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Pull Out Retentive Strength of Single Fiber Post Cemented with Two Different Luting Cement at Different Times in Canal and Obturated with Two Different Sealers. – An In Vitro Study

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ABSTRACT

Background: Post and core systems are widely used for restoring endodontically treated teeth, with retention being vital for the longevity of restorations. Several factors influence retention, including post space preparation, luting agents, and root canal sealers. Eugenol-based sealers, although commonly used, can interfere with resin polymerization, affecting material properties. Due to increasing aesthetic demands, fiber posts are preferred over cast posts. Their retention depends heavily on the adhesive system used. Fiber posts are typically luted with dual- or self-curing resin cements. Poor adaptation can lead to excessive cement thickness, creating voids and microcracks that may result in debonding or failure under stress.

Aim : The purpose of this study was to evaluate the retentive strength of fiber post cemented with two different luting agents- Resin cement and Zinc phosphate cement cemented after 24 hours or 2 weeks in root canals obturated with gutta percha and two different types of sealers- Bioceramic sealers and Calcium Hydroxide sealers.

Materials and Methods : Fifty-six mandibular premolars were obturated using either bioceramic or calcium hydroxide sealers, then divided into eight groups. Post spaces were prepared at 24 hours or 2 weeks and luted with self-adhesive or zinc phosphate cement. Pull-out bond strength was tested and analyzed using Shapiro-Wilk and Kruskal-Wallis tests.

Result: Fifty-six premolars were prepared, obturated with two sealers, and cemented using two luting agents at two time intervals. Group 4 showed the highest pull-out bondstrength at 491.80 ± 1.16 N ; Group 7 the lowest at 281.27 ± 1.89 N. Significant differences existed across all groups ($p = 0.001$).

Conclusion : Post retention is significantly influenced by the timing of fiber post cementation after root canal obturation. Generally, a two-week delay improves retention, except when using resin cement with bioceramic sealers, where 24-hour placement performs better. Material compatibility and timing are key to optimizing post-endodontic restoration durability

KEYWORDS: Bioceramic Sealer, Calcium Hydroxide Sealer, Resin cement, Zinc Phosphate cement**.**

I. INTRODUCTION

Dental trauma, extensive restorative procedures, and endodontic treatments often lead to significant loss of tooth structure, reducing the strength and stability of affected teeth and increasing their susceptibility to fracture[1]. Despite this structural compromise, advancements in endodontic therapy and restorative dentistry have considerably improved the prognosis of such teeth, enabling long-term function and supporting a shift toward conservative, tooth-preserving treatment approaches rather than extraction[2-5]. Evidence-based restorative techniques now prioritize the retention of natural teeth, resulting in improved clinical outcomes.

Endodontic therapy involves the removal of diseased or necrotic pulp tissue, leaving the tooth non-vital and structurally weakened[5,6]. Earlier theories suggested that reduced moisture content in endodontically treated teeth increased fracture risk[7]; however, current understanding emphasizes the loss of internal tooth structure as the primary contributor to reduced strength. This necessitates reinforcement strategies to protect teeth from functional stresses. Prosthodontic and restorative dentistry aim to restore lost tooth structure, maintain function, enhance aesthetics, and prevent further damage or infection[5].

Reinforcement of endodontically treated teeth commonly involves intraradicular posts, adhesive systems, and full-coverage restorations.

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The selection of an appropriate post system is crucial, as it must provide adequate support while preserving remaining tooth structure. Biological, mechanical, and aesthetic factors all influence long-term success[8,9].

The use of intracanal posts has been documented for over two and a half centuries. In 1728, Pierre Fauchard described metal "tenons" screwed into tooth roots to retain dental prostheses[10,11]. By the mid-19th century, wooden pivot crowns replaced metal posts due to better adaptability; however, moisture absorption caused expansion and a high incidence of root fractures[12]. Later, the Richmond crown emerged as a significant advancement, incorporating a porcelain-faced, post-retained single-unit restoration designed to serve as a bridge retainer[12,13].

A major milestone occurred in the 1930s with the introduction of the custom cast post-and-core system, which replaced one-piece post crowns[12,14]. Fabricating the post-and-core separately from the crown improved marginal adaptation, allowed greater flexibility in crown placement, and enhanced restoration longevity. Although cast metal posts were long considered the gold standard, their use declined due to disadvantages such as increased risk of vertical root fracture, corrosion, biocompatibility concerns, poor aesthetics, higher costs, and the need for multiple clinical appointments[15-17].

Modern dentistry emphasizes aesthetics and biomechanical compatibility, leading to the widespread use of tooth-coloured, non-metallic posts such as fiber-reinforced composites and ceramics[18]. These materials better mimic dentin and offer favourable stress distribution. Advances in adhesive bonding have further shifted post retention from mechanical interlocking to chemical adhesion, improving load distribution and reducing fracture risk[19].

Post retention is influenced by multiple factors, including post design, dimensions, luting agents, post space preparation, and root canal sealers[20-23]. Eugenol-based sealers, though commonly used, may interfere with resin polymerization and compromise bonding[24,25]. The purpose of this study is to evaluate the retentive strength of single fiber post cemented with two different luting agents- Resin cement and Zinc phosphate cement cemented after 24 hours or 2 weeks in root canals obturated with gutta percha and two different types of sealers- Bioceramic sealer and Calcium Hydroxide sealer.

II. MATERIALS AND METHODS

Table 1. The composition and manufacturer details of the tested Glass Fiber post

TRADE NAME	TYPE	COMPOSITION	MANUFACTURER
REFORPOST®	Glass Fiber serrated parallel intraradicular post with conical tip	Glass Fiber (80%) Pigmented Resin (19%) Stainless Steel Filament (1%)	ANGELUS®, BRAZIL

Table 2. The composition and manufacturer details of the tested luting Cements

TRADE NAME	TYPE	COMPOSITION	MANUFACTURER
RelyX™ U200	Self adhesive Resin Cement	Base paste- Silane treated glass powder, phosphorylated methacrylate, TEGDMA, silane treated silica, glass powder, persulfate, perester. Catalyst paste- silane treated glass powder, substituted dimethacrylate, aliphatic dimethacrylate, salt of substituted barbituric acid, silane treated silica, calcium hydroxide, sulfinate, methacrylated amine, pigments including titanium dioxide	3M ESPE
Pyrax	Zinc Phosphate cement	Powder- Zinc oxide , Magnesium oxide, Strontium Chloride, Tannic acid ,	PYRAX®, INDIA

		Liquid – Ortho phosphoric acid and excipients.	

Table 3. The composition and manufacturer details of the tested Sealers

TRADE NAME	TYPE	COMPOSITION	MANUFACTURER
ROOTFYX	Bioceramic sealer	Calcium Silicate Tantalum Oxide in compatible media	MAARC® DENTAL
ENDOPEX	Calcium Hydroxide based sealer	Base Paste: • Salicylate Resin • Natural Resin • Calcium Tungstate • NanoparticulatedSilica • Pigments Catalyst Paste: • Diluting Resin • Mineral Trioxide Aggregate (MTA) • Nanoparticulated Silica • Pigments	SS WHITE DENTAL®

ELIGIBILITY CRITERIA

- **Inclusion criteria**: Extracted premolars.
- **Exclusion criteria:**
  - ✓ Teeth which are grossly decayed.
  - ✓ Teeth with developmental anomalies.
  - ✓ Teeth having restorations.

III. Methodology

Sample Preparation

Fifty-six freshly extracted, caries-free, single-rooted human mandibular premolars were selected. Radiographic evaluation in both buccolingual and mesiodistal directions confirmed the presence of a single, straight, non-calcified canal according to the Schneider method.

The crowns were sectioned 2 mm coronal to the mid-facial cementoenamel junction using a precision low-speed diamond saw under water cooling to prevent heat damage. Pulpal tissues were extirpated with a barbed broach (Mani Inc.). Working length was determined by inserting a size 10 K-file until visible at the apical foramen, followed by a 1 mm reduction.

Canal preparation was initiated with K-files (sizes 15 and 20), followed by Protaper Ni-Ti rotary instruments (S1, S2, F1, F2; HyFlexR CM, Coltene) using a crown-down technique in a torque-controlled motor (Orikam) at 350 rpm. Irrigation with 3 mL of 5.25% sodium hypochlorite was performed after each file using a 27-gauge side-vented needle.

Obturation

The specimens were randomly allocated into eight experimental groups (n = 7). Two root canal sealers were employed:

1. **Bioceramic sealer** (Rootfyx, MAARC^{R} Dental)
2. **Calcium hydroxide-based sealer** (Endopex, SS White Dental®)

Master cone obturation was carried out using F2 gutta-percha cones (Kerr Dental) coated with the assigned sealer. The sealer was applied to the canal walls with a K-file, and the master cone was seated apically. Vertical condensation with a heated plugger was used to compact the coronal gutta-percha.

A 3 mm space was prepared coronally and restored provisionally with Cavit (3M ESPE). All specimens were stored in 100% relative humidity at room temperature.

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Table 4. Experimental grouping of specimens

Group	Time Interval	Luting Cement	Sealer Type
1	24 hours	Self-adhesive resin cement	Bioceramic sealer
2	2 weeks	Self-adhesive resin cement	Bioceramic sealer
3	24 hours	Self-adhesive resin cement	Calcium hydroxide sealer
4	2 weeks	Self-adhesive resin cement	Calcium hydroxide sealer
5	24 hours	Zinc phosphate cement	Bioceramic sealer
6	2 weeks	Zinc phosphate cement	Bioceramic sealer
7	24 hours	Zinc phosphate cement	Calcium hydroxide sealer
8	2 weeks	Zinc phosphate cement	Calcium hydroxide sealer

Post Space Preparation

After the specified interval (24 hours or 2 weeks), coronal and middle thirds of gutta-percha were removed with a No. 5 Peeso reamer (Mani Inc.) at low speed, creating an **8 mm post space** while maintaining a **5 mm apical seal** (fig. 1). Continuous irrigation with NaOCl was used to ensure canal cleanliness.

FIGURE 1. Use of No.5 Peeso reamer for post space preparation

Post Cementation

All canals were dried with absorbent paper points before post placement.

- **Resin cement groups (1–4):** Fiber posts were cemented with **adhesive resin cement**, applied per manufacturer's instructions. The cement was coated on the post and introduced into the canal with gentle pressure and slight rotation to prevent air entrapment. Excess cement was removed with a fine brush, and polymerization was performed for 40 seconds using a halogen light-curing unit.
- **Zinc phosphate groups (5–8):Zinc phosphate cement** was introduced into the canal using a lentulo spiral. Fiber posts were seated with gentle pressure, and excess cement was removed.

All specimens were stored at **37°C in 100% humidity for 7 days** before testing.

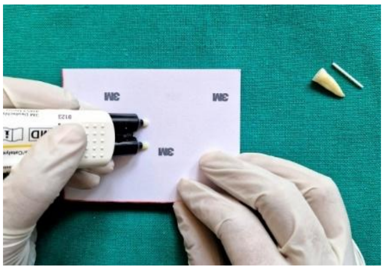

FIGURE 2. Manipulation of Self-adhesive resin cement

FIGURE 3. Cementation of fiber post

Pull out testing

- The specimens were then mounted with autopolymerizing resinin a short length of polyvinyl chloride pipe. (fig.4)
- Each dental specimen was positioned in a vertical orientation and securely mounted within a universal testing machine.
- Tensile force was applied to dislodge the post using pneumatic grips, which firmly engaged the post head and exerted traction along its longitudinal axis. (fig.5)

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- A uniform loading rate of 0.5 mm/min was maintained until failure of the luting cement was observed.
- The maximum force registered at the moment the post was extruded from the tooth structure was defined as the point of bond failure. The applied force was measured and recorded in newtons (N)

FIGURE 4. Specimens mounted with autopolymerizing resin in a pvc pipe.

FIGURE 5. Specimen mounted within a universal testing machine

IV. RESULTS

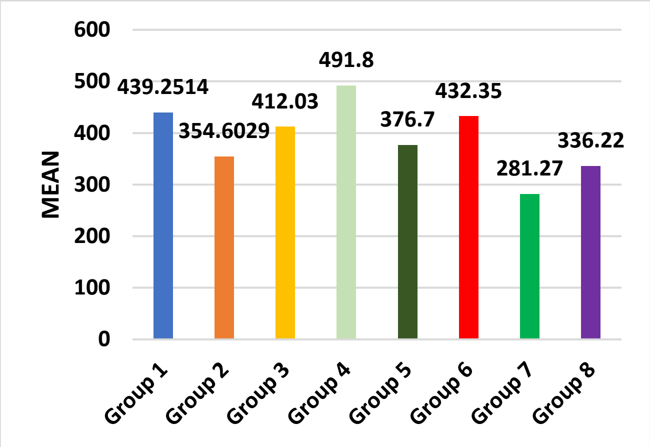
Fifty-six extracted mandibular premolars were instrumented, irrigated, and obturated, then divided into eight groups based on sealer type, post-space timing, and luting cement. Fiber posts were cemented and evaluated for pull-out retentive strength using standardized endodontic and restorative procedures protocols and the following results were obtained.

Table 5.Intergroup comparison of pull out bond strength

Group	Mean Bond Strength (N ± SD)	Median(IQR)	Range (N)	Skewness	Kurtosis
1	439.25 ± 1.54	439.28 N(2.70)	437.13–441.23	-0.047	-1.640
2	354.60 ± 1.58	354.45 N(1.84)	351.64–356.15	-1.085	1.210
3	412.03 ± 1.33	412.56 N (2.55)	410.27–413.78	-0.215	-1.587
4	491.80 ± 1.16	492.01 N (2.51)	490.30–493.11	-0.178	-1.914
5	376.70 ± 1.46	377.08 N (2.00)	-	-0.494	0.488
6	432.35 ± 3.23	431.78 N (5.44)	427.55–437.18	0.196	0.180
7	281.27 ± 1.89	281.37 N (2.68)	-	-0.027	-0.783
8	336.22 ± 1.46	335.63 N (3.21).	-	0.794	-1.298

The comparison between the eight groups showed that the differences in pull-out bond strength were statistically significant (P = 0.001), meaning the results are not due to chance. Among all the groups, Group 4 had the highest bond strength, indicating the strongest performance. In contrast, Group 7 had the lowest bond strength, making it the weakest group in terms of retention.

Group 1 and Group 6 also showed high bond strengths but were still lower than Group 4. On the other hand, Group 2, Group 5, and Group 8 had moderate bond strengths, falling between the highest and lowest performers. Group 3 also performed well but was weaker than Group 1 and Group 4.

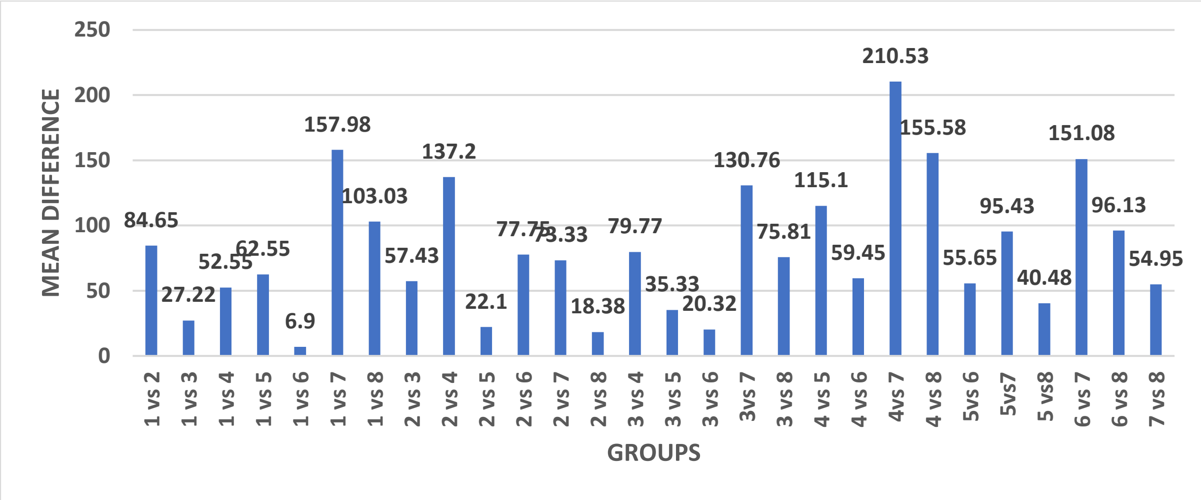


GRAPH 1. Intergroup comparison of pull out bond strength

The post hoc pairwise comparison shows significant differences ($p < 0.001$) in pull-out bond strength between almost every pair of groups. Each group differed significantly from others in terms of bond strength, with Group 4 being the best, followed by Groups 1 and 6, while Groups 7 and 2 were the weakest.

Table 6: Post hoc pairwise comparison of pull out bond strength

Group	Mean Difference (I–J)	Std. Error	95% CI (Lower–Upper)	Sig.
1 vs 2	84.65*	0.97	81.58 – 87.71	.000
1 vs 3	27.22*	0.97	24.16 – 30.29	.000
1 vs 4	-52.55*	0.97	-55.61 – -49.48	.000
1 vs 5	62.55*	0.97	59.49 – 65.62	.000
1 vs 6	6.90*	0.97	3.84 – 9.97	.000
1 vs 7	157.98*	0.97	154.92 – 161.05	.000
1 vs 8	103.03*	0.97	99.97 – 106.10	.000
2 vs 3	-57.43*	0.97	-60.49 – -54.36	.000
2 vs 4	-137.20*	0.97	-140.26 – -134.13	.000
2 vs 5	-22.10*	0.97	-25.16 – -19.03	.000
2 vs 6	-77.75*	0.97	-80.81 – -74.68	.000
2 vs 7	73.33*	0.97	70.27 – 76.40	.000
2 vs 8	18.38*	0.97	15.32 – 21.45	.000
3 vs 4	-79.77*	0.97	-82.84 – -76.70	.000
3 vs 5	35.33*	0.97	32.26 – 38.40	.000
3 vs 6	-20.32*	0.97	-23.39 – -17.25	.000
3vs 7	130.76*	0.97	127.69 – 133.83	.000
3 vs 8	75.81*	0.97	72.74 – 78.88	.000
4 vs 5	115.10*	0.97	112.03 – 118.17	.000
4 vs 6	59.45*	0.97	56.38 – 62.52	.000
4vs 7	210.53*	0.97	207.46 – 213.60	.000
4 vs 8	155.58*	0.97	152.51 – 158.65	.000
5vs 6	-55.65*	0.97	-58.72 – -52.58	.000
5vs7	95.43*	0.97	92.36 – 98.50	.000
5 vs8	40.48*	0.97	37.41 – 43.55	.000
6 vs 7	151.08*	0.97	148.01 – 154.15	.000
6 vs 8	96.13*	0.97	93.06 – 99.20	.000
7 vs 8	-54.95*	0.97	-58.02 – -51.88	.000



GRAPH 2. Mean Difference

V. DISCUSSION

Extensive dental procedures such as trauma management, restorative treatments, and endodontic therapy often compromise the structural integrity of teeth, increasing their susceptibility to fracture[1]. Advances in endodontics and restorative dentistry have shifted the clinical emphasis from tooth extraction to the preservation and reinforcement of natural teeth[5]. Reinforcement strategies including the use of posts, adhesive luting systems, and full-coverage restorations are now integral to restoring function and longevity in endodontically treated teeth.

Historically, post-retained restorations have evolved from materials such as metal and wood to porcelain and cast post-and-core systems[11]. Although custom cast posts improved precision and durability, their disadvantages—such as poor aesthetics, high cost, and increased risk of root fracture—limited their clinical appeal[12]. The introduction of fiber-reinforced posts represented a major advancement due to their tooth-colored appearance, elastic modulus similar to dentin, and favorable stress distribution[18,19]. Alongside this, adhesive bonding techniques have increasingly replaced purely mechanical retention, allowing better preservation of tooth structure and improved restoration outcomes[20,21].

Several factors influence the retention of fiber posts, including post design, luting cement, root canal sealer, and the timing of post space preparation. Eugenol-containing sealers are known to interfere with resin polymerization[26,27], prompting interest in alternative sealers such as bioceramic and calcium hydroxide–based formulations. The present study evaluated the pull-out bond strength of fiber posts cemented with either self-adhesive resin cement or zinc phosphate cement at two time intervals (24 hours and 2 weeks) following obturation with bioceramic or calcium hydroxide–based sealers.

Pull-out retentive strength was assessed using a universal testing machine, allowing comparison across eight experimental groups. Statistically significant differences were observed among all groups (P = 0.001), confirming that bond strength is strongly influenced by the interaction between cement type, sealer type, and post cementation timing.

In resin cement–bioceramic sealer combinations, a notable and unexpected reduction in bond strength was observed over time. Group 1 (24 hours) demonstrated high initial bond strength with excellent consistency, reflecting strong early compatibility between resin cement and bioceramic sealer. However, by 2 weeks (Group 2), bond strength declined markedly. This deterioration contrasts with findings from some previous studies but may be explained by the prolonged setting time, hygroscopic expansion, and hydrophilic nature of bioceramic sealers[28,29]. Over time, moisture absorption and dimensional changes may disrupt the resin–sealer interface, compromising micromechanical and chemical bonding[30,31]. These results raise clinical concerns regarding delayed post placement when resin cement is used with bioceramic sealers, as long-term bond stability may be jeopardized.

In contrast, resin cement combined with calcium hydroxide–based sealer showed a clear time-dependent improvement. Group 3 (24 hours) demonstrated reliable and consistent bond strength, while Group 4 (2 weeks) recorded the highest mean bond strength of all groups. This significant increase suggests that prolonged sealer maturation enhances resin cement interaction, likely through improved sealer adaptation, stabilization of the dentin–cement interface, and more complete polymerization[32,33]. These findings align with previous research reporting superior bond strength with calcium hydroxide–based sealers compared to resin- or eugenol-based alternatives[32]. Clinically, this supports delaying post cementation when calcium hydroxide sealers are used in conjunction with resin cements to optimize retention.

For zinc phosphate cement groups, overall bond strengths were lower and more variable compared to resin-based systems. When combined with bioceramic sealer, delayed cementation (Group 6) improved bond strength relative to 24-hour placement (Group 5). Since zinc phosphate cement relies solely on micromechanical retention, this improvement likely reflects sealer maturation rather than chemical interaction[33]. As bioceramic sealers fully set, they may provide a harder, more favorable surface for mechanical interlocking34. However, despite this improvement, zinc phosphate cement remained inferior to resin cement combinations in both strength and consistency.

The weakest performance was observed in zinc phosphate cement combined with calcium hydroxide–based sealer. Group 7 (24 hours) exhibited the lowest bond strength of all groups, highlighting the poor initial interaction between two non-adhesive materials. Although delayed cementation (Group 8) resulted in a measurable improvement, bond strength remained significantly lower than resin-based systems. The lack of chemical bonding and limited mechanical interlocking inherent to both materials restricts the potential for strong post retention, even with increased setting time[34,35].

Intergroup analysis further emphasized these trends. Group 4 (resin cement + calcium hydroxide sealer after 2 weeks) significantly outperformed all other combinations, indicating optimal conditions for post retention. Conversely, Group 7 consistently ranked lowest, confirming it as the least favorable option for clinical use. Groups involving resin cement generally demonstrated superior performance, reinforcing the advantages of adhesive luting systems over traditional zinc phosphate cement.

Post hoc pairwise comparisons confirmed that most groups differed significantly from one another, underscoring the sensitivity of post retention to material selection and timing. Notably, the substantial decline in bond strength between Groups 1 and 2 highlights the potential instability of resin–bioceramic combinations over time, whereas the marked improvement between Groups 3 and 4 illustrates the benefits of delayed cementation with calcium hydroxide sealers.

VI. CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

- The retentive strength of fiber posts is significantly influenced by both material selection and timing of post placement.
- Resin cement with calcium hydroxide sealer and delayed cementation (Group 4) achieved the highest bond strength, reflecting the benefits of sealer maturation and resin–dentin interface stability.
- The zinc phosphate–calcium hydroxide system at 24 hours (Group 7) showed the weakest performance, highlighting the limitations of mechanical retention without chemical bonding.
- Resin–bioceramic combinations exhibited a time-dependent decline in bond strength, attributed to the hydrophilic and expansion-prone properties of bioceramic sealers.
- Zinc phosphate–bioceramic groups demonstrated improved bond strength over time, likely due to enhanced mechanical interlocking with sealer maturation.
- Resin-based systems consistently outperformed zinc phosphate cements, while delayed post placement enhanced retention when compatible materials were used.
- Clinically, careful selection of cement–sealer systems and appropriate timing of post placement are essential for improving the longevity and stability of post-endodontic restorations.

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