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Assessment of Depth of ingress for Five Root Canal Sealers into Artificial Lateral Root Canals

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Abstract

Aim: To assess the depth of ingress of five endodontic root canal sealers into the artificial lateral canals (ALC).

Material & Methods 104 extracted human permanent mandibular premolars were randomly divided into five groups according to the sealer employed, Group 1: AD SEAL, Group 2: AH PLUS, Group 3: Apexit plus, Group 4: Endoseal, andGroup 5: MTA plus. Two artificial lateral canals were prepared on the mesial surface of the root of 6mm and 3mm from the apex. Cleaning and shaping of the canals were done till rotary Protaper F3 following irrigation protocol. After Thermoplastic obturation, radiographs were taken to evaluate the extent of sealers into artificial lateral canals. The teeth were decalcified in 5% hydrochloric acid, cleared with methyl salicylate and measured the extent of sealer into lateral canals under Stereomicroscope.

Result: Kruskal-Wallis test (p=0.00) and Mann-Whitney U (p=0.00) were applied to analyse the depth of penertration of sealers in the middle third: AHplus>Apexit plus>Endoseal> ADSEAL>MTA plus and in apical third: Apexitplus>AH Plus>Adseal>Endoseal≥MTA Plus.

Conclusion: Digital radiograph, clearing technique, and stereomicroscope analysis showed that both gutta-percha and sealer had better depth of ingress for AH Plus and

Apexit Plus groups into artificial lateral canals (middle & apical).

Keywords: Root canal sealers, Lateral canals, Radiovisiography, Thermoplastic obturation, Clearing technique.

Introduction

Lateral and apical ramifications of the main root canal are formed after a localized fragmentation of the epithelial root sheath, leaving a small gap, or when blood vessels running from the dental sac through the dental papilla. There are two main theories for the formation of accessory canals.[1]First, during odontogenesis, the continuity of Hertwig's root sheath is broken or is not established before dentin formation, so a defect in the dentinal wall of the pulp ensues. This accounts for the opening of accessory canals to the periodontal surface of the root. A premature break in the epithelial diaphragm would not further differentiate into the cells to odontoblasts. Hence dentin is not formed, leaving a portal of exit. Second, when the maturing Hertwig's epithelial root sheath encounters a neurovascular bundle, the dentin forms around the bundle, resulting in a portal of exit.

73.5% ramifications are found in the apical third of the root,11% in the middle third, and 15% in the coronal third.[2]Mandibular premolars have a high percentage of lateral canals.[3]The presence of lateral, secondary, and accessory canals can allow the passage of bacteria and other tissue breakdown products.Such ramifications will provide a pathway between the root canal and periodontal ligament causing infection and necrosis of the root canal[4].

Amongst various properties desired for an endodontic sealer, flow is important and facilitates penetration into small irregularities, ramifications of the root canal system, and dentinal tubules[5,6]and helps in the disinfection process.[7,8]The three-dimensional obturation of the root canal system can prevent reinfection[9] and isolate microorganisms from inaccessible areas without access to dead space and nutrients.[10]The presence of anatomical complexities and morphological configurations create difficulty in sealing of the root canal system.[11] Material types and techniques used can affect the overall success of endodontic treatment.[12-14]

Thus the study aimed to assess, the ability of five different endodontic root canal sealers penetration into two artificial lateral canals (ALC) (Middlte third and apical third) of human premolar teeth measured by digital radiographs, clearing technique, and stereomicroscope.

Methodology

One hundred four human permanent single-rooted mandibular premolars extracted for orthodontic reason was collected from Department of Oral And Maxillofacial Surgery, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be) University. The teeth were cleaned, stored in thymol solution until use. Teeth with natural lateral canals were discarded after confirming with a digital radiograph (RVG,CDR; FONA International, Assago, Milan, Italy) and X-ray unit (X-Mind DC, Acteon, Italy) operating at 7 mA and 70 kv for 0.1s.

The selected teeth were decoronated with diamond disc at low speed under constant irrigation with water and a standard length of 15 mm was achieved. Two artificial laterals canals (ALC) on mesial surface was prepared perpendicular to the long axis of teeth at middle third and apical third i.e. 6mm and 3mm respectively from the apex[15]using 0.175 mm tapering fissure diamond points(Pivo international,Mohali, India) (Fig 1 B.)

The teeth were randomly divided using online randomization (www.randomizer.org) into five groups

according to the sealers employed (n=20). Negative Control n=2 and Positive Control n=2, Group 1: ADSEAL (Meta Biomed, Europe), Group 2: AH Plus (Dentsply Maillefer, Konstanz,Germany), Group 3: Apexit Plus (IvoclarVivadent AG, Bendererstrasse,Liechtenstein), Group 4: Endoseal(Prevest- Denpro, jammu,India), Group 5: MTA Plus(Prevest- Denpro, jammu,India).

The teeth were mounted in alginate blocks to simulate the periodontal ligament. The coronal one third of teeth shaped with size 2 and 3 Gates Glidden(MANI,Utsunomiya,Japan). Ingle's method of working length was established with K-file no 10 (DENTSPLY MAILLEFER,NORTH AMERICA). The canal was prepared using rotary Protaper files (DENTSPLY, MAILLEFER, Switzerland.) till F3. Following canal preparation, 3ml of 17%EDTA (Avue Prep+, DENTAL AVENUE (I) PVT. LTD.Gurgaon,India))was used to remove the smear layer and then 3ml of 3% NaOCl (SAFE PLUS, NEELKANTH, HEALTH CARE (P) LTD.JODHPUR,Rajasthan,India) and 3 ml of normal saline was used as final irritant. Canals were dried using absorbent points (DENTSPLY,USA) and two coats of sealers were applied using lentulospirals (MANI Utsunomiya,Japan) and thermoplastized gutta-percha (Endo@pex, GUTTA FLOW,Feldwiesenstr,Switzerland). obturation technique was followed for the respective groups. Access restoration was done with composite (IvoclarVivadent,Bendererstrasse,Liechtenstein). Digital radiography (RVG) were taken to evaluate the depth of penetration of sealers into the lateral canals. The images were analyzed at 100% magnification using the colour inversion facility within the Computed Dental Radiography (CDR) software technology (EzDent-i,vatech,india). The total length of the filled ALC (Middle third and apical third) was measured.

The alginate blocks were removed and the external root surface was sealed with two layers of red nail varnish, except on ALC. Two unfilled teeth each were used as positive (unfilled ALC sealed without nail varnish) and Negative control (unfilled ALC sealed with nail varnish).

All teeth were immersed in methylene blue dye (Samarth Industries, Haryana, India) and storedfor 24 hours. The teeth were rinsed with running water and the nail varnish was completely removed with no 15 scalpel blade. The teeth were subjected to decalcification in 10% hydrochloric acid(Aarti industries limited,Mumbai,India) for 48 hours and cleared with methyl salicylates(Seema FineChem Industry LLP,NaviMumbai,India).The extent of sealer, Gutta percha, and depth of dye ingress into ALC was measured under a stereomicroscope (30X) (Motic, GM 168, Hong kong). (Fig 1. C) These measurements were converted to percentages and subjected to statistical analysis for comparison of data.

Results

Statistical analysis was conducted using IBM SPSS statistics 24.0, SPSS South Asia Pvt. Ltd. (http://www.spss.co.in).The Shapiro-Wilk test of normality was conducted to study the normality of data and non-parametric Kruskal wallis test (p=0.00) and Mann–Whitney U test (p=0.000)was applied to evaluated the depth of ingress into ALC: Middle third (6 mm from the apex) and apical one third (3mm from the apex) for 5 groups.

Comparison of percentage of depth of penetration of sealers in the middle third ALC.

Table 1,2 shows the highest penetration of sealer was observed in AH Plus (96.81±2.15%) followed by Apexit

Plus(95.30 ±3.02). The lowest depth of penetration was observed in MTA Plus (86.30±4.03%). The Mann–Whitney U test revealed that the penetration of AHPlus>ApexitPlus>Endoseal>ADSEAL>MTA Plus(p=0.000).

Comparison of percentage of depth of penetration of sealers in the apical third ALC.

Table 3,4 shows highest penetration ofApexit Plus (86.65 ± 3.25%)followed by AH Plus (84.8 ± 12.51%). The lowest mean percentage of penetration was exhibited by MTA Plus (67.91 ± 15.44%).Mann–Whitney U test revealed that Apexit plus>AH Plus>Adseal>Endoseal≥MTA Plus.

Clearing technique showed an increased level of gutta perch penetration compared to sealers in the middle third ALC for AH Plus and Apex it Plus group followed by Adseal, Endoseal, and MTA Plus. Whereas in apical third lateral canal presence of sealer instead gutta percha was noticed for four groups except MTA Plus group.

Discussion

The ramifications in the main canal, such as lateral canals associated with lesions have great clinical importance during endodontic therapy. In the present study, as to reproduce the clinical conditions simulated lateral canals were created with approximately 170 µm tapering fissure diamond point on the mesial external root surface 6mm and 3mm respectively from apex.[15]However, the taper does not impede the flow of filling material into the lateral canals.

Previous studies have concluded that lateral canals are filled with hybrid obturation techniques often sealed with gutta-percha and some times with sealer.[16,17]In Present study, thermoplasticized gutta-percha obturation technique exhibits fewer voids, better adaptation to the dentinal walls,[18]increased penetration into the lateral canals and on vertical condensation of warm gutta-percha produced consistently dense and three-dimensional obturation.[19,20]

Flow and adhesiveness are the essential properties of the endodontic sealer, as they seals the root canal system. Adequate flow allows sealing of irregularities, isthmuses, accessory canals, confining the microorganisms in the dentinal tubules, and provide better antiseptic action[6,21,22,23].The primary motive is to isolate microorganisms from inaccessible areas, without access to nutrients.[24]Thus, re-establishing the healthy periapical tissue.

In current study, AH Plus sealer group had the highest ability to fill the middle third ALC (6mm from the apex) and second-highest for apical third ALC (3mm from apex). On clearing technique there was penetration of gutta-percha along with the sealer in the lateral canals was noticed. Which revealed that AH plus (epoxy resin-based sealer) had significantly superior flow rate,[15,25] with low solubility and disintegration, adequate radiopacity[26] and adhesion is by mechanical interlocking between sealer and root dentine.[27] The ISO specification 6876 requires a film thickness of ≤ 50 µm.This sealer is slightly thixotropic and has a film thickness of 22.72±1.75µm which conformsto the ISO specificationfor root canal sealing materials.[28]In **Apexit plus group,** depth of penetration into lateral canals was substantially similar to the results of AH plus sealer. Apexit Plus sealeriscalcium oxide based which is converted into calcium hydroxide when in contact with water. This sealer has a lower contact angle (greater surface free energy), interacts better with the dentin surface[29] film thickness of 11µm,Apexit plus sealer had better flow rate 49.20±1.43% in accordance to ISO standardization. The present study result showed that Apexit Plus sealer had better flow than Adseal, Endoseal, and MTA plus sealers. **Adsealgroup,** showed

depth of Penetration inmiddle third 93.16±1.75 and apical third 78.71±11.15.Adsealis an epoxy resin-based root canal sealer that contains bismuth phosphate and zinc-oxide mixed with vinyl polymer in a paste-paste type of dual syringe. The previous study showed thatAdseal had a similar root canal adaptation, solubility, flow, an film thickness when compared to AH Plus and Acroseal sealer.[30]But in the present study, AH Plus had a better depth of penetration than the Adsealsealer. **Endosealgroup** showed the depth of penetration 86.81±4.29 % and 69.21±13.64 % in middleand apical third respectively, it's a zinc oxide eugenol based sealer which contains Dexamethasone, thymol iodide & Hydrocortisone Acetate.Astudy showed that Zinc Oxide Eugenol based sealer had the least flow in the canals when compared to MTA based sealer,[31] which contradicted with the present study result.**MTA Plus**group showed the least depth of penetration of (86.30±4.03 %) and (67.91±15.44 %)in middle and apical third respectively when compared with other sealer groups. MTA Plus consitst of Di and Tri-Calcium Silicate, derived from advanced material research in inorganic hydraulic powder technology. The vehicle used is viscous polymer hydrogel/ distal water with setting time 1.2 hrs, might be the reason for inadequate penetration into the lateral canals[32-34].

Radiographic and stereomicroscopic analysis showed that the depth of penetration of all sealers in the middle third (6mm from apex) was better than apical third. Clearing technique revealed that both gutta-percha and sealer had better penetrated in middle third lateral canalsfor AH Plus and Apexit Plus followed by Adseal, Endoseal, and MTA Plus groups and presence of only sealers (5 groups) in apical third and is in agreement with other studies.[35]Reason being the depth of penetration of gutta-percha depends on the viscosity, force applied during thermomechanical compaction, and mode of action of pluggers [36]. Authors have concluded that the quality of gutta-percha adaptation is compromised in the apical root canal, as heat is applied 2mm from the apex[37]and presence of lesser density of the apical dentin[38,39]. Confocal laser study suggested that maxium depth penetration was seen with AH Plus[40] and steromicroscope study resulted that AH Plus sealer has better penetration than calcium silicate -based sealer in the simulated lateral canals [41].

Conclusion

Under the limitation of the study, AH Plus and Apexit Plus had better capacity to penetrate in the lateral canal followed by ADSEAL. Endoseal and MTA Plus sealer had the least depth of penetration. Gutta-percha penetration into the middle lateral canal along with sealer is seen when thermoplasticized gutta-percha obturation technique was implemented.

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Table Legends

Table 1: Depth of Sealer Ingress (%) in Middle third: Comparison of Group Mean

Group	`	Mean	SD	Minimum	Maximum	Kruskal Wallis Test	
						Mean Rank	p value
AD SEAL	20	93.16	1.75	88.89	96.06	55.65	0.000
AH PLUS	20	96.81	2.15	92.86	100	82.38	
APEXIT PLUS	20	95.30	3.02	89.68	102.26	70.8	
ENDOSEAL	20	86.81	4.29	75.91	92.62	23.2	
MTA	20	86.30	4.03	75.91	92.62	20.48	
Total	100	91.68	5.38	75.91	102.26		

Table 2: Depth of Sealer Ingress (%) in middle third - Pair wise comparison of group means

Group No.	Pair of Group	N	Mean Rank	Mann-Whitney U p value
1	AD SEAL	20	12.38	0.000
	AH PLUS	20	28.62	
2	AD SEAL	20	15.55	0.007
	APEXIT PLUS	20	25.45	
3	AD SEAL	20	29.35	0.000
	ENDOSEAL	20	11.65	
4	AD SEAL	20	29.88	0.000
	MTA	20	11.12	
5	AH PLUS	20	24.25	0.042
	APEXIT PLUS	20	16.75	
6	AH PLUS	20	30.5	0.000
	ENDOSEAL	20	10.5	
7	AH PLUS	20	30.5	0.000
	MTA	20	10.5	
8	APEXIT PLUS	20	29.85	0.000
	ENDOSEAL	20	11.15	
9	APEXIT PLUS	20	30.25	0.000
	MTA	20	10.75	
10	ENDOSEAL	20	21.40	0.626
	MTA	20	19.60	

Table 3: Depth of sealer Ingress (%) in Apical third Comparison of Group Mean

Group	N	Mean	SD	Minimum	Maximum	Kruskal Wallis Test	
						Mean Rank	p value
AD SEAL	20	78.71	11.15	56.25	91.6	52.65	0.000
AH PLUS	20	84.8	12.51	52.94	96.69	69.72	
APEXIT PLUS	20	86.65	3.25	79.69	92.62	68.4	
ENDOSEAL	20	69.21	13.64	44.07	88.1	31.28	
MTA	20	67.91	15.44	36.67	89.17	30.45	
Total	100	77.45	14.06	36.67	96.69		

Table 4: Depth of sealer Ingress (%) in Apical third - Pair wise comparison of group means

Group No.	Pair of Group	N	Mean Rank	Mann-Whitney U p value
1	AD SEAL	20	16.95	0.055
	AH PLUS	20	24.05	
2	AD SEAL	20	17.45	0.099
	APEXIT PLUS	20	23.55	
3	AD SEAL	20	24.70	0.023
	ENDOSEAL	20	16.30	
4	AD SEAL	20	25.05	0.014
	MTA	20	15.95	
5	AH PLUS	20	22.08	0.394
	APEXIT PLUS	20	18.92	
6	AH PLUS	20	27.45	0.000
	ENDOSEAL	20	13.55	
7	AH PLUS	20	27.65	0.000
	MTA	20	13.35	
8	APEXIT PLUS	20	28.65	0.000
	ENDOSEAL	20	12.35	
9	APEXIT PLUS	20	28.78	0.000
	MTA	20	12.22	
10	ENDOSEAL	20	20.58	0.968
	MTA	20	20.42	

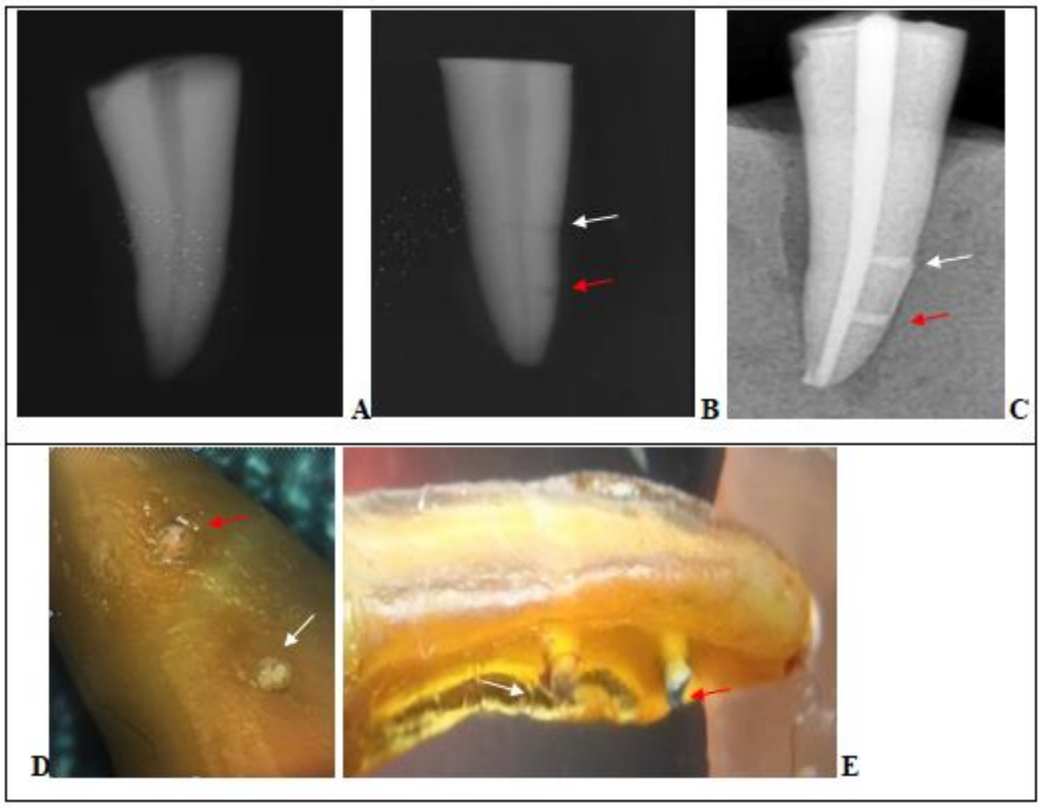

Figure 1. A, B, C: Pre-Operative Radiograph, created artificial lateral canal at middle third (white arrow) and apical third (red arrow) (6mm and 3mm from the apex respectively) and Radiograph after obturation showing the filled lateral root canals. D: Stereomicroscope picture of obturated tooth, E: Tooth sample after clearing technique showing gutta percha in middle third and sealer in apical third of lateral root canal.