



EVALUATION OF APICAL LEAKAGE AFTER IMMEDIATE AND DELAYED POST-SPACE PREPARATION USING DIFFERENT ROOT CANAL SEALERS: AN INVITRO STUDY

¹Dr. Ananthakrishna S., ²Dr. Sameer Mohideen Gani S., ³Dr. Pradeep P. R., ⁴Dr. Iffath Hussain and ⁵Dr. Sai Radhika Palagiri

¹Professor and HOD, Department of Conservative Dentistry and Endodontics, M. R. Ambedkar Dental College and Hospital, Bangalore.

^{2,4,5}Post-Graduate Student, Department of Conservative Dentistry and Endodontics, M. R. Ambedkar Dental College and Hospital, Bangalore.

³Principal and Professor, Department of Conservative Dentistry and Endodontics, M. R. Ambedkar Dental College and Hospital, Bangalore.



*Corresponding Author: Dr. Ananthakrishna S.

Professor and HOD, Department of Conservative Dentistry and Endodontics, M. R. Ambedkar Dental College and Hospital, Bangalore.

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ABSTRACT

Aims and Objectives: The aim of this study was to evaluate the apical leakage after immediate and delayed postspace preparation using three root canal sealers – Sealapex, Ceraseal and MTA Fillapex. **Materials and Methods:** Sixty single-rooted teeth were decoronated, prepared with Pro Taper instruments, and obturated using gutta-percha with three sealers: Sealapex, Metaceraseal, and MTA Fillapex. Teeth were divided into groups based on immediate or delayed (1 week) post space preparation. Gutta-percha was partially removed, and post space was prepared using Peeso reamers. Samples were sealed with Cavit G, coated with nail varnish, and immersed in Rhodamine dye for 72 hours. After longitudinal sectioning, dye penetration was analyzed under a stereomicroscope at 10x magnification to assess apical sealing. The extent of dye penetration was measured using an image analysis system. **Results:** Sealapex showed the most apical leakage due to volumetric expansion and high solubility during setting. Its calcium hydroxide content promotes healing but compromises sealing. MTA Fillapex, with better sealing, sets in moisture and forms calcium hydroxide, which reacts to create calcium carbonate and a calcium silicate hydrate gel, enhancing retention and reducing gaps over time. Ceraseal, a bioceramic sealer, exhibited intermediate leakage. It absorbs water from dentinal tubules, releasing ions like Ca⁺⁺ and OH⁻ to form hydroxyapatite, creating a strong chemical bond with dentin. Its small particle size and smooth flow enhance sealing without shrinkage. **Conclusion:** This study found apical leakage in all groups, regardless of sealer or post-space preparation timing. MTA Fillapex showed the least leakage, while Sealapex had the most. Immediate post-space preparation resulted in slightly less leakage than delayed preparation for all sealers, though the difference was not statistically significant.

INTRODUCTION

The ability to maintain an apical closure and a three-dimensional root canal filling are critical factors for the long term success of an endodontic therapy. Retreatment is necessary when the tooth becomes reinfected due to a breakdown in the apical seal. For this reason, Careful.

Assessment of the root canal filling material's sealing capacity is required.^[1] Leakage typically happens at the sealer/dentin or gutta-percha/sealer contact. Thus, it is obvious that the sealer's adhesion to the dentinal wall plays a vital role.^[2]

An ideal root canal sealer should effectively fill up any

gaps with the primary core material by penetrating the untreated areas of the root canal and creating a hermetic seal.^[3] As a result, the perfect sealer and substrate must create a solid interface. There should be little shrinkage or expansion of this interface's dimensions.^[4] For these reasons, sealers are very important to help achieve a three-dimensional obturation.

Sealapex (Kerrdental, Brea, CA, USA) is a traditional calcium hydroxide sealer with a long and successful history of therapeutic use. It enhances periapical tissue repair, has antibacterial activity, and encourages the creation of hard tissue. Due to these benefits, Sealapex is widely utilised in endodontics all over the world. Due to

Sealapex's soluble nature, there has been much discussion on the material's capacity to offer a long-lasting seal. These issues arise from The way it works, which necessitates the material to undergo ionic disassociation into hydroxyl and calcium ions.^[5]

A novel bioceramic sealer called CeraSeal (Meta Biomed Co., Ltd. Korea, Republic) was released onto the market. It comes in a flowable paste form that needs to be inserted into the root canal right away. According to the producers, it has a special stability that never shrinks or expands. They also assert that it has outstanding sealing power.^[6]

MTA Fillapex®, a brand newly introduced by Angelus Industrial de Produtos Odontológicos S/A, Londrina, PR, Brazil, was developed. Its chemical makeup is derived from the MTA and is supplemented with other materials to give it a consistency appropriate for use in root canal therapy. Although the exact contents of Fillapex® are kept under wraps, it is known that disalicylate and synthetic Portland cement clinkers are the building blocks needed to create an ionic polymer. Its specifications state that it has a 35-minute working time, a 27.66-mm flow capacity, a 130-minute setting time, an optical density of 77%, and 0.1% solubility. Furthermore, handling it is simple. It was not noted in the literature reviews assessing Fillapex®'s sealability.^[7]

AIM

The aim of this study was to evaluate the apical leakage after immediate and delayed postspace preparation using three root canal sealers – Sealapex, Ceraseal and MTA Fillapex.

MATERIALS AND METHODOLOGY

Sixty single-rooted teeth were decoronated and roots were biomechanically prepared and obturated with gutta-percha and 3 sealers:

1. Sealapex (Group A, n = 20)
2. Metaceraseal root canal sealer (Group B, n = 20)
3. MTA fillapex (Group C, n = 20)

The teeth were decoronated at the cemento-enamel junction with a slow-speed diamond disc under constant water cooling. Working length was determined by placing a size 15 K-file (Mani Inc. Japan) into the canal until the file tip was visible at the apical foramen. 1 mm was subtracted from this length to obtain the final working length. Instrumentation of canals was done using Pro Taper instruments (Dentsply Maillefer) till F3 17% EDTA gel (RC Help) was used as a lubricant. After the use of each instrument, the canals were irrigated with 5% sodium hypochlorite solution. The canals were finally rinsed with sterile saline to remove any dentin debris that remained in the canal after instrumentation.

Root-canal sealers were mixed as instructed by the manufacturers and root canal obturation was done by

lateral compaction technique. The postspace preparation in all the samples was made according to the study protocol. Coronal 2–3 mm of the gutta-percha was removed and the coronal end of the canals was sealed with Cavit G.

The samples for the delayed postspace preparation were stored in normal saline for a week. The postspace in each sample was prepared with Peeso reamer. The size of the Peeso reamer was determined according to the original canal size (from size 1–4) to a depth that will leave a minimum of 5 mm of gutta-percha apically. Samples were randomly assigned into two main groups. Each of these groups was then divided into two subgroups to receive the treatment as follows

Group A1: Gutta-percha + Sealapex sealer followed by immediate post-space preparation
Group A2: Gutta-percha + Sealapex sealer and the post space preparation were done 1 week after the obturation.

Group B1: Gutta-percha + Metaceraseal root canal sealer followed by immediate post-space preparation.

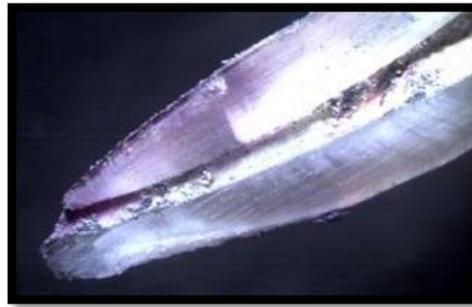
Group B2: Gutta-percha + Metaceraseal root canal sealer and the post-space preparation were done 1 week after the obturation.
Group C1: Gutta-percha + MTA fillapex root canal sealer followed by immediate post-space preparation.

Group C2: Gutta-percha + MTA fillapex root canal sealer and the post-space preparation were done 1 week after the obturation.

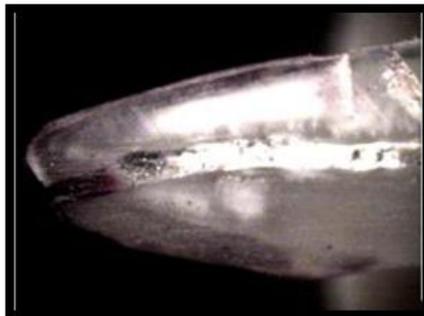
After post-space preparation, the access cavities were sealed with Cavit G. The samples were coated with two layers of nail varnish covering it entirely including the access restoration except apical 2 mm. The samples were then immersed in Rhodamine dye for 72 h. The samples were then ground longitudinally at high speed under constant water cooling with a cylindrical diamond disc until the root canal filling was reached on one side, whilst keeping a thin layer of apical dentin intact. Sections were examined under the stereomicroscope (Wuzhou New Found Instrument Co. Ltd., China Model: XTL 3400E) at × 10 magnification. The depth of dye penetration was measured linearly from the apical root end to the maximum extent of penetration of dye in the coronal direction with Image Analysis System (Chroma Systems Pvt., Ltd., and India. Model: MVIG 2005).



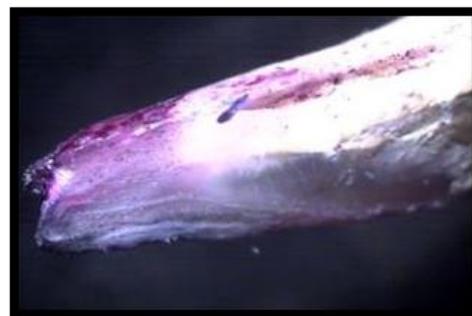
Seal Apex - Immediate



Seal Apex - 1week



Ceraseal - Immediate



Ceraseal - 1week



MTA -Immediate



MTA-1 week

RESULTS

The normality of data was checked by Shapiro-Wilk tests. Independent sample t-test was used to compare two

independent numeric groups. One-way analysis of variance was used to compare more than two independent numeric groups.

Comparison of mean Microleakage (in mm) b/w 3 groups at Immediate time interval using One-way ANOVA Test						
Groups	N	Mean	SD	Min	Max	p-value
Seal Apex	5	0.544	0.223	0.25	0.81	<0.001*
MTA Fillapex	5	0.526	0.117	0.38	0.67	
Ceraseal	5	1.030	0.015	1.01	1.05	

Statistically Significant

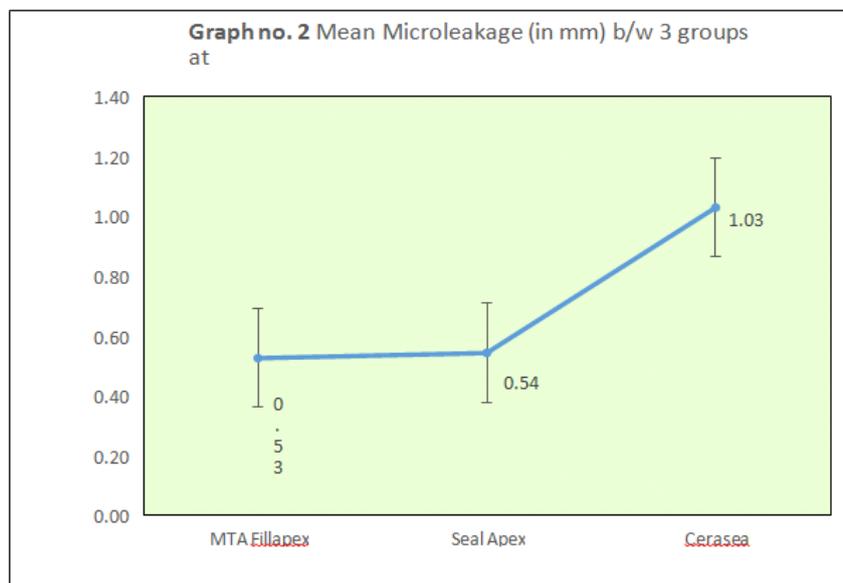
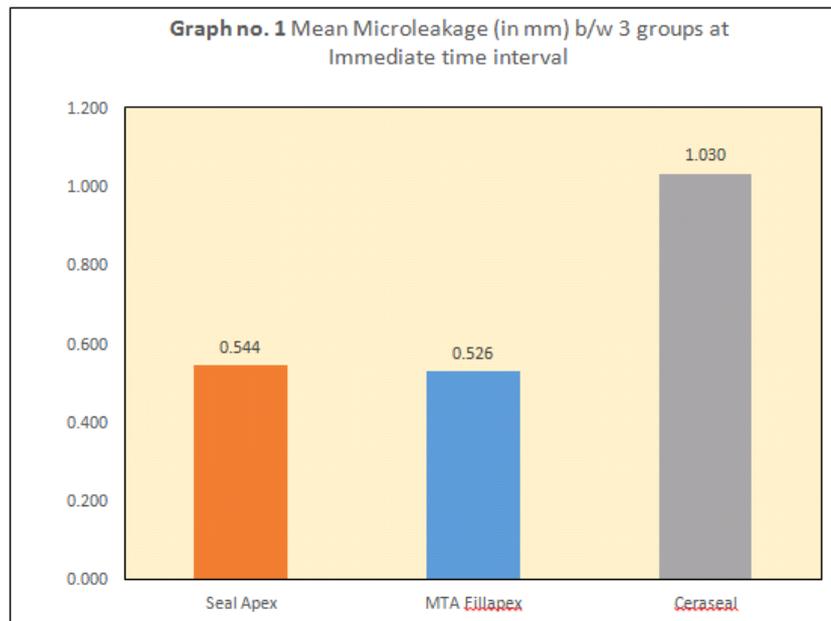
Multiple comparison of mean diff. in mean Microleakage b/w 3 groups at Immediate time interval using Tukey's Post hoc Test					
(I) Groups	(J) Groups	Mean Diff.(I-J)	95% CI for the Diff		p-value
			Lower	Upper	
Sealapex	MTA Fillapex	0.017	-0.228	0.263	0.98
	Ceraseal	-0.486	-0.732	-0.241	0.001*
MTA Fillapex	Ceraseal	-0.504	-0.749	-0.258	<0.001*

*Statistically Significant

The mean Microleakage in Seal Apex group was 0.544 ± 0.223 , in MTA Fillapex group was 0.526 ± 0.117 and in Ceraseal group was 1.030 ± 0.015 . This difference in the mean Microleakage between 3 sealer groups at Immediate time interval was statistically significant at $p < 0.001$. [Refer Graph no. 1].

Multiple comparisons of mean differences between groups revealed that the Ceraseal group showed significantly increased mean Microleakage as compared

to Sealapex and MTA Fillapex groups and the mean differences were statistically significant at $p = 0.001$ & $p < 0.001$ respectively. However, no significant difference was observed in the mean Microleakage between Sealapex and MTA Fillapex groups [$p = 0.98$]. This infers that the mean Microleakage at Immediate time intervals was significantly higher in the Ceraseal group and lesser in the Seal Apex and MTA Fillapex groups. [Refer Graph no. 2].



Comparison of mean Microleakage (in mm) b/w 3 groups after 1-week time interval using One-way ANOVA Test						
Groups	N	Mean	SD	Min	Max	p-value
Seal Apex	5	0.911	0.422	0.58	1.47	<0.001*
MTA Fillapex	5	0.808	0.170	0.53	0.97	
Ceraseal	5	1.475	0.265	1.03	1.71	

* Statically significant

Multiple comparison of mean diff. in mean Microleakage b/w 3 groups after 1-week time interval using Tukey's Post hoc Test

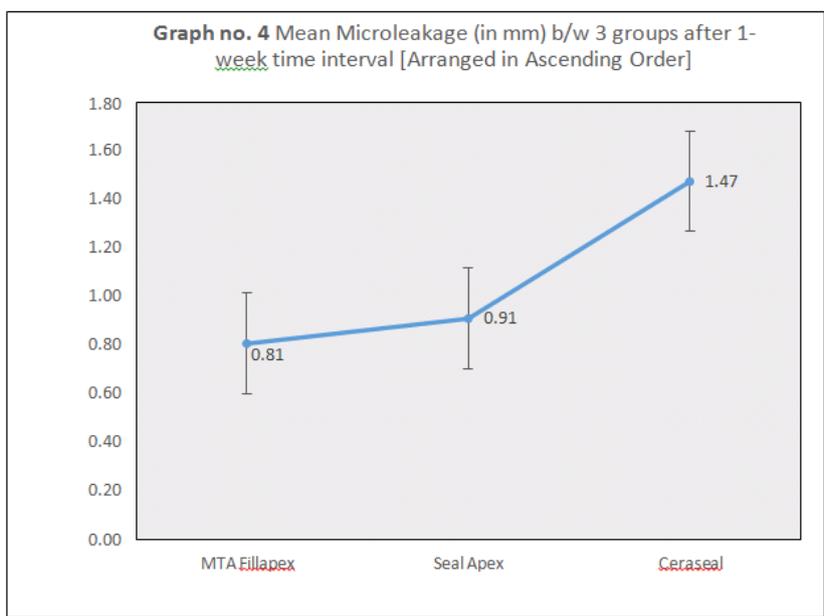
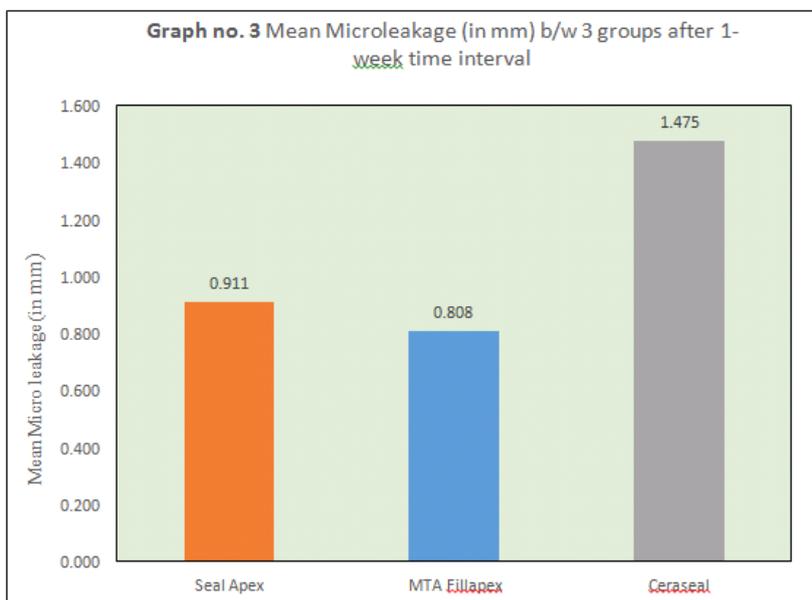
(I) Groups	(J) Groups	Mean Diff.(I-J)	95% CI for the Diff		p-value
			Lower	Upper	
Sealapex	MTA Fillapex	0.103	-0.410	0.616	0.86
	Ceraseal	-0.564	-1.077	-0.051	0.03*
MTA Fillapex	Ceraseal	-0.667	-1.180	-0.154	0.01*

*Statistically Significant

The mean Microleakage in Seal Apex group was 0.911 ± 0.422 , in MTA Fillapex group was 0.808 ± 0.170 and in Ceraseal group was 1.475 ± 0.265 . This difference in the mean Microleakage between 3 sealer groups after 1-week time interval was statistically significant at $p < 0.001$. [Refer Graph no. 3]

significantly increased mean Microleakage as compared to Sealapex and MTA Fillapex group and the mean differences were statistically significant at $p = 0.03$ & $p = 0.01$ respectively. However, no significant difference was observed in the mean Microleakage between Sealapex and MTA Fillapex group [$p = 0.86$] This infers that the mean Microleakage at 1-week time interval was significantly higher in Ceraseal group and lesser in Seal Apex and MTA Fillapex groups. [Refer Graph no. 4].

Multiple comparison of mean differences between groups revealed that the Ceraseal group showed

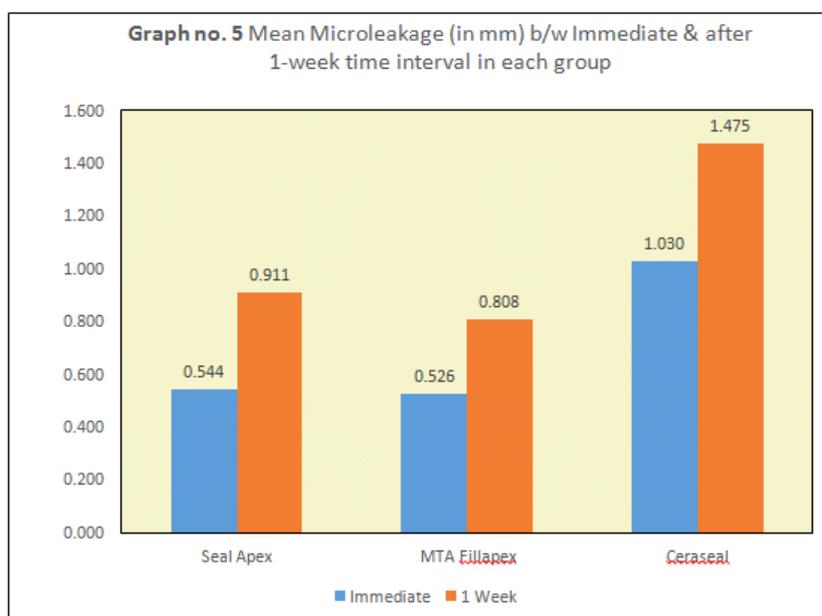


Comparison of mean Microleakage (in mm) b/w Immediate & after 1-week time interval in each group using Student Paired t Test						
Groups	Time	N	Mean	SD	Mean Diff	p-value
Seal Apex	Immediate	5	0.544	0.223	-0.367	0.04*
	1 Week	5	0.911	0.422		
MTA Fillapex	Immediate	5	0.526	0.117	-0.281	0.05#
	1 Week	5	0.808	0.170		
Ceraseal	Immediate	5	1.030	0.015	-0.445	0.02*
	1 Week	5	1.475	0.265		

*Statistically Significant

In Seal Apex and Ceraseal group, the mean Microleakage significantly increased at 1-week time interval [0.911 ± 0.422 & 1.475 ± 0.265] as compared to immediate time-interval [0.544 ± 0.223 & 1.030 ± 0.015] and the mean differences between 2-time intervals were statistically significant at $p=0.04$ & $p=0.02$ respectively. In the MTA Fillapex group, the mean Microleakage relatively

increased at 1-week time interval [0.808 ± 0.170] as compared to Immediate time- interval [0.526 ± 0.117] and the mean difference between 2 time intervals showed a borderline significance at $p=0.05$. This infers that the mean Microleakage in all the 3 groups showed significant increase at 1-week time interval as compared to immediate time period. [Refer Graph no. 5].



DISCUSSION

This study compared the apical leakage of MTA Fillapex, Ceraseal, and Sealapex sealers. Sealapex exhibited the highest leakage. It is a non-eugenol, radiopaque calcium hydroxide and polymeric resin sealer used with gutta-percha points. While Sealapex promotes apical closure through cementogenesis, accelerates healing, and inhibits osteoclastic activity due to its alkaline pH^[8], its tendency to absorb water leads to significant volumetric expansion during setting.^[9] This expansion increases its solubility^[10], compromising its sealing ability and resulting in higher leakage.

MTA Fillapex, presented as a paste, contains MTA, resins, bismuth trioxide, nanoparticulated silica, and pigment. In this study, it showed less leakage than both Sealapex and Ceraseal. Its ability to set in a moist environment likely contributed to this outcome. MTA's calcium oxide reacts with water or tissue fluids to

produce calcium hydroxide, which further dissociates into calcium and hydroxyl ions. These ions interact with tissue carbon dioxide to form calcite-like calcium carbonate crystals^[11], improving retention by minimizing marginal gaps and porosities.^[12] Over time, MTA hydration creates a calcium silicate hydrate gel, enhancing its sealing capability by binding to dentinal calcium and phosphate ions, forming calcium phosphate precipitates.^[13] Irrigating with NaOCl at the end of canal preparation creates an alkaline environment that promotes the hydration of calcium silicate cement, further strengthening the sealer's performance.^[14]

Ceraseal, a bioceramic sealer made of tricalcium silicate, dicalcium silicate, calcium aluminate, zirconium oxide, and a thickening agent, demonstrated intermediate performance. It is known for its stability, bioactivity, and biocompatibility. Its fine particle size, water affinity, and low contact angle allow it to flow smoothly over dentinal

walls and penetrate lateral micro-canals, forming a chemical bond with the dentin.^[15] Its setting process begins by absorbing water from dentinal tubules, producing calcium hydroxide, which releases ions like Si⁴⁺, Ca⁺⁺, and OH⁻.^[16] This reaction creates calcium silicate hydrogel and hydroxyapatite crystals, which chemically bond with hydroxyl groups in the hydrogel.^[17-18] The continuous growth of these hydroxyapatite crystals strengthens the sealer's bond with dentin, preventing shrinkage and reducing leakage, consistent with the findings of Zang et al.^[19] and Bayram et al.^[20]

Several techniques, including dye penetration, radioactive isotope penetration, fluid filtration, and scanning electron microscopy, are used to evaluate root canal sealing ability.^[21, 22] Dye penetration, chosen for this study, is widely used due to its simplicity, affordability, and reliability, relying on passive fluid movement through capillaries.^[22] For delayed postspace preparation, samples were stored in saline at 37°C for a week to ensure complete setting of the sealers and to avoid water evaporation during measurement.^[23, 24]

Although both immediate and delayed postspace preparation groups showed leakage, the immediate group had slightly better results. When postspace preparation was performed immediately, the sealer was still within its working time, reducing the risk of microcracks. In contrast, delayed preparation may disrupt the set sealer, as Peeso reamers can cause vibrations or twists, leading to microcracks and weakening the sealer-dentin interface.^[25, 26]

Prior studies by Lyons et al.^[27], Saunders et al.^[28], and Rybicki and Zillich^[29] also reported no significant difference between immediate and delayed postspace preparation, which aligns with our findings. However, as this is an in vitro study, it does not fully replicate clinical conditions, such as exposure to tissue, periapical, or oral fluids. Thus, further in vivo research is necessary to confirm these findings and optimize sealer selection and post-space preparation timing.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that.

1. Apical leakage was observed in all the groups irrespective of the sealers used and time of postspace preparation.
2. MTA Fillapex showed lesser apical leakage than Metaceraseal sealer in both the sub-groups (immediate and delayed postspace preparation groups), while Sealapex has the highest apical leakage in both the sub groups.
3. Apical leakage in the immediate postspace preparation group was lesser than delayed postspace preparation

group for both the sealers, however, the difference was not statistically significant.

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