



## Effect of Post Space Preparation Time on the Apical Seal of Three Different Root Canal Sealers Using Dye Penetration Method; An In-Vitro Comparative Study

Dr. Kiran J Kasti<sup>1</sup>, Dr. Nadendla Maneesha<sup>2</sup>, Dr. Ananthakrishna S<sup>3</sup>, Dr. Pradeep P.R<sup>4</sup>, Dr. Dhanushree D R<sup>5</sup>, Dr. Sowmya S<sup>6</sup>

<sup>1</sup>Reader, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India

<sup>2</sup>Post Graduate Student, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India

<sup>3</sup>Professor And HOD, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India

<sup>4</sup>Professor And Principal, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India

<sup>5</sup>Post Graduate Student, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India

<sup>6</sup>Post Graduate Student, Department Of Conservative Dentistry And Endodontics, M.R Ambedkar Dental College And Hospital, Bangalore, India

Date of Submission: 20-07-2025

Date of Acceptance: 30-07-2025

### ABSTRACT

**AIM:** To compare the effect of post space preparation on the apical seal using three different ( AH-PLUS, BIOCERAMIC, MTA BASED ) root canal sealers.

**MATERIALS AND METHOD:** Thirty single rooted teeth, both maxillary and mandibular, caries free, no fracture and extracted purely for periodontal reasons were collected. Access cavity preparation is done followed by biomechanical preparation of the root canal was done using Hy flex Files upto size F3 followed by irrigation with 2ml of 3% NaOCl after each file. The teeth were then assigned into three groups depending upon the sealer used (10 teeth per group). GROUP A- AH plus sealer

GROUP B- Bioceramic sealer, GROUP C- MTA sealer. Gutta percha was used to obturate the canal using the single-cone technique. Post space preparation was done 1 day after obturation. Post space preparation was done using peeso reamers keeping 5mm of GP apically. Samples were immersed in 2% methylene blue solution for 24 h at room temperature. To remove excess dye from the external root surface, the teeth were washed under running tap water. Vertical sectioning of whole teeth into two halves was along their long axis using a diamond sectioning disc underwater coolant. A stereomicroscope magnification was used to measure the linear extent of dye penetration from the apical root ends (in mm). Data collected was analyzed One-way ANOVA test followed by Tukey's Post hoc test / Kruskal Wallis Test

followed by Dunn's post hoc test [Based on data distribution] will be used to compare the mean Depth of dye Penetration between 3 study groups. The level of significance [P-Value] will be set at  $P < 0.05$ .

**RESULTS:** Bioceramic sealer showed less microleakage compared to AH-PLUS and MTA based sealer. The microleakage from highest to lowest as follows AH-PLUS > MTA > BIOCERAMIC Sealer

**CONCLUSION:** The quality of the root canal filling is important to maintain the integrity of the apical seal during postspace preparation. Bioceramic emerges as the most effective material in minimizing microleakage followed by MTA and AH-PLUS

**KEY WORDS** - AH-PLUS SEALER, BIOCERAMIC SEALER, MTA BASED SEALER, APICAL MICROLEAKAGE

### I. INTRODUCTION

Successful endodontic therapy depends not only on effective cleaning and shaping of the root canal system but also on achieving a hermetic seal to prevent microleakage and bacterial reinfection [1]. Root canal sealers are essential for filling the spaces between gutta-percha and dentinal walls, as well as sealing lateral and accessory canals. However, in many clinical cases—especially when there is significant coronal tooth structure loss—placing a post is necessary to retain the final restoration and reinforce the tooth. This often involves the removal of a portion of the



root canal filling, a procedure known as post space preparation.[2]

Different root canal sealers behave differently during post space preparation due to their physical and chemical properties. AH Plus, an epoxy resin-based sealer, is known for its excellent adhesion and dimensional stability. However, its extended setting time (approximately 8 hours) can make it vulnerable to disruption if post space preparation is done too early [3]. MTA-based sealers, composed mainly of tricalcium silicate, offer good biocompatibility and sealing ability but may also be affected by moisture and handling during the initial setting phase [4]. On the other hand, bioceramic sealers have gained attention for their faster setting, superior flow, hydrophilicity, and chemical bonding to dentin, potentially making them more resistant to leakage even with immediate post space preparation [5]

Post space preparation involves the partial removal of root canal filling material, which can potentially compromise the integrity of the apical seal and increase the risk of microleakage. When mechanical instruments are used during this process, the remaining sealer or gutta-percha may become dislodged, vibrated, or twisted. Such disturbances can create pathways for bacterial penetration, thereby increasing the likelihood of recontamination and subsequent failure of endodontic treatment[[6,7]

Therefore the present invitro study was undertaken to compare the effect of post space preparation on the apical seal using three different ( AH-PLUS,BIOCERAMIC,MTA BASED ) root canal sealers.

## II. MATERIALS AND METHODS

Thirty single rooted teeth, both maxillary and mandibular, caries free, no fracture and extracted purely for periodontal reasons were collected.

Access opening is done using endo round burs (BR-41) and a number10 K-file was introduced into the canal and was pushed towards apical part until the tip of the instrument was just

visible at the apical foramen.This length of the file was recorded and 1mm was subtracted from the recorded length and the working length was determined.

Biomechanical preparation of the root canal was done using Hy flex Files upto size F3 17% EDTA was used during biomechanical preparation followed by irrigation with 2ml of 3%NaOCl after each file.

The teeth were then assigned into three groups depending upon the sealer used (10 teeth per group)

GROUP A- AH plus sealer

GROUP B- Bioceramic sealer

GROUP C- MTA sealer

Gutta percha was used to obturate the canal using the single-cone technique. In all groups, post space preparation was done utilizing size 1–4 Peeso reamers . The length of peso reamers inserted inside each canal was justified using a rubber stopper and an endodontic ruler to remove the coronal portion of gutta percha, so that the residual apical length of gutta percha is 5 mm .The external surface of teeth was coated with varnish leaving apical 5mm uncoated

Samples were immersed in 2% methylene blue solution at 24 h at room temperature. To remove excess dye from the external root surface, the teeth were washed under running tap water .Vertical sectioning of whole teeth into two halves was along their long axis using a diamond sectioning disc underwater coolant.A stereomicroscope magnification was used to measure the linear extent of dye penetration from the apical root ends (in mm)

Data collected was analyzed One-way ANOVA test followed by Tukey's Post hoc test / Kruskal Wallis Test followed by Dunn's post hoc test [Based on data distribution] used to compare the mean Depth of dye Penetration between 3 study groups .The level of significance [P-Value] was set at  $P < 0.05$



#### STEROMICROSCOPE IMAGES



AH-PLUS



MTA SEALER



BIOCERAMIC SEALER

### III. RESULTS

TABLE 1-Descriptives of mean Depth of Dye Penetration (in mm) b/w 3 groups using One-way ANOVA Test

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
AH PLUS	10	2.280	.3425	.1083	2.035	2.525	1.8	2.8
MTA	10	1.880	.3765	.1191	1.611	2.149	1.4	2.6
BIO CERAMIC	10	.740	.2633	.0833	.552	.928	.4	1.2
Total	30	1.633	.7364	.1344	1.358	1.908	.4	2.8

**TABLE 2-Comparison of mean Depth of Dye Penetration (in mm) b/w 3 groups using One-way ANOVA Test**

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.771	2	6.385	58.323	<0.001*
Within Groups	2.956	27	.109		
Total	15.727	29			

**TABLE 3-Multiple Comparison of mean Depth of Dye Penetration (in mm) b/w 3 groups using post hoc Tukey test**

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
AH PLUS	MTA	.4000*	.1480	<0.05*	.033	.767
	BIOCERAMIC	1.5400*	.1480	<0.001*	1.173	1.907
MTA	AH PLUS	-.4000*	.1480	<0.05*	-.767	-.033
	BIOCERAMIC	1.1400*	.1480	<0.001*	.773	1.507
BIOCERAMIC	AH PLUS	-1.5400*	.1480	<0.001*	-1.907	-1.173
	MTA	-1.1400*	.1480	<0.001*	-1.507	-.773

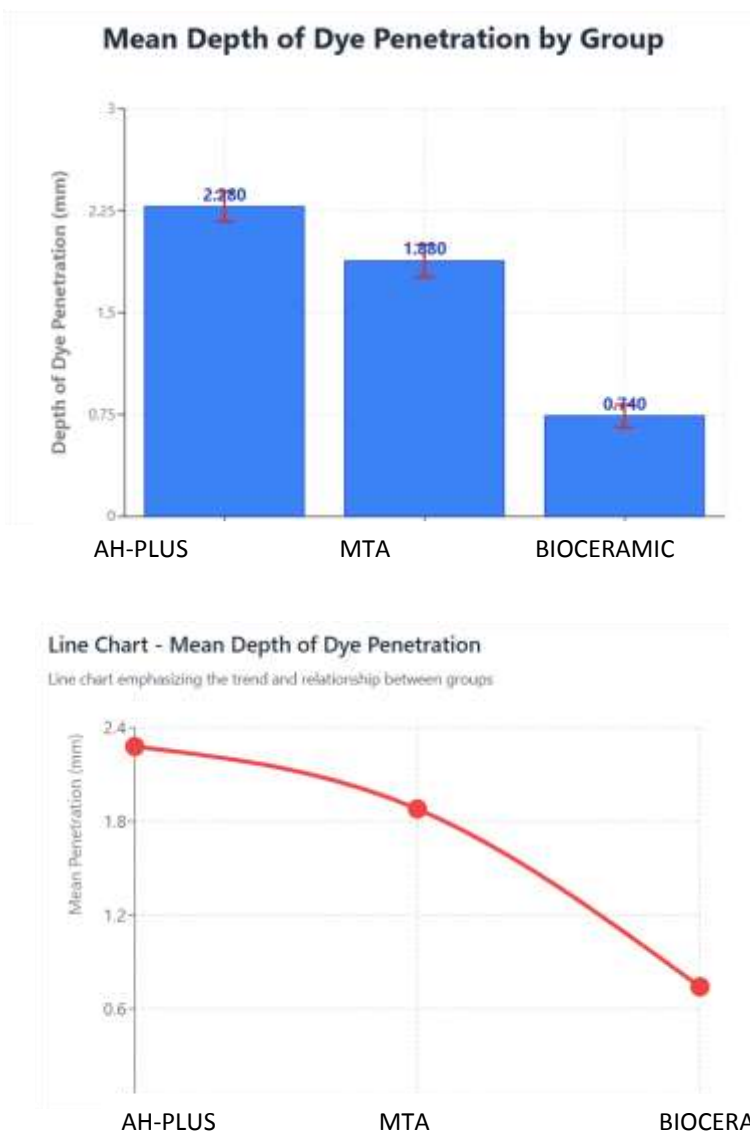
\*. The mean difference is significant at the 0.05 level.

The present study evaluated the mean depth of dye penetration among three endodontic materials—AH Plus, MTA, and Biceramic—using a one-way ANOVA test. Descriptive analysis (Table 1) revealed that AH Plus exhibited the highest mean dye penetration (Mean = 2.280 mm, SD = 0.3425), followed by MTA (Mean = 1.880 mm, SD = 0.3765). In contrast, Bioceramic showed the lowest dye penetration (Mean = 0.740 mm, SD = 0.2633), indicating superior sealing ability. The 95% confidence intervals for the mean dye penetration further confirmed this pattern, with Bioceramic ranging between 0.552 and 0.928 mm, significantly lower than the other two groups. The values also showed that all three groups had relatively low standard errors, suggesting precise mean estimates within each group as in **TABLE-1**.

To determine whether the observed differences in dye penetration among the three groups were statistically significant, a one-way ANOVA was conducted (Table 2). The results indicated a highly significant difference in mean dye penetration between the groups, with an F-value of 58.323 and a p-value of <0.001. The between-group variability (Sum of Squares =

12.771) was substantially higher than the within-group variability (Sum of Squares = 2.956), reinforcing the likelihood that the differences are not due to random variation. These findings suggest that the type of endodontic material has a strong influence on the sealing ability, as measured by the depth of dye penetration as in **TABLE-2**.

To identify which specific pairs of groups differed significantly, a post hoc Tukey test was performed (Table 3). The results showed statistically significant differences between all group pairs at the 0.05 level. AH Plus demonstrated significantly greater dye penetration than MTA (Mean Difference = 0.400 mm,  $p < 0.05$ ) and Bioceramic (Mean Difference = 1.540 mm,  $p < 0.001$ ). Similarly, MTA showed significantly more dye penetration than Bioceramic (Mean Difference = 1.140 mm,  $p < 0.001$ ). These findings confirm that Bioceramic has a significantly better sealing ability compared to both AH Plus and MTA, while AH Plus showed the poorest sealing among the three. Thus, Bioceramic emerges as the most effective material in minimizing microleakage, as evidenced by the lowest depth of dye penetration as in **TABLE-3**.



#### IV. DISCUSSION

Teeth that have undergone endodontic treatment often lack sufficient structural support to retain a permanent restoration. As a result, intra-canal posts are frequently required to provide retention for the coronal core buildup [8]. Gutta-percha, which is the most commonly used core material for root canal obturation, lacks both adaptability and adhesion to the root canal dentin. Hence, it is typically used in combination with a root canal sealer to enhance the seal and reduce microleakage[9].

An ideal root canal sealer should not only fill irregularities and seal the canal system effectively but should also allow for easy removal of gutta-percha during post space preparation without disturbing the integrity of the apical seal. If leakage occurs, it may arise either at the interface

between the sealer and dentin wall or between the gutta-percha and the sealer itself, compromising the long-term success of the treatment [9].

Several studies have emphasized that maintaining at least 4–5 mm of apical gutta-percha is crucial during post space preparation to preserve the apical seal and prevent reinfection [10]. Removing too much of the filling material can damage the seal and create a potential pathway for microleakage and bacterial ingress.

Post space preparation can generate mechanical stresses within the root canal, which may interfere with the polymerization process and chemical integrity of the root canal sealer. These alterations can compromise the long-term sealing ability, potentially leading to increased apical microleakage[11]. Interestingly, if post space preparation is performed before the sealer has completely set, the unset material may still possess



some flow characteristics. In such cases, the sealer might adapt better to canal irregularities and fill apical voids, potentially reducing microleakage in the short term [12]. However, this advantage may be short-lived. The mechanical stress applied during post preparation can disrupt the polymerization reaction and alter the chemical stability of the sealer, resulting in a compromised seal over time [13]. This effect highlights the importance of timing post space preparation carefully, considering both the physical properties of the sealer and its setting dynamics, to minimize the risk of long-term microleakage and treatment failure

AH Plus, an epoxy resin-based sealer, tends to exhibit more microleakage than MTA and bioceramic sealers (refer graph 1) during post space preparation due to differences in their chemical composition and physical behavior. Although AH Plus initially offers good sealing ability, it is sensitive to moisture and undergoes polymerization shrinkage, which can result in microgaps, especially if the post space is prepared before complete setting [11]. The mechanical stresses generated during post preparation can disrupt the integrity of the sealer and reduce its long-term sealing effectiveness. In contrast, MTA and bioceramic sealers are hydrophilic, bioactive, and dimensionally stable. They bond chemically with dentin and can form hydroxyapatite at the interface, enhancing the seal and maintaining it even under stress [14]. Their minimal shrinkage and slight expansion upon setting allow them to better adapt to canal walls and prevent microleakage over time [15]

Bioceramic sealers demonstrate significantly less microleakage compared to AH Plus and MTA-based sealers (refer graph 2) during post space preparation, primarily due to their superior chemical and physical properties. These sealers are hydrophilic and bioactive, enabling them to chemically bond to dentin and form hydroxyapatite crystals at the sealer-dentin interface, which enhances the seal and prevents microleakage even under mechanical stress [14]. Unlike AH Plus, which is epoxy resin-based and susceptible to polymerization shrinkage and moisture sensitivity, bioceramic sealers are dimensionally stable and even exhibit slight expansion upon setting, which improves adaptation to canal walls [12]. Bioceramics also exhibit slight expansion upon setting, which aids in closing microgaps caused by post space drilling [17]. Additionally, they have shorter setting times, minimal solubility, and high pH, which contribute to their antibacterial properties and improved

dimensional stability over time [18]. These combined properties make bioceramic sealers more resistant to mechanical disruption and leakage during post space preparation compared to traditional sealers.

Compared to MTA-based sealers, bioceramics offer better flowability, finer particle size, and deeper penetration into dentinal tubules, contributing to superior sealing and resistance to leakage when post space is prepared (refer graph 1). Their ability to set in moist environments and maintain chemical stability despite mechanical intervention makes them more reliable in preserving apical seal integrity during post space procedures [16].

MTA-based sealers generally exhibit better sealing ability and less microleakage than epoxy resin-based sealers like AH Plus (refer graph 1) during post space preparation due to their bioactivity, hydrophilicity, and chemical bonding to dentin. MTA (Mineral Trioxide Aggregate) sets in the presence of moisture and forms calcium hydroxide, which leads to the precipitation of hydroxyapatite crystals at the material-dentin interface, enhancing sealing and biocompatibility [19]. Unlike AH Plus, which is susceptible to polymerization shrinkage, moisture sensitivity, and poor bonding to canal walls, MTA-based sealers are dimensionally stable and less affected by the wet canal environment often encountered during post space preparation [11]. These features reduce the risk of disruption at the sealer-dentin interface during mechanical preparation. MTA stands between AH Plus and bioceramic sealers in terms of microleakage resistance, offering better performance than resin-based sealers but slightly inferior sealing compared to advanced bioceramic materials

This results were similar to the studies done by Torabinejad, M et al, Sarkar, N. K., Caicedo, R. et al and Al-Hadlaq et al. However the results showed in ascending order that is Bioceramic showing least microleakage followed by MTA and AH-PLUS sealers

## V. CONCLUSION

According to this study, it was concluded that

The quality of the root canal filling is important to maintain the integrity of the apical seal during postspace preparation. Results show less microleakage in Bioceramic group followed by MTA and AH-plus groups. There was minimum statistically significant difference in the apical dye microleakage between AH-PLUS and MTA groups



## REFERENCES

- [1]. Wiaam M. O. Al-Ashou, Rasha M. Al-Shamaa, Shaymaa S. Hassan Sealing Ability of Various Types of Root Canal Sealers at Different Levels of Remaining Gutta Percha After Post Space Preparation at Two Time Intervals
- [2]. Chen G, Chang C. The effect of immediate and delayed post space preparation using extended working time root canal sealers on apical leakage. *J Dent Sci* 2013;8:31-6.
- [3]. Tay, F. R., Loushine, R. J., Lambrechts, P., & Pashley, D. H. (2009). Geometric factors affecting dentin bonding in root canals. *Journal of Endodontics*, 35(3), 391–394.
- [4]. Torabinejad, M., Hong, C. U., McDonald, F., & Pitt Ford, T. R. (1995). Physical and chemical properties of a new root-end filling material. *Journal of Endodontics*, 21(7), 349–353
- [5]. Zhang, W., Li, Z., & Peng, B. (2009). Assessment of a new root canal sealer's apical sealing ability. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, 107(6), e79–e82
- [6]. Metzger, Z., Beitlitum, I., Zary, R., Weis, M., & Teperovich, E. (2000). The effect of immediate vs. delayed post space preparation on sealing ability of different sealers. *Journal of Endodontics*, 26(12), 755–758.
- [7]. Abramovitz, I., Lev, R., Fuss, Z., & Metzger, Z. (2001). The unpredictability of seal after post space preparation: A fluid transport study. *Journal of Endodontics*, 27(4), 292–295.
- [8]. Al-Hashimi, R. A., Mannocci, F., & Sauro, S. (2020). Effect of different post space preparation techniques on the integrity of root canal obturation: A micro-CT study. *Journal of Endodontics*, 46(6), 808–813
- [9]. Siqueira Jr, J. F., & Rôças, I. N. (2008). Clinical implications and microbiology of bacterial persistence after treatment procedures. *Journal of Endodontics*, 34(11), 1291–1301
- [10]. Al-Hadlaq, S. M., Aljarbou, F. A., & AlThumairy, R. I. (2006). Evaluation of post space preparation techniques and their effect on apical seal using a fluid filtration method. *Journal of Endodontics*, 32(2), 163–166.
- [11]. Tay, F. R., Pashley, D. H., Loushine, R. J., Weller, R. N., Monticelli, F., & Osorio, R. (2005). Self-etching adhesives increase collagen solubilization in demineralized dentin. *Journal of Dental Research*, 84(6), 476–481
- [12]. Kim, Y. K., & Kim, S. K. (2002). Microleakage of AH Plus and Apexit root canal sealers. *International Endodontic Journal*, 35(6), 408–413.
- [13]. De-Deus, G., Gurgel-Filho, E. D., Magalhães, K. M., & Coutinho-Filho, T. (2007). A laboratory analysis of gutta-percha-filled area obtained using Thermafil, System B and lateral condensation. *International Endodontic Journal*, 40(10), 844–850.
- [14]. Han, L., & Okiji, T. (2011). Bioactivity evaluation of three calcium silicate-based endodontic materials. *International Endodontic Journal*, 44(9), 800–807.
- [15]. Celikten, B., Uzuntas, C. F., Orhan, A. I., Orhan, K., Tufenkci, P., Kalender, A., & Kose, T. (2016). Evaluation of root canal sealer filling quality using micro-computed tomography. *Journal of Endodontics*, 42(2), 230–235.
- [16]. Ghoneim, A. G., Shaheen, N. A., & Abo El-Fotouh, M. M. (2020). Sealing ability of three bioceramic root canal sealers: A comparative study. *European Journal of Dentistry*, 14(1), 80–85.
- [17]. Jeong, J. W., Park, J. H., Kim, H. C., & Yoon, T. C. (2018). Comparison of apical sealing ability of bioceramic and epoxy resin-based sealers using a dual-chamber leakage model. *Restorative Dentistry & Endodontics*, 43(3), e27.
- [18]. Al-Haddad A, Che Ab Aziz ZA. Bioceramic-Based Root Canal Sealers: A Review. *Int J Biomater*. 2016;2016:9753210.
- [19]. Torabinejad, M., & Parirokh, M. (2010). Mineral trioxide aggregate: A comprehensive literature review—Part II: Leakage and biocompatibility investigations. *Journal of Endodontics*, 36(2), 190–202.