IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 25, Issue 7 Ser. 5 (July. 2026), PP 48-52
www.iosrjournals.org

Comparative Evaluation Of Dentinal Tubule Penetration Depth Of Three Root Canal Sealers – In Vitro Scanning Electron Microscope Study

Dr. Sadashiv Daokar, Dr. Nikita Sarate, Dr. Rahul Kshirsagar, Dr. Sana Khan, Dr. Priyanka Chavan
(Department Of Conservative Dentistry And Endodontics, C.S.M.S.S's Dental College, India)

Abstract:
Background*: Complete three-dimensional obturation of the root canal system with an impervious, biocompatible and dimensionally stable obturating material is important for endodontic success.*
Root canal sealers serve as lubricants and are necessary to fill voids and irregularities in the space between dentinal walls and the obturating material, so as to effectively seal the interface. Thus, a desirable property of a root canal sealer is to have good sealing ability.The aim of this study is to establish the average depth of penetration of three resin-based root canal sealers into the dentinal tubules at the cervical, middle and apical third levels.
Materials and Methods*: Sixty extracted single-root premolars were selected and divided into three groups (20 teeth in each group) according to the type of sealer used, namely, mineral trioxide aggregate (MTA) Fillapex, AH Plus, and Bio C Sealer. Root canal preparation and obturation were done in all the samples. Roots was dissected transversely in apical plane. Percentage of gap from region to canal circumference was calculated using a scanning electron microscope. Samples were subjected to statistical analysis.*
Results*: AH plus sealer showed higher penetration of dentinal tubules than MTA and Bio C sealer..*
Conclusion: *This study helps to appraise the sealing ability of the different types of sealers using Scanning electron microscopy which is useful for the success of root canal treatment.*
Key Word: *mineral trioxide aggregate (MTA) Fillapex, AH Plus, and Bio C Sealer,*

Date of Submission: 20-07-2026 Date of Acceptance: 30-07-2026

I. Introduction

The main objective of a root canal treatment is the elimination of microorganisms from the root canal space and the prevention of reinfection. Cleaning and shaping is considered the most important step in the management of the infected root canal system; however, it is difficult or even impossible to eliminate all organisms from the canal space. Bacteria may persist in areas such as lateral canals and dentinal tubules, as these areas may provide as a haven for the bacteria, protecting them from the disinfecting actions of irrigants and medicaments. These persisting bacteria may play a role in periapical diseases.[1]

Sealers are used to attain an impervious seal between the core material and root canal walls. They can be grouped according to their basic components as: Zinc oxide eugenol, Calcium Hydroxide based sealers, Glass ionomer sealers, bioceramic sealers and medicated sealers.

Sealers based on epoxy resins afford very good physical properties and adequate biological performance. Excellent apical sealing has been found with epoxy resin-based sealers. Previous studies showed that the epoxy resin-based root canal sealer AH plus is biocompatible, has good tissue tolerance, long-term dimensional stability and good sealing ability. MTA sealer exhibits excellent biocompatibility and capacity for inducing mineralized tissue formation with sealing of root canal dentin.[2] The excellent biological properties of MTA sealers are attributed to its alkaline pH and calcium ion release capacity .The need for a biocompatible sealer that induces the formation of mineralized tissue, and also having suitable manipulation and flow rate, led to the development of new MTA-based root canal sealer. MTA Fillapex was developed by Angelus Londrina, PR, Brazil. It has resinous components and its manufacturer claims that it has excellent radiopacity, easy handling and ideal working time.

A sealers ability to penetrate into the dentinal tubules is regarded as a relevant aspect in the prevention of the reinfection of the dentinal tubules and of the root canal itself. Penetration of sealer cements into dentinal tubules is influenced by a number of factors including smear layer removal, dentine permeability and filling technique.

Variations in the physical and chemical properties of sealer cements also influence the depth of penetration. It is therefore important to compare the penetrability of different types of sealers used. This study is

a comparison of the dentin tubule penetration of three distinct root canal sealers using a Scanning Electron Microscope.

II. Material And Methods

This prospective comparative study was carried out in the of Department of Conservative Dentistry and Endodontics at C.S.M.S.S'S Dental College and Hospital, Chatrapati Sambhajinagar, Maharashtra on March 2025. A total 30 samples were used in this study.

Study Design: Prospective Comparative study.

Study Location: Department of Conservative Dentistry and Endodontics at C.S.M.S.S'S Dental College and Hospital, Chatrapati Sambhajinagar, Maharashtra.

Sample size: 30 samples (10 from each group)

Sample size calculation: The sample size actually obtained for this study was 30. (Group 1: AH plus (Dentsply, maillefer, germany)Group 2: MTA fillapex (Angelus, londrina, PR, brazil),Group 3: Bio C (Angelus, londrina, PR, brazil).

Procedure methodology

Thirty freshly extracted human single rooted premolar teeth were used for this study. The teeth were placed for 8 hours in 5.25% sodium hypochlorite to remove surface soft tissue and debris, then washed with tap water and subsequently stored in saline solution until they were used. All teeth had intact roots. Teeth with radicular resorption, immature apex, fracture or an endodontic filling were rejected. The coronal portions were cut with a diamond disc and the root canal length standardized. The pulp tissues were removed using standardized broaches.

Root Canal Preparation And Filling:

Working length was established 1mm short of apex. Then, the teeth were instrumented by using ProTaper technique (Dentsply Maillefer, Ballaigues, Switzerland) to a size of the F3 instrument at the working length. Irrigation procedures were accomplished by using 2 mL of 2.5% sodium hypochlorite for each file used. Apical patency was maintained by passing a size 10 K-file through the apical foramen between files. To remove the smear layer, all canals were irrigated with 3 mL of 17% ethylene diamine tetra acetic acid over 2 minutes followed by 3 mL of 2.5% sodium hypochlorite over 1 minute. A final rinse of 5 mL distilled water was used to remove any remnant of the irrigating solutions. The canals were dried using paper points. After preparation; the roots were randomly divided into 3 groups according to the sealer used;

- Group 1: AH plus (Dentsply, maillefer, germany)
- Group 2: MTA fillapex (Angelus, londrina, PR, brazil)
- Group 3: Bio -C(Angelus, londrina, PR, brazil)

The sealers were mixed according to their manufacturer's instructions. Sealer was placed into the canals using a size 25 Lentulo spiral (Dentspiy Maillefer, Ballaigues, Switzerland) in a slow speed handpiece introduced to approximately 2 mm short of the working length. After sealer placement a F3 size Gutta-percha cone coated with the sealer was seated to the working length. Excess gutta-percha was removed and vertical compaction was performed at the orifice level. The filling materials were then allowed to set for 48 hours.

Specimen Preparation:

The teeth were sectioned using a slow-speed diamond disc under a copious water supply. Horizontal sections were done at the 4 and 8 mm levels from the apical foramen the cuts were made perpendicular to the long axis of the root thereby obtaining a 4 mm thick specimen. The sections were then rinsed in 3% NaOCL for 2 minutes to remove the organic debris and then a final wash with distilled water and dried using a gentle stream of air.

The specimens were mounted on a stub and gold sputtered. The specimens were observed in a Scanning Electron Microscope, and of each specimen one photomicrograph most representative of the section was taken from the root sealer interface at a magnification of 500 X. On each of these photomicrographs, the minimum and maximum depth of sealer penetration in the tubules was measured. The Tukeys Post Hoc test was used to compare the penetration depth between the different sealers and between the two levels. The P value was set at .05.

III. Results

Table 1: Depth Of Penetration Of Sealer (IN Mm) In Dentinal Tubules At 8mm Between The Groups

		N	Mean	Standard Deviation	t-value	Significance
GROUP 1 VS GROUP 2	GROUP 1	10	59.70	35.634	1.620	0.128 (NS)
	GROUP 2	10	39.10	18.651		
GROUP 2 VS GROUP3	GROUP 2	10	39.10	18.651	3.475	0.004 (S)
	GROUP 3	10	15.60	10.458		
GROUP 1 VS GROUP 3	GROUP 1	10	59.70	35.634	3.755	0.003 (S)
	GROUP 3	10	15.60	10.458		

Table 2 : Depth Of Penetration Of Sealer (IN Mm) In Dentinal Tubules At 4mm Between The Groups

		N	Mean	Standard Deviation	t-value	Significance
GROUP 1 VS GROUP 2	GROUP 1	10	10.20	10.271	1.663	0.120 (NS)
	GROUP 2	10	4.20	4.962		
GROUP 2 VS GROUP 3	GROUP 2	10	4.20	4.962	2.677	0.025 (S)
	GROUP 3	10	0	0		
GROUP 1 VS GROUP 3	GROUP 1	10	10.20	10.271	3.140	0.012 (S)

Table 3: Comparison Of Penetration Of Each Sealer Between Different Root Sections

	t-value	Significance	t-value	Significance	t-value	Significance
8 mm – 4 mm	4.175	0.002 (S)	5.854	0.000 (S)	4.717	0.001 (S)

Chart 1: Depth of penetration of sealers (in m) in to dentinal tubules – 8 mm and 4mm

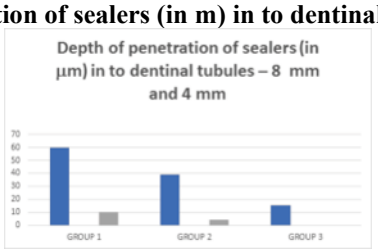


Chart 2 : Depth of penetration of sealers (in m) in to dentinal tubules – 8 mm between the groups

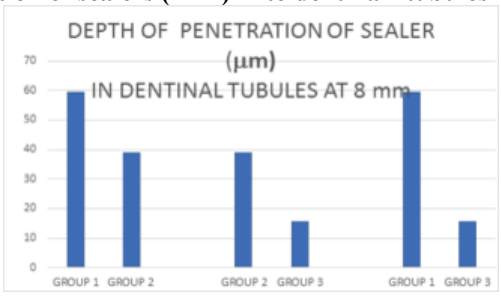
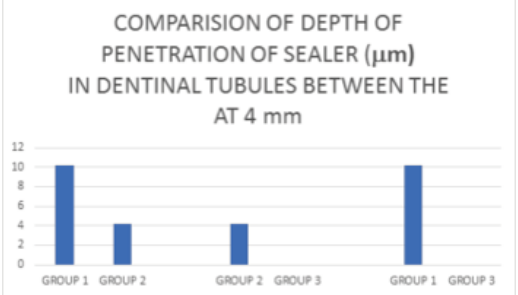


Chart 3: Depth of penetration of sealers (in m) in to dentinal tubules – 4 mm between the groups



IV. Discussion

The sealing ability of root filling materials is important for success in root canal treatment. Ideally, the root canal filling material should seal the root canal system and favour tissue repair.[3] The preliminary objectives of obturation are total debridement of the pulpal space, development of a fluid-tight seal at the apical foramen, and total obliteration of the root canal.[4]

The most commonly used core material is Gutta-percha, which can be placed into the root canal in a cold or a warm state. The main purpose of the root canal sealer is to fill the interface between the core material and the dentine wall, the voids inside the core material and the accessory canals, to serve as a lubricant and to obtain a hermetic apical seal.[5]

Sealers are used to attain an impervious seal between the core material and root canal walls. They can be grouped according to their basic components, such as zinc oxide eugenol, calcium hydroxide, resins, glass ionomers, iodoform or silicone. Ideally, these materials should seal the canal laterally and apically, and have good adaptation to root canal dentine.[6] According to Grossman, the endodontic sealers, regardless of type, should exhibit some requirements, as follows: biocompatibility, easy insertion into and removal from root canal, viscosity while handling, good adhesion to root canal walls, satisfactory handling time, promotion of a three dimensional sealing, dimensional stability, good flowing, good radiopacity, lack of color change, insolubility in tissue fluids and saliva, solubility to common solvents when necessary, impermeability, and anti-microbial activity.[7] The penetration of sealer cements into dentinal tubules is considered to be a desirable outcome for a number of reasons: it will increase the interface between material and dentine thus improving the sealing ability and retention of the material may be improved by mechanical locking. Sealer cements within dentinal tubules may also entomb any residual bacteria within the tubules and the chemical components of sealer cements may exert an antibacterial effect that will be enhanced by closer approximation to the bacteria[1].

In this study Group I and Group II showed higher penetration depth values compared to Group III. This can be attributed to its specific composition, because these sealers contain resin components. However, AH plus showed more penetration into dentinal tubules compared to MTA fillapex. The results of the present study confirm the findings of other studies that suggest that the penetration of sealer cements may be a function of their chemical and physical characteristics.[23]

The persistence of microorganisms in dentinal tubules, lateral canals and apical ramifications after root canal treatment has been reported. If the filling provides a good seal, it will only impair the exit of bacteria entrapped in the root canal system[2]. However, to eradicate the remaining microorganisms, the antimicrobial activity and optimal penetration of the sealer could play an important role.

V. Conclusion

Root canal sealers, although used only as adjunctive materials in the obturation of root canals, have been shown to influence the outcome of endodontic treatment. An ideal root canal sealer should possess perfect combination of sealing ability and biocompatibility.

Significant difference was found between the sealing ability of AH Plus, MTA Fillapex, and Bio C Sealers.

Understanding of the current concepts in the usage of different sealers in endodontic therapy and their comparison is essential in order to draw some clinical inferences.

Further investigations are needed for Bio C Sealer.

References:

[1]. Tyagi S, Mishra P, Tyagi P. Evolution Of Root Canal Sealers: An Insight Story. Eur J Gen Dent 2013;2(3):199–218. Doi: 10.4103/2278-9626.115976.

[2]. Gomes-Filho Je, Moreira Jv, Watanabe S, Et Al. Sealability Of Mta And Calcium Hydroxide Containing Sealers. J Appl Oral Sci 2012;20(3): 347–351. Doi: 10.1590/S1678-77572012000300009.

[3]. Almeida Jf, Gomes Bp, Ferraz Cc, Et Al. Filling Of Artificial Lateral Canals And Microleakage And Flow Of Endodontic Sealers. Int Endod J 2007;40(9):692–699. Doi: 10.1111/J.1365-2591.2007.01268.X.

[4]. Camilleri J, Gandolfi Mg, Siboni F, Et Al. Dynamic Sealing Ability Of Mta Root Canal Sealer. Int Endod J 2011;44(1):9–21. Doi: 10.1111/J.1365-2591.2010.01774.X.

[5]. Al-Haddad A, Che Ab Aziz Za. Bioceramic-Based Root Canal Sealers: A Review. Int J Bio 2016; 1–10. Doi: 10.1155/2016/9753210.

[6]. Al-Haddad A, Abu Kasim Nh, Che Ab Aziz Za. Interfacial Adaptation And Thickness Of Bioceramic-Based Root Canal Sealers. Dent Mater J 2015;34(4):516–521. Doi: 10.4012/Dmj.2015-049.

[7]. Khandelwal D, Ballal Nv. Recent Advances In Root Canal Sealers. Int J Clin Dent 2016;9(3):183–194.

[8]. Henston Jl, Sharma N, Subhash C, Et Al. Root Canal Sealers And Its Role In Successful Endodontics: A Review. Adr 2012;2(2):68–78.

[9]. Wu Mk, Van Der Sluis Lw, Ardila Cn, Et Al. Fluid Movement Along The Coronal Two Thirds Of Root Fillings Placed By Three Different Guttapercha Techniques. Int Endod J 2003;35:54–63.

[10]. Gomes-Filho Je, Bernabé Pf, Nery Mj, Et Al. Reaction Of Rat Connective Tissue To A New Calcium Hydroxide Based Sealer. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106(2):71–76. Doi: 10.1016/ J.Tripleo.2008.03.030.

[11]. Venturi M, Prati C, Capelli G, Et Al. A Preliminary Analysis Of The Morphology Of Lateral Canals After Root Canal Filling Using A

Tooth Clearing Technique. Int Endod J 2003;36(1):54–63. Doi: 10.1046/J.0143-2885.2003.00613.X.
[12]. Marín-Bauza Ga, Silva-Sousa Yt, Da Cunha Sa, Et Al. Physiochemical Properties Of Endodontic Sealers Of Different Bases. J Appl Oral Sci 2012;20(4):455–461. Doi: 10.1590/S1678-77572012000400011.
[13]. Rawtiya M, Verma K, Singh S, Et Al. Mta Based Root Canal Sealers. J Orafacres 2013;3(1):16–21. Doi: 10.5005/Jp-Journals-10026-1057.
[14]. Angelus. Mta Fillapex Bio Ceramic Endodontic Sealer. Scientific Technical Profile 2018; 8–18.
[15]. Gandolfi Mg, Prati C. Mta And F-Doped Mta Cements Used As Sealers With Warm Gutta-Percha Long-Term Study Of Sealing Ability. Int Endod J 2010;43(10):889–901. Doi: 10.1111/J.1365-2591.2010.01763.X.
[16]. Viapiana R, Flumignan Dl, Guerreiro Tjm, Et Al. Physicochemical And Mechanical Properties Of Zirconium Oxide And Niobium Oxide Modified Portland Cement-Based Experimental Endodontic Sealers. Int Endod J 2014;47(5):437–448. Doi: 10.1111/Iej.12167.
[17]. Candeiro Gt, Correia Fc, Duarte Ma, Et Al. Evaluation Of Radiopacity, Ph, Release Of Calcium Ions, And Flow Of A Bioceramic Root Canal Sealer. J Endod 2012;38(6):842–845. Doi: 10.1016/J.Joen.2012.02.029.
[18]. Hubbe Kl, De Oliveria Kvd, Coelho Bs, Et Al. Ah Plus Extrusion Into Apical Tissue: Literature Review Of Main Related Properties And Report Of Clinical Cases. Rsbo 2016;13(4):280–288. Doi: 10.21726/Rsbo.V13i4.352.
[19]. Wang Z, Shen Y, Haapasalo M. Dentin Extends The Antibacterial Effect Of Endodontic Sealers Against Enterococcus Faecalis Biofilms. J Endod 40(4):505–508. Doi: 10.1016/J.Joen.2013.10.042.
[20]. El Hachem R, Khalil I, Le Brun G, Et Al. Dentinal Tubules Penetration Of Ah Plus, Bc Sealer And Novel Tricalcium Silicate Sealer: A Confocal Laser Scanning Microscopy Study. Clin Oral Inv 2019;23(4):1871–1876. Doi: 10.1007/S00784-018-2632-6.
[21]. Zhou Hm, Shen Y, Zheng W, Et Al. Physical Properties Of 5 Root Canal Sealers. J Endod 2013;39(10):1281–1286. Doi: 10.1016/J. Joen.2013.06.012.