus had the highest mean sealer depth with highly significant difference from other two sealers. IRoot SP sealer showed less mean sealer depth than AH Plus and the difference was non-significant.

These results can be attributed to that both Apexit Plus and AH Plus sealers had good flow property which are in agreement with ANSI/ADA standard specification No. 57, and Apexit Plus exhibits greater flow than AH Plus probably due to the presence of epoxy resin in the composition of AH Plus that might be responsible for the increase of its viscosity (Marin-Bauza *et al.,* 2012). However IRoot SP sealer showed least flow property due to its higher viscosity that can be attributed to the presence of calcium silicate.

The results of present study comes in agreement with results of Souza *et al.,* (2012) whom compared the depth of penetration of seven sealers into artificial lateral canals (Epiphany, AH Plus, EndoRez, EndoFill, Endomethasone, Sealapex and Sealer 26) and they found that AH Plus exhibited the greatest depth. Also these results agreed results of Chadha *et al.,* (2012) whom compared the depth of tubular penetration of three resin-based sealers and they found that AH Plus had the greatest flow.

Comparison of coronal and apical lateral canals: In straight canals, only AH Plus exhibited highly significant difference between coronal and apical sealer depth. Other two sealers showed non-significant difference. However in all types of sealers the mean sealer depth was greater in coronal than apical lateral canals.

In curved canals, all sealers showed greater mean sealer depth in coronal than apical lateral canals, the difference in all sealers was highly significant.

The reason for this difference of sealer depth might be due to that less amount of sealer were introduced into apical area than coronal area, and this was because of the difference in taper of master cone (0.02) and the canal (0.04) that made the diameter of coronal part of canal largely greater than gutta-percha cone as compared to the diameter difference at apical area. This would make coronal part occupy greater amount of sealer that can be pressed into coronal lateral canal during lateral condensation.

These results were in agreement with Sevimay and Kalayci, (2005) and Chadha *et al.,* (2012) where they compared the sealer depth of different sealers into dentinal tubules, they reported greatest sealer depth in coronal third, followed by middle third and the least was in apical third.

Comparison of straight and curved canals: At coronal lateral canals, all types of sealers showed greater mean sealer depth in straight than in curved canals. However, only AH Plus showed highly significant difference. Other two sealers showed non-significant differences.

At apical lateral canals, all sealers exhibited highly significant differences between sealers mean depth in straight and curved canals, with greater sealer depth was in straight canals.

These results can be due to during insertion of sealer with master cone in curved canals, part of the sealer was washed away as the master cone was introduced into the canals, and hence less amount of sealer will reach apical area of curved canals as compared to that of straight canals. Another reason can be proposed is that during lateral condensation, the amount of lateral forces that pressed sealer into lateral canals was greater in straight canals than in curved canals. This might be due to that finger spreader penetrated deeper in straight canals than in curved.

Conclusions

Many types of sealers can be used with cold lateral condensation technique to obturate lateral canals effectively. The depth of sealer penetration into lateral canals is dependent on the flow property of the sealer used, which is in tern dependent on the type of sealer and its composition.

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